Smarter Regulation of Waste in Europe
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LIFE SMART Waste Project

Action B4:

Horizon scanning – Phase 1 (Research)

Literature review

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About the authors

Cranfield University and Waverley Consultants have extensive (+16 years) research experience and track record in developing and delivering horizon scanning and foresight studies that support Government with policy development and regulatory review.

Cranfield University has conducted horizon scanning and foresight research for Government Departments/agencies, including delivering a three-year Defra Futures Partnership project (£1.8M); a pan-governmental foresight programme for 9 partners including the Scottish and Welsh Governments, Environment Agency and Natural England. The project has produced scenarios for the UK food and feed system that are informing the development of food policy within the Food Standards Agency, and also water management scenarios for England and Wales that are being used to future-proof river basin management measures within the Environment Agency. The Institute has worked with Natural Resources Wales and CAMERAS (a partnership of Scottish government and private sector organisations) to stress-tests their environmental strategies, using the UK National Ecosystem Assessment (NEA) scenarios, to assess the drivers of change for ecosystem services and the implications for the natural environment and human well-being in Scotland and Wales. More recently, the Institute (through Fiona Lickorish) has been instrumental in advising governments and other bodies on the use of foresight in emerging risk identification and analysis, including presenting written and verbal evidence to the UK Government's Science and Technology Select Committee on Government Horizon Scanning (2013/14), the IRGC Guidelines on Emerging Risk Governance (2015), the Lloyd's Register Foundation's foresight report on Engineering Resilience (2015).

Waverley Consultants (Alister Wilson) has delivered a range of horizon scanning and scenario projects across government and in the private sector. He has worked with the Government Office for Science's Foresight programme and managed their Futures Analysts Network from its launch in 2005 until it wound down in 2010. Alister has created futures toolkits for BIS, GO Science and the Department for Transport (DfT) and is currently providing design support to The Scottish Government on Horizon Scanning. Alister first worked with SEPA in 2004, when he provided scenario planning training for senior staff and helped develop scenarios for sustainable development. He has worked with SEPA several times since then, first revising the original scenarios and then, in 2011, working with 3rd Horizons to explore the leadership implications of the refreshed scenario set. He provided facilitation support to the Board and Management Team as part of the Transformational Change Programme in 2012 and provided futures advice to the Landscape Review in early 2013.

1.0 Executive Summary

SEPA has commissioned Cranfield University to develop a horizon scanning and predictive analysis tool to build their understanding of how current and future changes in the market, in technology and in the legislative environment can influence waste crime and affect criminal behaviours.

This report presents the output from Phase 1, a desk-top review of the academic and grey literature, which focused on the specific context of horizon scanning applications to identify the salient features and success factors for their adoption in an environmental regulatory context. The review provides insights on the organisational approaches and design principles for scanning systems, and reflects on the generic and specific challenges that environmental regulators are likely to face as they seek to develop and implement such as system.

An early warning system for waste crime

One key element of an effective early warning system for detecting waste crime is horizon scanning – the systematic and intelligence-led gathering of high-level information about current and future changes influencing waste crime and criminal behaviours. Some information collected through horizon scanning may relate to established patterns of crime (e.g. non-compliance with existing permits) and some may relate to surprise elements or blind spots, that reveal new criminal activity or behaviour (e.g. new market-related opportunities for crime). Making sense of this information requires a range of analytical tools – such as predictive analysis – to assess current patterns of criminal activity and to anticipate future developments of this pattern.

Design principles for a horizon scanning system

The Report identifies some key design principles for a horizon scanning system and poses important design questions regarding implementation in an environmental regulatory context. These questions are set out below and will inform design of the early warning system (Phase 2).

Scanning function

Scanning for warning signals can be exploratory or issue-focused depending on the context and information needs of the organisation, and the time and other resources available.

- Should the scanning be exploratory, looking for indicators of crime at a macro level (i.e. across whole supply chain operations)?
- Should the scanning be issue-focused, looking to fill analytical gaps by examining indicators of crime at a micro level (i.e. in a particular problematic area or regarding a problematic waste stream)
- If both types of scans are desirable, what is the right balance between the two?
- What is the right time horizon for the scanning function (e.g. 5, 10+ years?)

Scanning team

The selection of the scanning team is influenced by the complexity of the problem space and the wider political and operational context, the purpose of the scans and their intended end-use.

- Does the complexity of the problem space require collaboration between departments or broader inter-agency collaborations?
- Is there appropriate in-house capacity/capability and resources to support the scanning function?
- What measures are needed to ensure scanners (and other users) understand the toolkit, and have sufficient time to provide material in the correct format?

Assessment and data synthesis

A systematic process for collecting and evaluating content needs agreed standards and protocols for searching and for updating information. It also needs meaningful evaluation of scan data against agreed metrics so that outputs are relevant to organisational priorities / policies.

- What protocols will be put in place to guide searches and ensure information collected is relevant and up-to-date?
- How should scans be assessed to ensure they are systematic, consistent and meaningful? How can system design ensure scans capture the 'big picture' issues (e.g. fallout from Brexit) and set out implications for specific sectors (e.g. regulation of waste; supply chain operations)?
- How will adjustments and updates be made (in light of, for example single significant events), so that individual scans are not rendered redundant?

Communication and influence

Communication of horizon scanning outputs to environmental regulators should emphasise the breadth of information (issues across the supply chain), depth of information (sector-specific implications) and supporting evidence to encourage fast action on emerging crime problems. To optimise action, scanning outputs should ideally feed directly into planning and regulatory processes (e.g. Compliance assessments, Duty of Care Code of Practice).

- How often should scanning outputs be produced (e.g. quarterly, bi-annually, annual)?
- What should the format be? Should scanning outputs align directly with organisational priorities and/or broader goals/objectives/

- What is the best format for scanning outputs to ensure they are easily accessible to decision-makers and other end-users?

