



Smarter Regulation of Waste in Europe (LIFE13 ENV-UK-000549) LIFE SMART Waste Project

Action B14 – Phase 1: Intervention design literature review

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8 January 2016

This report was prepared with the contribution of the LIFE financial instrument of the European Union

AN EU LIFE+ PROJECT FOR 2014–2019

Version 1.1



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SUMMARY

This literature review has examined:

- methods for characterizing the targets of interventions to address environmental non-compliance and/or environmental harm and the framework in which the targets are acting;
- information on interventions and where and how they have been applied
- decision-making tools that could be used to support the choice of appropriate interventions according to circumstances.

Where possible it has examined literature on waste management. However the bulk of the available evidence is about wider environmental performance and sustainability rather than specifically about waste.

CHARACTERISING THE TARGETS OF INTERVENTIONS

There are a number of systems for characterizing the targets of interventions in order that you can then develop appropriate interventions. These have become more sophisticated as regulation has evolved from traditional regulation, through stages such as risk-based regulation, responsive regulation, smart regulation, broader “environmental governance” etc. (Gunningham, 2011)(Delmas, 2009)

The majority of these systems, especially the earlier ones, are essentially about risk. For example, risk of offending or risk of harm to environment. Tools such as OPRA were developed initially to allocate resources according to risk rather than decide on which intervention to apply.

A further development were “responsive regulation” tools which essentially use a risk assessment of the target to suggest points on a scale from being helpful and supportive to tough enforcement and closing down the illegal business. Examples are: SEPA’s 6 Cs and the “enforcement pyramid”. These only have limited ability to give you appropriate interventions because there are factors other than risk that can be taken into account in this regard.

A more recent set of methods recognise you need to assess factors other than risk and that you also need to consider the framework within which the target acts. Essentially these methods support “smart regulation”. The factors which such methods take account of are things such as:

- How regulation can be designed and applied (for example by using the table of 11) (Van der Schraaf & Roessen A., 2014)
- Drivers for compliance and internal factors in a business (SNIFFER, 2013). So you choose interventions that will compensate for weak drivers for compliance (such as financial drivers) or you support less developed internal factors such as capacity.
- Behavioural aspects such as the “Individual, Social and Material” (Scottish Government , 2013). Or “Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect and Commitments” (Dolan, 2010)
- The needs, tools, processes of perpetrator and society (Van Dorp, 2014)

- What the whole "system" looks like, so you need to “unravel the knots” and “sabotage the vulnerable nodes” (Sparrow M. K., 2000) (Sparrow M. K., 2008)
- The objectives you want to achieve (White, 2013).
- The nature of the sector. So for diffuse pollution from thousands of farms you need a different answer than for waste carriers or for large companies with reputations to consider.

In general the above systems and guidance cover wider aspects of environmental regulation and none of them were specifically just for waste regulation.

Although some regulators have published factors to take account of when choosing interventions, few have detailed methodologies let alone structured tools to direct the final choice.

INTERVENTIONS

There are a limited number of sources which describe and categorise various interventions used by regulators and policy makers in an environmental context. Some (but not many) of these include interventions which have been specifically designed and applied to waste crime (Environment Agency, 2012). Some, but not all, of these offer a typology (which are generally similar) and classify interventions into types: regulatory, market based, behavioural and so on). A smaller number of sources provide information on where and how they have been applied or provide evaluation of their success.

Some regulators refer to some structured lists of interventions but these are mostly increasing degrees of regulation from supportive through to enforcement, based on risk.

DECISION-MAKING AND CHOOSING INTERVENTIONS

These days, decisions are, probably rightly subject to more scrutiny than previous regulators experienced. Indeed, judicial review of decisions is more and more an occupational hazard as well as a human right. In such a review, formally only the process of arriving at a decision, not the actual decision itself is subject to legal challenge. However, the need for public reassurance in regulatory credibility these days tends to demand a rational basis as well as a more transparent process to be discoverable on the record. This is why regulators are exploring more formal techniques to help arrive at appropriate solutions, but also whether these methodologies and tools developed can be documented to demonstrate an “audit trail” that can justify why and what decisions were arrived at.

In the context of environmental regulation most of these decision-making systems are applicable to wider business decision-making of a regulator or government department. They address issues such as resource needs or cost benefits of policies or priority of (say) addressing any one particular non-compliance / harm scenario compared to another. Few of them address the different types of decision-making needed for this project, in particular decisions about:

- the objectives you wish to achieve (e.g. compliance and/or environmental outcomes);
- the people / organisations contributing to the non/achievement of objective
- the target of any interventions

- the actors who might deliver the interventions
- the specific interventions to use in any one scenario and appropriate actors who should deliver them.

The literature for this specific multi-factor decision-making is very sparse and only few decision-making tools have been applied specifically to support this specific type of decision-making with the exception of problem solving techniques (Dorp V. , 2014) (available [here](#)) and dependency analysis (Giddens).

The scope of this review does not include making recommendations on how the SMART Waste project should take this forward. That will be undertaken in phase 2. However, it seems from our interpretation of the literature, that there are several stages needed to arrive at choice of interventions for example:

- The Target. Who, what is /are the targets?
- Nature of the traditional policy and regulatory framework available, including the law itself and the bodies who implement the law. Are they adequate or do we need to seek alternative interventions?
- Consideration of the wider network in which the target(s) operate. For example waste flows, values of waste, taxes on waste disposal.
- Information about influences on and motivations of the target. For example, drivers on business, behavioural factors which influence the actions of the target, propensity to engage in criminal acts.
- The various actors who might deliver interventions.
- A menu of interventions available, including which are suitable for particular circumstances. Perhaps this could be constructed and presented in a way similar to the “What Works Centre” for crime reduction (UCL, 2015).
- How to use the considerations above to choose the best interventions for the circumstances
- Feedback loop. The UCL what works web site provides an example of that. The current work by the Environment Agency is another example.

None of the sources examined appear to have covered all the above stages, rather they usually consider just one or two aspects.

Table 1 is an attempt to represent how each of the 20 or so methods/tools that we have examined can take account of each of the 10 or so factors that seem to be relevant in choosing interventions. It also indicates which were specifically developed for waste crime.

Most systems only take account of about 3 or less of the factors. The systems which tick the most number of boxes are *iDEPEND* and the problem solving approach developed by Rob Van Dorp. However, neither have been specifically developed for or used for waste crime

This phase of the project does not involve making recommendations, but it seems that the way forward might involve some use of problem solving followed by using *IDEPEND*, tested on waste crime situations. In phase 2 we intend to make recommendations how they might be combined to design and deploy effective interventions against waste crime.

Table 1. Comparison of Methods against required attributes

		Potential Tools to select interventions according to circumstances																
		Regulatory		Behavioural			Decision tools		Problem solving			IMPEL		Tools of Ministries and Regulators				
ATTRIBUTES		Regulatory Ladder	Table of 11	ISM	Mind space	Behaviour change wheel	MCM	Catalyze	Problem Solving Sparrow	Problem Solving Van Dorp	EPOW	Complementary approaches project	iDEPEND	Defra Guidance	SEPA 6Cs	Victoria EPA	Ontario Min of Env	BC Min of Env
Attributes of target	Risk of harm or non-compliance	√							√	√		√			√	√	√	√
	Behavioural aspects of target			√	√	√				√					√		√	
	Business' compliance drivers & internal factors											√	√	√				
Attributes of wider framework in which target operates	How regulation can be designed and applied		√										√					
	The needs, tools, processes of perpetrator and society									√								
	What the whole "system" looks like, so you need to "unravel the knots"								√	√	√							
	The objectives you want to achieve			√	√	√			√	√		√	√				√	
	Menu of interventions	√										√	√		√	√		√
	Process of collective engagement			√	√	√	√	√			√		√				√	
	Mechanism to select interventions	√											√		√	√		√
	Specifically for waste crime										√							

1. SCOPE

This literature review is phase 1 of the LIFE SMART Waste project “action B.14”, namely to “create an innovative interventions manual and design manual that allows interventions to be selected according to the specifics of the situation”.