Visibility

There are challenges around ensuring any horizon scanning tool is visible in the organisation. Visibility can be increased by active promotion (perhaps by a scanning champion) and by ensuring those responsible for action are aware of the tool and how to use it. Appropriate alignment of horizon scanning with other tools (e.g. risk assessment) is key to achieving good visibility and supporting decision-making.

2.0 Purpose and scope of the report

This report presents a review of the academic literature and other appropriate sources of information, relating to the use of horizon scanning approaches, methods and techniques adopted in the public sector. The review focuses on examining the specific context of horizon scanning applications to identify the salient features and success factors for its adoption in an environmental regulatory context.

The review considers within its scope horizon scanning and predictive analysis, subsumed within the concept of an 'early warning system'. As established in Section 3.1 of the report, a horizon scanning system is conceived as the mechanism (i.e. framework or tool) for systematically gathering a broad range of information and evidence about emerging issues and trends. It is within this framework that a wide range of analytical approaches, methods and techniques, including predictive analysis, is incorporated to assess, synthesise and evaluate potential policy impacts or consequences of emerging issues and trends.

The review of horizon scanning in practice is followed by a discussion that offers our perspectives and insights on the organisational approaches and design principles that need to be considered in developing an early warning system for waste crime. It reflects on both generic and specific challenges that environmental regulators are likely to face as they seek to develop and implement an early warning system. Finally, we suggest the need for modifications and customisation of standard horizon scanning approaches, methods, and techniques to meet the specific needs of environmental authorities.

3.0 Literature review

3.1 Aims and objectives

The aim of this phase of the research was to produce a literature review from academic and grey literature sources of existing predictive analysis and horizon scanning approaches, tools and best practice that could apply in the context of identifying and analysing early signals of waste crime. The specific objectives addressed in this phase include to:

- identify reports, articles and examples on the application of horizon scanning and predictive analysis in public sector agencies and, specifically, environmental authorities engaging in tackling waste crime.
- understand the challenges that environmental authorities face in delivering a horizon scanning and predictive analysis capability.
- identify practical developments that environmental authorities should apply in order to move forwards with a horizon scanning and predictive analysis strategy.
- compile a report to document findings from the literature review

The review of the academic and other literature sources was guided by the following research questions:

- What are the salient features of horizon scanning programmes in the public sector?
- What are the most common methods and techniques used for: a) scanning and conducting searchers, 2) collecting, filtering and assessing data, and 3) interpreting and synthesising the data to draw out implications for policy or strategy?
- What is the scanning team structure and composition? What protocols and methods of analysis are put in place to elicit expert views? How is the credibility of the process assured?
- What formats and structures are used to communicate scanning outputs? What methods and procedures are adopted to ensure outputs taken up in decision-making?
- What tangible links are established with administrative structures? How is the scanning process connected to decision-making?

3.2 General approach and limitations

One of the key findings of this phase of the research is that there is limited literature available on horizon scanning processes in the public sector (or, indeed, in the private and third sectors). What literature there is can generally be assigned to one of two broad categories: review of the practice (the process) of futures thinking or description of the findings or output from futures thinking exercises. There is no body of literature that provides a detailed description of futures thinking toolkits.

The lack of available literature meant that we could not include in-depth case studies of public sector horizon scanning programmes at this stage. To compensate for this we have carried out a thorough review of the existing published literature, and drawn on our extensive experience in the field of horizon scanning to identify salient features and success factors for its adoption in an environmental regulatory context.

The design principles and recommendations in this report will be expanded and checked against subsequent data from workshops and interviews with stakeholders across the sector (phases 2 – 4). Through our established networks we aim to assess UK public sector experiences with horizon scanning, focusing on evaluating the approaches and tools used,

actors involved, deliverables, timelines and resources (where possible). This will provide further baseline information to supplement the content of this report.

3.3 Search strategy

The literature search was carried out on four databases, Scopus, Web of Science, and Environment Complete for published academic papers with no restrictions on the year of publication. A similar search was conducted on Google and Google Scholar for grey literature (e.g. research or government reports) and 'fringe' sources including documents published on websites (e.g. technical reports). A search protocol was developed and implemented, using the keywords in Table 1.

Stages	Search terms
1. Generic descriptions of methods / approaches	"Horizon scanning" AND "tools" OR "methods" OR "techniques" OR "approaches"
	"Predictive analysis" AND "tools" OR "methods" OR "techniques" OR "approaches"
2. Public and private sector applications of methods / approaches	"Horizon scanning" AND "tools" OR "methods" OR "techniques" OR "approaches" AND "health" OR "defence/security" OR "infrastructure/transport/utilities" OR "business/corporate"
	"Predictive analysis" AND "tools" OR "methods" OR "techniques" OR "approaches" AND "health" OR "defence/security" OR "infrastructure/transport/utilities" OR "business/corporate"
3. Public and private sector applications of combined methods / approaches	"Horizon scanning" AND "Predictive analysis" AND "tools" OR "methods" OR "techniques" OR "approaches" AND "health" OR "defence/security" OR "infrastructure/transport/utilities" OR "business/corporate"

Table 1 - Search protocol

3.4 Evaluation and selection of sources

The search of the published academic literature yielded 389 records from the four databases, of which 86 were duplicates and 265 deemed to have insufficient and or irrelevant information for the review. Using similar key words, a search of the grey literature retrieved a number of relevant published reports. An initial retrieval of the reports was assessed for relevance by scanning titles and abstracts (where possible). In some cases documents retrieved were subjected to a 'scan read' to determine relevance.