Phase 1 was defined in the Invitation to Tender as

“a desktop exercise to identify and review all relevant literature, research, information, data and any other appropriate sources identified by the contractor, related to dependency modelling, iDepend, and tools to assess behavioural changes such as the Scottish Government ISM tool. The researcher will identify and evaluate these sources and develop a plan to explore the information contained. A key aspect of this research will be a comparative study of approaches from the UK and in an international context.”

This was elaborated on in our proposal which said:

“consider and document suitable, available and appropriate methodologies to be used to design and deploy more effective interventions for use against waste crime. While the academic acceptability of the approaches identified will be important, it will be just as important to recognise and include the real world challenges and the variety of clients that such interventions should be designed to address”.

The review is therefore structured to look at available literature and other evidence regarding the following three aspects:

- What influences individual and corporate behaviours to behave in a sustainable and legal manner, and particularly regarding waste where the literature differentiates?
- What options are available in terms of interventions; regulatory and non-regulatory options and application by different “actors”; and then
- What tools are available to aid decision making among options, to choose the most effective.

As well as the academic literature the review examines different approaches already employed in some UK and international applications including any available and relevant case studies to examine the appropriateness of the different tools identified for the purposes of “creating an innovative interventions manual and design manual that allows interventions to be selected according to the specifics of the situation”.

2. INTRODUCTION

EVOLUTION OF REGULATION AND TOOLS AND GUIDANCE TO SUPPORT IT

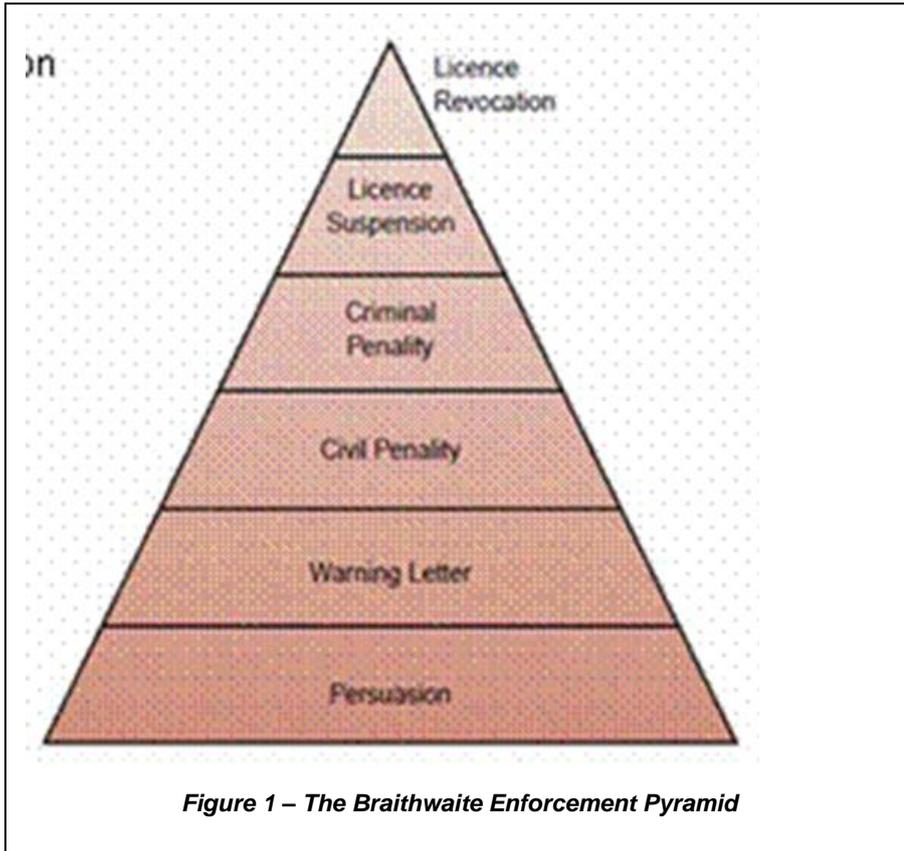
Regulation has developed in several stages (Gunningham N. , 2011) and the tools to support it have become more sophisticated as regulation has developed. A simplified categorization of the stages might look like:

- Traditional Regulation: Rules and Deterrence:
- Risk-Based Regulation: This uses an assessment of risk (usually of non-compliance and/or harm) to allocate resources and decide on the scale of enforcement response in the event of non-compliance.
- Responsive Regulation: This holds that the best outcomes will be achieved if inspectors employ a blend of persuasion and coercion, the actual mix being adjusted to the particular circumstances and motivations of the regulatee. Regulators should begin by assuming virtue (to which they should respond by offering cooperation and information), but when their expectations are disappointed, they respond with progressively punitive and deterrence oriented strategies until the regulated group conforms.
- Smart Regulation: expands on some of the insights of Responsive Regulation, by suggesting how markets, civil society and other institutions can sometimes act as surrogate regulators and accomplish public policy goals more effectively, with greater social acceptance and at less cost to the state. It also argues that complementary mixes of enforcement strategies and tools will be more effective than 'stand-alone' strategies. In some cases this involves using behavioural science to develop "nudges" to improving environmental behaviour, usually of individuals rather than companies.

Historically the best regulators were appointed for their skills and experience in achieving compliance. In Victorian times this was known as "Good Man" regulation. You appointed the right man and let him get on with it. (E.g. Angus Smith, the first Alkali Inspector). If he failed you merely substituted a better! These single regulators (Byatt, Littlechild, etc.) have since been replaced by substantial organisations where not everybody, though formally well educated, has the benefit of the relevant innate experience and skills to understand and respond to the practical problems of non-compliance, as is not necessarily as imagined by the legislators.

This necessitated producing formal guidance for inspectors to help ensure consistency of approach if not guarantee success and the first systems for doing this were based on risk. One of the more successful applications of **risk based regulation** was developed by HMIP in the early 90's, namely OPRA (Slater D. , 2000) which focussed resources on those companies that were more likely to have a problem and the size of the consequences if it happened. However, this did not address what form of interventions to apply.

Towards the end of the twentieth century, it became widely recognized that the best outcomes will be achieved if inspectors employ a blend of persuasion and coercion. This concept was coined "**responsive regulation**" and the concept of the "enforcement pyramid" shown in figure 1, developed by Ayers and Braithwaite (Ayers & Braithwaite, 1992)



In England Wales, HMIP developed this further into the “Regulatory Ladder” of recommended responses to a spectrum of high to low ranges of perceived attributes of situations. See figure 2.

The Regulatory Ladder

Performance	Risk	Cost	Deregulatory	Regulatory Mechanisms	Examples
Good ↑	Low ↑	Low ↑	High ↑	Ignore	Inspector informed/accountable judgements/discretion
				Inform	Oil disposal video, publications
				Educate	Seminars, papers, leaflets
				Advise	Discussion
				Guide	Guidance notes, waste-management papers
				Influence	Licence applications
				Encourage	Public opinion
				Instruct	Licences
				Direct	Licences
				Warn	Code of practice
				Threaten	Code of practice
				Sanction	EMAS, licence modifications, operator's licence withdrawal
				Enforce	Licence, fit and proper person: suspension/withdrawal
Poor ↓	High ↓	High ↓	Regulatory ↓	Prosecute	Prosecution policy

UMIST EMT Course – March 2004

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Figure 2 – Recommended responses to a range of regulatory situations