Due to the limited number of published papers and reports retrieved in the searches an initial appraisal of the documents was restricted to an assessment of 'relevance'. We drew on our extensive expertise in horizon scanning to assess the quality of sources, considering criteria such as methodological rigour, auditability, validation and objectivity. Where the quality of sources was questionable, we excluded these from the review and supplemented data with our own reflections on the appropriate uses and applications of horizons scanning in the public sector.

4.0 General findings

4.1 Definition of Horizon Scanning and Predictive Analysis

4.1.1 Horizon scanning

Strategic foresight has been pursued by governments to anticipate emerging trends, issues, opportunities and risks in an increasingly, turbulent operational environment (Rathe et al. 2013). The goal is to derive indications of crucial future developments that allow decision-makers to effectively plan for the future and take timely action, and more broadly, to build strategic thinking capability and foster a culture of foresight in the organisation (Bengston 2013; Schultz 2006). Horizon scanning is a foresight tool used in government agencies to meet the need for 'high-level strategic foresight'. Some examples include horizon scanning units for environment and food, science and technology, international development, defence, health, and a specialist unit tasked with review horizon scanning methodologies (BIS Foresight 2012). The most common definition of horizon scanning (also known as environmental scanning, external scanning, and strategic scanning) was produced by the UK Department for Environment, Food and Rural Affairs (Dalton 2002), and later amended by the UK Government Chief Scientific Advisor's Committee (CSA in Dalton 2002):

…the systematic examination of information to identify potential threats, risks, emerging issues [including weak signals] and opportunities, and their likely future developments including – but not restricted to – those that are at the margin of current thinking and planning.

In an April 2014 report by the UK House of Commons Science and Technology Committee, the use of horizon scanning for strategic decision-making was clarified:

…it can help organisations to detect signals, identify trends and think more inventively about what the future might hold, enabling them to capitalise on opportunities and better mitigate threats. It is a crucial activity for any organisation tasked with long-term decision-making.

The main elements of horizon scanning that differentiate it from other foresight approaches include its ability to distinguish different forms of change (i.e. constant, incremental, volatile or rapid change), focus on weak signals[1] as well as persistent problems and trends, carry out comprehensive assessments of all sectors, and include issues at the margin of current thinking (e.g. wild cards, which are low probability, high impact events) (Bengston 2013; Dreyer and Stang 2013).

4.1.2 Predictive Analysis

Predictive analytics is a broad term used to describe a range of statistical and analytical techniques that make use of current and historical trends to predict future events or behaviours (Nyce 2007). The most common uses are in business (e.g. credit bureaus) and law enforcement, where the form of predictive models varies depending on the type of event or behaviour assessed. For instance, in business predictive models derive patterns from historical and transactional data by capturing relationships among a range of factors to identify future risks and business opportunities (Palomino et al. 2013a). In law enforcement, predictive models utilise existing data (e.g. market-based, demographic/social, spacio-

[1] Weak signals are defined as past or current developments (i.e. emerging issues) with ambiguous interpretations of their origin, meaning and/or implications. Often these are unclear observable trends or patterns that warn us about the possibility of future events (iKnow 2016).

temporal) to identify geographic features, individual profiles and behavioural characteristics that increase the risk of crime (Perry et al. 2013).

There are distinguishing features of predictive analysis methods that define its application in law enforcement (Perry et al. 2013):

- Predicting crimes - forecast places and times with an increased risk of crime,
- Predicting offenders - identify individuals at risk of offending in the future, and
- Predicting criminal perpetrators' identities - create profiles that accurately match likely offenders with specific past crimes.

Each method may be applied to consider potential crime and criminal behaviour at different levels: local (affecting a basic command unit), cross border (affecting more than one basic command units), and national or international (organised crime affecting dedicated units). In law enforcement, predictive analysis methods tend to be implemented as part of a broader business planning approach, requiring an understanding of the (NCIS 2000):

- business environment
- situation on the ground
- nature and extent of the problem
- patterns and trends, and
- where the main threats lie.

4.2 An 'early warning system' (EWS): Establishing what Horizon Scanning and Predictive Analysis mean in an EWS waste crime context

An early warning system (EWS) has the potential to detect a wide range of emerging issues and trends or driving forces. EWS is defined in the context of environmental protection as "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable organisations threatened by a potential hazard to prepare and act appropriately and in sufficient time to reduce harm or loss" (UNISDR 2007; p.4). An EWS is implemented for the systematic identification of warning signals. However, these signals tend to be weak, which makes the detail and impact of an emerging threat uncertain and difficult to anticipate. Weak signals emerge from disconnected data or 'chatter', but can form part of a larger pattern when viewed through a 'specified frame' or connected with other pieces of information (Palomino et al. 2013b, Ansoff 1975). Environmental protection is inherently linked to issues relating to crime, criminality and the potential to do harm. Waste management presents many opportunities for crime, but often there is little knowledge of the scale of the problem, the types of criminality and motivations involved, and the precise nature of the crime (Crocker & Leinster in conversation 2016). A judgement is needed about the 'knowability' of an issue or emerging threat, and the ability to pick them up in an EWS (Table 2):

Ability to detect in an EWS	'Knowability' of the issue	State of knowledge	Type of indicator	Example
Easier, somewhat easier to detect	Known Knowns	Things we are aware of, and understand	Trend or driving force (something that is taking a general direction)	'Site' operational indicators that regulators recognise and understand regarding the likelihood of an increased chance of non-compliance or crime (e.g. noise, odour, unusual operating patterns that are often causes of complaints)
	Known unknowns	Things we are aware of, but do not understand	Counter-trend or driving forces (something that is pushing in the opposite direction) Uncertainty about how trends or driving forces interact with each other or with countertrends	'Non-site' operational indicators around market and supply chain relationships where regulators display various levels of understanding and awareness (e.g. incongruent or illogical supply-chain relationships in moving waste between sites or financially vulnerable sites embarking on non-compliant operations)
	Unknowns knowns	Things we understand, but are not aware of		
Harder / not possible to detect	Unknowns unknowns	Things we are neither aware of nor understand	Emerging issue, tipping point, wildcard or black swan event (little to no data to establish trend)	'Site' and 'non-site' operational indicators that regulators neither recognise nor understand such as market, technological and legislative pressures that may create opportunities for waste crime
Source: Cranfield University (2016); Delaney (2014); NATO (2002)				

Table 2 - A typology of warning signals

Novel approaches for detecting waste crime stress the need for an intelligence-led EWS that detects a broad category of signals across the supply chain, and gathers macro-level information about the changing landscape, characteristics of vulnerabilities and motivations for crime (White and Heckenberg 2011). In investigating vulnerabilities in the management of hazardous waste and its disposal, Lawton and Briscoe (2012) suggests a multi-prong approach to assess current and future threats in light of the dynamics, dimensions and discourses of the industry and jurisdictional domain. We suggest that horizon scanning provides an appropriate framework for such a multi-prong approach in that it combines these fundamental design principles (Forum for the future n.d.; Garnett et al. 2016):

- an intelligence-gathering function that collects a wide range of information to consistently disrupt conventional thinking,
- a sense-making function that transforms data into knowledge to better inform decision-making.

Defining the design parameters and structure of an EWS, based on a horizon scanning system, will help to establish a common set of tools and techniques for identifying signals and standard metrics for meaningful evaluation of emerging issues and trends.

4.3 Evaluation of horizon scanning systems in practice

4.3.1 Overview of key features

Detecting early warning signals from horizon scanning can be exploratory (based on generated hypotheses and a search for unknown unknowns) or issue-focused (based on previously identified issues or trends). Generic features of a horizon scanning process include: early recognition of signals through exploratory or issue-focused scanning, assessment of emerging issues and trends, assessment of their strategic significance and design of policy options within the existing decision system (Figure 1).

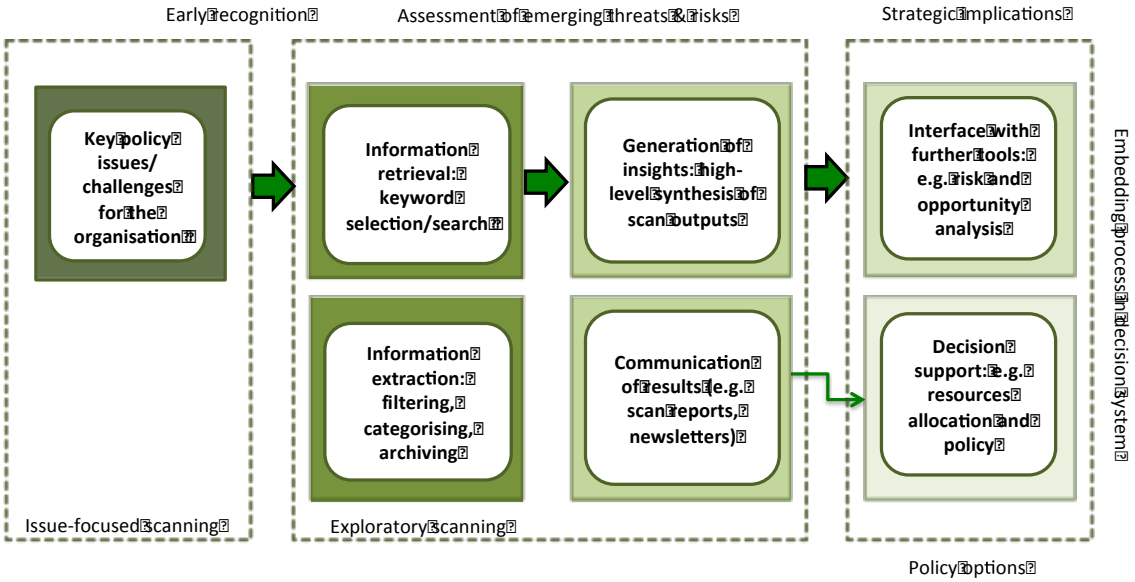

Figure 1 - General process for horizon scanning using web-based information (Adapted from Palomino et al. 2012)

In a study of public sector horizon scanning activities within 15 European countries (including the UK), van Rij (2010) defined key characteristics of a robust scanning process (Table 3).

Key characteristics
A **systematic process**, designed to deliver a comprehensive scanning programme that captures emerging issues and trends for an actor (or set of actors), usually defined by key themes / factors of interest, to support strategic considerations, decisions and actions.
A focus on **all signals** that might have **significant impact** on the strategic mission and underlying values of the actor(s).
An attempt to **look forward as far as possible** (bounded by limits of reality), and the deliberate inclusion and **recognition of weak signals**.
An analysis of weak signals and the **possible interactions of all scanned issues** (including cross-cutting issues) and their relevance for strategic decision-making.
Continuous or repetitive scanning to search for new emerging issues and trends, but also to see what has changed, and to check how phenomena previously observed are developing over time.
A highly participatory process, involving a wide range of societal and government stakeholders, not only during data collection, but also in guiding the interpretation and synthesis of data to encourage buy-in and create opportunities to impact / inform policy development.

Table 3 - Key characteristics of a 'robust' scanning system

Delaney (2014) has identified key design parameters for implementing horizon scanning in the public sector (Table 4).