Regulatory "Reform": 5 more profound developments

- 1) Increased emphasis on the "Expert" model (rather than "Legal" model) of Regulation
- 2) Emergence of Regulatory Craftsmanship, utilizing broader range of tools
- 3) Recognition of the Limits of private sector prescriptions (e.g. customer-service, process management)
- 4) New organizational behaviors (organized around risks, problems, patterns, issues, etc.)
- 5) Fitting different regulatory *structures* to different classes of risk (structural versatility & wisdom)

Malcolm K. Sparrow

John F. Kennedy School of Government, Harvard University

Figure 4 – Sparrow's Reform Recommendations

Sparrow argues that particular difficult "knotty" problems causing harm require a different approach to the regulatory approaches discussed above and he describes a problem solving approach for more expert regulators to be more effective.

A parallel development, especially in the UK and the US is application of behavioural economics to develop non regulatory interventions (sometimes referred to as "nudges" after Thaler and Sunstein (Thaler & Sunstein, 2009)"). Examples of tools which recognise these concepts are ISM (Scottish Government I, 2013) and MINDSPACE (Dolan, 2010) .

3. METHODS FOR CHARACTERISING THE TARGETS OF INTERVENTIONS

There are many ideas and accompanying methodologies to help regulators develop interventions based upon the nature of the target of interventions. Each of these seems to look at the problem from quite different angles to see where and how to intervene and most do not actually provide a methodology for the final stage of actually of *choosing* appropriate interventions. Some of those that are most specific in this regard are the risk based approaches, but they only characterise the target in term of risk and often only offer a limited set of (mainly) regulatory interventions. Others consider aspects of the target (other than risk) such as:

- How regulation can be designed and applied (for example by using the table of 11) (Van der Schraaf & Roessen A., 2014)
- Drivers for compliance and internal factors in a business (SNIFFER, 2013). So you choose interventions that will compensate for weak drivers for compliance (such as financial drivers) or you support less developed internal factors such as capacity.
- Behavioural aspects such as the “Individual, Social and Material” (Scottish Government I, 2013). Or “Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect and Commitments” (Dolan, 2010)
- The needs, tools, processes of perpetrator and society (Dorp V. , 2014).
- What the whole "system" looks like, so you need to “unravel the knots” and “sabotage the vulnerable nodes” (Sparrow M. K., The Regulatory Craft: Controlling Risks, Solving Problems and Managing Compliance, 2000) (Sparrow M. K., 2008)
- The objectives you want to achieve (White, 2013).
- The nature of the sector. So for diffuse pollution from thousands of farms you need a different answer than for waste carriers or for large companies with reputations to consider.

However these newer methods still normally examine only one perspective. For example from just an economic, business, regulatory, or behavioural perspective. We will look at each aspect in turn below.

METHODS CONSIDERING REGULATORY ASPECTS

In the Netherlands, the Ministry of Justice developed the ‘Table of Eleven’ (Van der Schraaf & Roessen A., 2014) which consists of eleven dimensions, which together decide the extent to which legislation is complied with. The eleven dimensions are formulated with a view to as high a practicability as possible in the fields of policy development and law enforcement. See Box 1 below

Box 1 The Table of 11

The Table of 11

Spontaneous compliance dimensions

1. Knowledge of the rules

Familiarity and clarity of legislation among the target group

2. Cost/ Benefits

The tangible/intangible advantages and disadvantages of breaking or complying with the rule, expressed in time, money and effort

3. Degree of acceptance

The degree to which the target group regards the policy and the rules as acceptable

4. Target group's respect for authority

The extent to which the target group is willing to respect governmental authority

5. Non-governmental control (social control)

The risk, as estimated by the target group, of positive or negative sanctions on their behaviour other than by the authorities

Enforcement dimensions

6. Risk of reporting

The risk, as estimated by the target group, of a violation detected by others than the authorities being reported to the authorities