Element	Design parameters
Purpose of scanning function	• clear, agreed objectives linked to degree of focus (e.g. on-going or periodic vs. ad-hoc scanning) • weigh the need for inter-departmental or inter-agency collaboration • adequate buy-in from senior management and external stakeholders • clear timescales and provision of resources weighed against expectation of outputs
Scanning team:	• diverse, multidisciplinary team, appropriately balanced (i.e. experts, stakeholders, decision-makers) • judge the need for in-house vs. external collaborators
Scanning approach	• select scanning approaches, tools and techniques that are 'culturally appropriate' for the organisation • set protocols for retrieving, categorising and archiving information, consider breadth, depth and quality of data gathered
Assessment and data synthesis	• build on existing scans (in-house or external) • consider the utility of the scan, and the appropriateness of data analysis, contributing expertise and wider input • assess whether 'public sector thinking' needs to be balanced with broader views
Communication & influence	• consider the appropriateness of language and tone, and inclusion of possible sensitivities when disseminating outputs to target audience • consider effectiveness of messages and formats used to disseminate outputs (e.g. infographic, policy / strategically relevant sound bites) • consider the time in which outputs are released and fed into other decision-making processes (e.g. strategic plan, budget cycle, corporate plan cycle) • consider how you will get traction between scan results and actual decisions • consider translating insights with long-term implications into consequences relevant to decision-makers in the short and medium-term • establish practical and influential links to organisational processes (e.g. strategy or policy process, risk registers) • consider how you will measure success of the process, its outputs and use.

Table 4 - Key design parameters for a horizon scanning system

4.3.2 Early recognition

Scanning for warning signals can be exploratory or issue-focused depending on the context and information needs of the organisation, and the time and other resources available. Exploratory scanning identifies a wide range of signals from broad searches of the literature using key words or factors of interest. Exploratory scans highlight alternative plausible future events, and the inherent risks and opportunities for the organisation. In contrast, issue-focused scanning identifies signals of relevance to a policy issue using specified searches of the literature. Issue-focused scans support future narratives for policies and identifies short-term responses needed (Cuhls et al. 2015; FAO 2013; Butter et al. 2010). This is not to say

scanning systems restrict how far forward the scans will canvas, rather it could include multiple time horizons to detect a broader range of issues that may have an impact at different points in the future (Bengsten 2013). There are three common time horizons adopted in public sector scanning programmes to consider different types of indicators of change (Rathe et al. 2013; Brown 2007):

- Horizon 1: trends or driving forces that are having an impact on an organisation now or in the short-term (i.e. 1-3 years)
- Horizon 2: emerging trends that are expected to have an impact in the near future or medium-term (i.e. 3-10 years)
- Horizon 2: less known, 'new' driving forces that may shape an organisation's environment in the long-term (i.e. 10+ years)

Scanning typically consists of a team effort to examine a wide range of information sources in order to detect signals of change, emerging trends and countertrends. Scanning teams in the public sector are often a select group that are multidisciplinary and knowledgeable about the problem or policy space and also the wider organisational context. This provide useful 'knowledge frames' from which the team operates, but at the same time the diverse disciplinary backgrounds widen the 'scanning lens' to capture a broader range of signals. Scanning in government tends to include diverse stakeholders from relevant agencies to capture different policy perspectives (Cuhls et al. 2015; Bengston 2013). Public sector horizon scanning programmes are frequently implemented by external consultants working with small in-house teams. Such collaboration help to ensure scanning outputs are relevant, and its interpretation and analysis is meaningful, and its outputs are effectively communicated to executives (Day and Schoemaker 2005).

Recent reviews of horizon scanning programmes has revealed common methods used, and the pros and cons for the public sector (Table 5):

Scanning method	Description	Pros and Cons
Desk-top scanning	Desk-top research using a wide variety of mainly fringe sources (e.g. websites, government departments and agencies, non-governmental organisations, international organisations, companies, research communities, and on-line and off-line databases and journals	Pro: Low resource required Con: Requires additional foresight input to obtain robust results
Expert groups (specialists)	A small group of experts at the forefront in the area of interest, sharing perspectives and knowledge on how new phenomena might influence the organisation in the future.	Pro: Flexible approach to obtain broad information Con: Requires additional foresight input to obtain robust results:
Web-assisted horizon scanning	Use of software to capture data from websites (e.g. zotero, pearltree, evernote) including meta-data. Researchers assign sources to pre-defined hierarchical structure, and may follow-up interviews and survey.	Pro: Systematic and flexible to obtain mass information of great depth Con: Resource intensive
Source: Cuhls et al. (2015), Delaney (2014), FAO (2014)		

Table 5 - Common scanning methods

4.3.3 Assessment and data synthesis

Horizon scanning data is analysed and a high-level synthesis of trends and weak signals is produced that distils the broad implications for policy. A wide range of methods is employed to analyse and synthesis scan data, but the most common method in public sector horizon scanning involves (Cuhls et al. 2015):

- analysis of the content of documents
- categorisation of data to form themes according to, for example, sectors, key words or frames (e.g. PESTLE[2])
- implementation (in some instances) of analytical schemes (e.g. weight of evidence frameworks) for more robust analysis
- expert elicitation using stakeholder workshops or dialogue with external experts to synthesise the data

A challenge with synthesising data on emerging or new issues (weak signals) is the lack of consensus among experts as often insights generated represent challenges to current thinking and expert knowledge (Schultz 2006). Eastlough (2014) suggests earlier engagement is needed with 'strategic thinkers' who can isolate intangible information from group discussions, transform them to tangible facts, figures, charts and observations, and draw out policy implications. Responding to these challenges, some horizon scanning practitioners have adopted more robust analytical methods to assess the credibility of information used to substantiate scan data. A common method in public sector horizon scanning is a simple risk prioritisation method to identify which emerging issues or trends may be of greater importance to decision makers (Table 6). Typically this involves assigning a nominal (value) score to assess the probability (i.e. likelihood of occurrence) and impact of an emerging issue, often through expert consultation. The range of scores are then discussed and debated, often in a stakeholder workshop, to gain some consensus on the relative 'importance' of the threat for the organisation (or a number of organisations).

Institution / horizon scanning initiative	Assessment method	Pros and Cons
Cranfield Institute for Resilient Futures (CIRF) – Defra's futures partnership	An importance rating on a 5-point scale for 3 criteria (environmental, social and economic) is derived for each issue and then plotted against the expected timing of a development (short, medium and long-term) to indicate when an emerging threat is likely to have an impact.	Pro: Great potential to be integrated with broader risk assessment frameworks in public sector decision processes. Con: 'Value' based scoring open to bias and misrepresentation of issues.
US Environmental Protection Agency, Office for Research and Development - Foresight	An importance rating on a 5-point scale for 5 criteria (novelty, scope, severity, visibility, timing, probability, and organizational relevance) is derived for each issue to assess its overall relevance.	Pro: Wider range of criteria included for more comprehensive review of relevance. Con: 'Value' based scoring open to bias and misrepresentation of issues.
Sources: Garnett et al. (2016); US EPA (2005)		

Table 6 - Examples of risk prioritisation methods used in public sector scanning

[2] PESTLE (Political, Economic, Social, Technological, Legal and Environmental) is a framework used to identify the different signals in play in a particular situation.

Risk prioirtisation techniques employed in public sector organisations (Table 5) have proven useful in scoping potential impacts of emerging issues at the individual policy level. However, for issues to be taken forward into policy formation it is often necessary to synthesise them into meaningful clusters that are linked to decision-making structures (Georghiou and Cassingena Harper 2011). Some horizon scanning practitioners in the public have employed a number of methods to assess 'high-order' consequences and cross-cutting issues that my have an impact at the meta-policy level. The futures wheel (also called the Implications Wheel) explores the direct and indirect consequences of an emerging threat or trend (Glenn 2009). Using network models, expert groups conduct a structured brainstorming exercise to explore what are the first, second and third-order consequences of future change or potential change (e.g. the first order consequence of climate change may be increased incidents of extreme weather events such as floods, the second-order consequence may be a decline in fertile agricultural land in flood affected areas, and the third order consequence may closure of small farms). In applying the future wheel, the desirability/undesirability and likelihood of occurrence of each consequence is rated, and comparing the rating of different expert groups (Bengston 2013).

The use of the futures wheel is less prominent in public sector horizon scanning, but is often adopted as part of broader foresight initiatives (e.g. scenario planning). In contrast, an examination of cross-cutting issues at a meta-policy level is more common in public sector horizon scanning (Table 7).

Institution / horizon scanning initiative	Assessment method	Pros and Cons
Cranfield Institute for Resilient Futures (CIRF) – Defra's futures partnership	Cross-cutting issues are identified using a survey tool, which allow individual experts and policy makers to compare individual issues or tends and link those that they feel are strongly connected. Such pair wise connections are used to form cross-cutting issues, where multiple connections across key factors (used to focus scan activities) are made to define an underlying trend and narrative for the cross-cutting issue.	Pro: Conveys information about a cross-cutting challenge that fits to broad policy agendas. Con: 'Value' based assessment open to bias and misinterpretation of issues.

Table 7 - Example of an evaluation of cross-cutting issues in public sector scanning

4.3.4 Design of policy options and links to the decision system

Take-up of horizon scanning outputs in the public sector requires a champion within senior management, effective communication of outputs, timeliness in its release, and support and facilitated translation of the outputs (Delaney and Osbourne 2013). The experiences of horizon scanning practitioners suggest that take-up of scanning outputs is more likely when produced in carefully written documents that capture the attention of policy-makers (Garnett et al. 2016; Havas et al. 2010; Delaney 2014).

Cuhls et al. (2015) study on the integration of horizon scanning programmes in EU policy processes revealed that communications of outputs, commonly through distributed reports, newsletters, briefings, leaflets, are either be 'top-down' (e.g. from senior management to policy officers or middle management) or bottom-up (e.g. from policy officers to senior management). The latter is particularly challenging due to limited capacity and time constraints of senior management, particularly when it comes to drawing their attention to long-term issues. Similar findings were reported in reviews of public sector horizon scanning activities in UK government agencies (Day 2013) and the Australasian Joint Agency

Scanning Network (Delaney and Osborne 2013). These reviews revealed several challenges in attempts to embed horizon scanning into the policy process (Table 8).

Challenge	Description
Cultural and institutional challenge	This relates to poor alignment with decision-making processes and priorities: • Horizon scanning is often self-tasked or commissioned with limited understanding of what it might be used to inform – i.e. more generic pieces of work are pursued that do not translate well if used to answer specific questions on completion. • Horizon scanning activities lack cross-governmental oversight and coordination, which prevents cross-cutting work reaching relevant audiences.
Capability challenge	This related to the capacity of policy officials to engage with uncertainty, suspend disbelief and maintain an open mind: • Policy officials focused on tactical issues find it challenging to engage on emerging issues that may not materialise or have an impact for up to 50 years.
Evaluation challenge	This relates to the difficulty of measuring horizon scanning impacts in a meaningful way: • Horizon scanning outputs rarely include policy implications or an analysis of how the information could be used to inform decision-making.

Table 8 - Challenges in embedding horizon scanning into policy processes

An informal survey of 136 members of the UK public sector futurist community conducted as part of GO Science's Futures Analysts Network in 2008 (Day 2013) examined the perceived blockages to effective use of futures thinking in supporting decision making in government. One in four of the barriers relate to cultural differences between horizon scanners and operational staff and, in particular, the different ways that each group relates to uncertainty (horizon scanners seek it out, whereas operation staff want clarity in how to respond). This raises important design questions for the toolkit and how it should present uncertainty.

Other commentary in the literature suggests support of policy-makers and other stakeholders require a greater understand of the benefits of horizon scanning, the nature of its outputs, and more broadly the political and institutional context in which horizon scanning messages are delivered (Mulgan 2013; Halvorson and Higgins 2013):

- a clear understanding decision-makers' perspectives and needs is needed to produce 'influential' outputs
- knowledge of political context (multiple goals, conflicting values) allows for producing outputs that are better aligned to the priorities of governments
- tailoring messages to decision-makers' natural 'promotion and prevention' orientations (e.g. decrease loss, maximise gain, maintain status quo) will increase the potential to produce 'influential' outputs

A 2013 survey of global foresight (including horizon scanning) programmes suggest a number of criteria for successful communication of outputs (Dreyer and Stang 2013):

- identify target audiences (using stakeholder mapping methods for precision)
- include input from target audience in setting the horizon scanning agenda
- ensure outputs is targeted at the audience
- communicate using clear language, and utilise media easily accessible to the audience

- establish early, and maintain close ties with senior decision-makers and policy makers
- establish clear links between horizon scanning topics and current policy agendas.

Communicating outputs from horizon scanning can take a number of formats, but the literature revealed outputs in the public sector can be categorised based on the focus of scan and the time horizons considered (Table 9).

Focus of scans	Time horizon		
	Short-term (1-3 years)	**Medium-term (3 – 10 years)**	**Long-term (+ 10 years)**
Exploratory (broad)	• Infographic summaries, videos or other interactive media on website platform • News digests • Short papers • Regular / periodic newsletters (i.e. electronic or print) • News flash • Urgent memos	• Regular / periodic newsletters (i.e. reported quarterly in electronic or print) • Network scanning reports • Special topical presentations (e.g. at strategic meetings, workshops) • Selective dissemination of information • Directory of experts' views • Market / business research reports	• Regular / periodic reports (i.e. reported annually) • Network scanning reports • Scoping reports (i.e. research priorities, investment reviews) • Trends, drivers, cross-cutting issues analysis • Policy roadmaps / assessments • Analysis of strategic issues
Source: Cuhls et al. (2015); Delaney (2014); Rathe et al. (2013)			

Table 9 - Common formats of horizon scanning outputs in the public sector

5.0 Design principles for an early warning system for waste crime

5.1 Purpose of horizon scanning function

The 'value' that environmental regulators place on an early warning system and its sustainability over time is a key determinant of the focus of the scan (Table 10). There are key considerations around the **purpose (focus) of horizon scanning** including:

- will horizon scanning be undertaken to provide decision-makers and policy makers with space to think more broadly about the scale of waste crime problem, the types of criminality and motivations involved, and the precise nature of the crime (e.g. illegal dumping, combining illegal waste with legal waste, illegal export)?
- will horizon scanning be undertaken to fill an analytical gap between existing current trends analysis (e.g. crime 'hot spot' analysis, market analysis) with the broader indicators that drive criminal behaviour and is likely to unfold in the medium to long-term?

	Main design principle: purpose of scanning function		
Design options	Broad scan for all relevant sectors	Issue-focused scan for all relevant sectors	Regulatory scan for specific strategy framework
Explanation of options	Covers a broad range of indicators of crime, allowing for assessment of cross-cutting issues with impacts at meta-policy level (e.g. economic and environmental interests creative incentives for illegal profit maximisation)	Covers a limited number of key indicator(s), allowing for the design of appropriate sectoral responses (e.g. new definitions of waste that open up opportunities for crime)	Identifying regulatory gaps and overlaps to ensure problem areas are targeted and cohesive enforcement strategy development

Table 10 - Purpose of scanning function

Clarifying the purpose of scanning efforts will allow for assessing what sectors to cover in the scans (e.g. financial, legal, regulatory, police/intelligence etc.), whether it is should be focused on specific issues or areas of vulnerability, and whether scans should be based on broader inter-departmental or inter-agency collaboration?

The survey of the Futures Analysts Network (see Day 2013) identified that one of the most challenging barriers to effective horizon scanning is the perception of it amongst leaders. In particular, the survey highlighted that leaders often want horizon scanning to provide straightforward answers to short term problems. The perceived failure of horizon scanning to deliver this reinforced a view amongst some leadership groups that horizon scanning has no track record, is not robust and is difficult to connect into the planning process.

This is a complex issue about the perceived purpose of horizon scanning and, consequently, the nature of trust and expectation that exists between leaders and any horizon scanning system. One key design issue, therefore, is how to build and early warning system that achieves an effective balance between developing a long term perspective and informing short term action.

These informal findings are borne out by the work of Sheate et al. (2012) [who undertook analysis on behalf of the European Environment Agency to identify approaches to institutionalising long-term futures thinking in government. The authors identified short termism – and, in particular, budgetary and legislative cycles – as major barriers to

successful take up of futures thinking. More positively, they also identified that policy demand and political support are the most significant success factors for embedding futures thinking in environmental policy.

5.2 Scanning team

Selecting the scanning team will be influenced by the focus (or purpose) of the scans and their intended use. While it is accepted that a 'dedicated', multidisciplinary team that is knowledgeable about the problem space and the wider political and operational context is desirable, there are key considerations around the **level of involvement** of the team in scanning activities (Table 11):

- is there appropriate in-house capacity and resources available to conduct scanning and analyse outputs to inform regulatory responses?
- does the complexity of the problem space necessitate collaboration (and wider involvement) in scanning efforts?

	Main design principle: scanning team		
Design options	Large, dedicated inter-departmental or inter-agency team representing wide range of sector expertise	Small, dedicated team representing wide range of sector expertise	External consultants working with small, dedicated team representing wide range of sector expertise
Explanation of options	Involves a wide range of sectoral experts in scanning and assessing potential impacts (e.g. covers all areas of supply chain operations, market dynamics/demand, criminal/penal system etc.)	Involves a small group of sectoral experts in scanning and assessing potential impacts (e.g. multidisciplinary group of regulatory-relevant stakeholders)	External consultants producing scans, and working with a small group of sectoral experts in assessing potential impacts (e.g. multidisciplinary group of regulatory-relevant stakeholders)

Table 11 - Scanning team

5.3 Scanning approach

Environmental regulators will need to fully appreciate what the data and outputs from horizon scanning mean and the context in which they are derived so as to increase its utility (Table 12). There are considerations around the **appropriateness of the tool** and the capacity of regulators to use it:

- is a tool for automated, semi-automated or qualitative scanning and searching appropriated?
- what is the most appropriate techniques and protocols for searching, filtering and categorising information retrieved, and discussing the content?
- how will the information be stored/archived, and updated to remain relevant?

	Main design principle: scanning approach		
Design options	Desk-top scanning using a wide variety of sources representative of the sector	A small group of experts at the forefront in the area of interest, sharing perspectives and knowledge of the sector	Web assisted scanning where researchers assign sources to pre-defined hierarchical structure and sense-check with experts
Explanation of options	Conduct both issue-focuses and exploratory scanning as the need arises	Use of collective intelligence to question and challenge existing hypothesis	Identify diversity of data sources - from fringe to traditional sources using Google alerts, blogs, journals, etc.

Table 12 - Scanning approach

Establishing the probing questions to define the scan field is needed, subsequent searches and sense-making is fundamental to ensure scanning is systematic. However, this has to be balanced so that predefined questions about commonly accepted motivator for crime (e.g. opportunism, market dynamics, lack of threat due to lenient penal system) does not prevent scanning from responding to new information (e.g. change in market dynamics, regulations).

5.4 4.4 Assessment and data synthesis

Scanning and searching for information is the first step, but the second more challenging step involves (table 13):

- assessing the data to better understand the 'big picture' issues (e.g. understanding how macro-economic conditions such as pressure to cut costs, lack of competition from legitimate waste collectors may drive the growth of illegal collections)
- interpreting and synthesising the data to transform it into knowledge, asking questions about what it means in a specific context (e.g. regulation of waste, supply chain operations, business and market developments).

	Main design principle: assessment and data synthesis		
Design options	Organise and analyse data to provide a high-level synthesis of broad implications for the sector	Prioritise patterns of data that occur more frequently to provide synthesis of sector-specific implications	Prioritize patterns of data that occur more frequently, and assess cross-cutting issues to further expand from sector-specific to sector-wide implications
Explanation of options	Outputs from the scan will be useful in framing policy discussions, and setting agenda for more focused scanning or other futures analysis (e.g. scenario planning).	Outputs will identify critical issues that can be progressed to action through further exploration of issues in, for example deep-dive projects, or at departmental workshops that feed directly into planning.	Outputs will identify critical issues that can be progressed to action through further exploration of issues in, for example deep-dive projects, or at inter-agency workshops that feed directly into planning, investment or regulatory reviews.

Table 13 - Assessment and data synthesis

5.5 Communication and influence

Communication of horizon scanning outputs to environmental regulators should emphasise the breadth (e.g. issues across the supply chain) and depth (e.g. sector-specific implications) of information and the supporting evidence to encourage fast action on emerging crime problems. Outputs have a high probability of leading to actions if there are opportunities for scan data to feed directly into planning and regulatory processes (e.g. Compliance assessments, Duty of Care Code of Practice). Communicating outputs require consideration be given to (Table 14:

- frequency in which outputs are generated
- timeliness of messages and its alignment with regulatory priorities
- media and format used to disseminate outputs

5.6 Visibility of the early warning system

Waverley conducted a review of futures training for GO Science in 2012 (cited in Day, 2013) to assess existing training provision in futures and horizon scanning and to identify future training needs of horizon scanning practitioners across government.

One striking outcome of the review was that, although practitioners had been trained by HSC in horizon scanning techniques, less that one third of them used the toolkit. The review noted that "part of the problem seems to be awareness – which is low – and…that the toolkit may be intimidating for new futures practitioners."

One of the key issues to explore in phase 2, therefore, is how to ensure that the horizon scanning toolkit is visible, is promoted and is non-intimidating to users.

6.0 Conclusion

One of the key findings of our research is that there is limited literature available on horizon scanning processes in the public sector. Another is that what literature there is can generally be assigned to one of two broad categories: review of the practice (the process) of futures thinking or description of the findings or output from futures thinking exercises. There is no body of literature that provides a detailed description of futures thinking toolkits.

Our review nevertheless highlights some important design questions which we will explore further in the stakeholder workshop and interviews to be conducted during phases 2 and 3 of the project. These include:

- The focus of the horizon scanning activities;
- Exploring what capabilities, capacities and resources are available to conduct maintain the horizon scanning tool. In particular,
- The most appropriate techniques and protocols to use and whether they should be updated following a period of use and evaluation
- Whether the tool should be automated, semi-automated or qualitative
- How information will be stored and updated to remain relevant
- How the toolkit needs to be designed to enable users to transform big picture issues and data into focused knowledge and action to transform regulation;
- Identifying potential barriers to effective implementation of horizon scanning activities and devising strategies within the toolkit for overcoming them;
- Establishing a mechanism to update links between horizon scanning topics and policy agendas as required;
- Establishing clear and appropriate links between horizon scanning topics and current policy agendas that require short-term action;
- Using clear language and definitions to describe horizon scanning concepts and techniques;
- The most appropriate format of communicating horizon scanning outputs;
- Designing communication to secure influence; and
- Ensuring the toolkit is visible and utilised.

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