7. Risk of inspection

The risk, as estimated by the target group, of being inspected by the authorities for possible violations

8. Risk of detection

The risk, as estimated by the target group, of a violation being detected if the authorities inspect

9. Selectivity

The perceived increased risk of inspection and detection of a contravention resulting from selecting the businesses, persons, actions or areas to be inspected

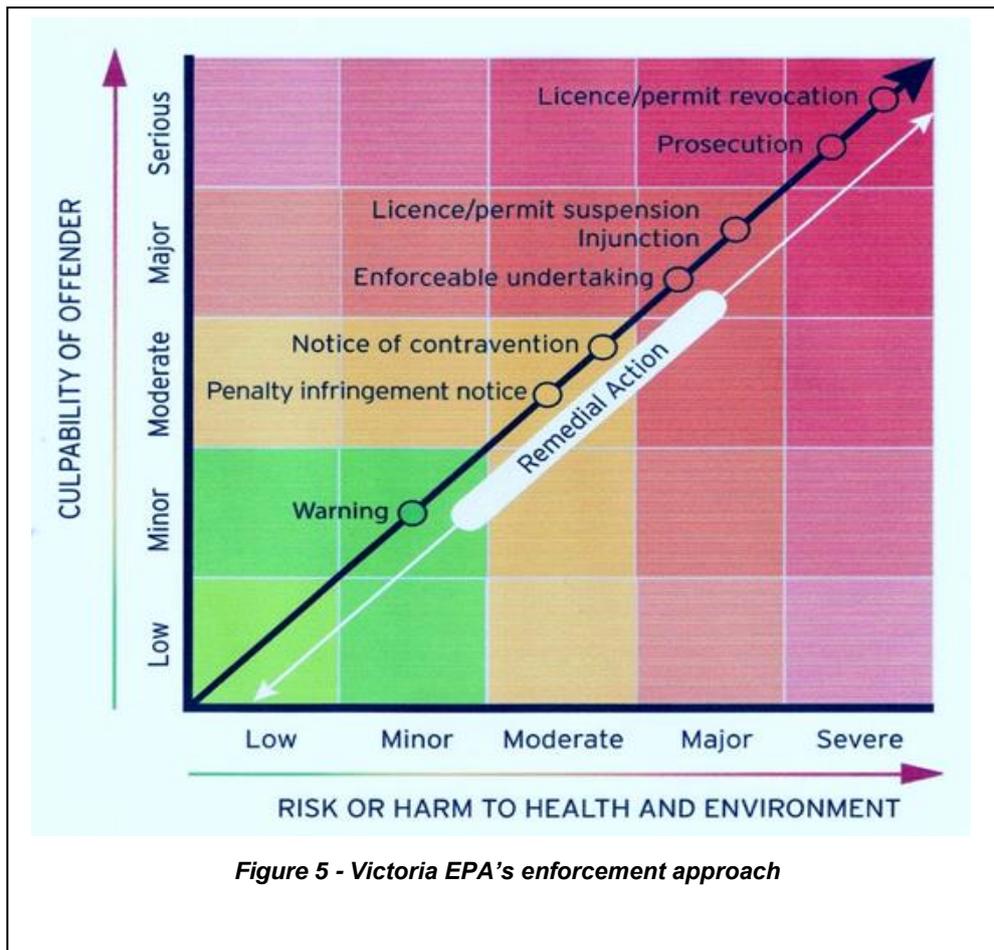
10. Risk of sanction

The risk, as estimated by the target group, of a sanction if a violation is detected in an inspection

11. Severity of sanction

The severity and type of sanction associated with the violation and additional disadvantages of being sanctioned

Victoria EPA in Australia has a method which combines risk with a behavioural aspect of "the offender" namely culpability as demonstrated in figure 5.



METHODS CONSIDERING EXTERNAL DRIVERS ON BUSINESS FOR COMPLIANCE AND INTERNAL FACTORS

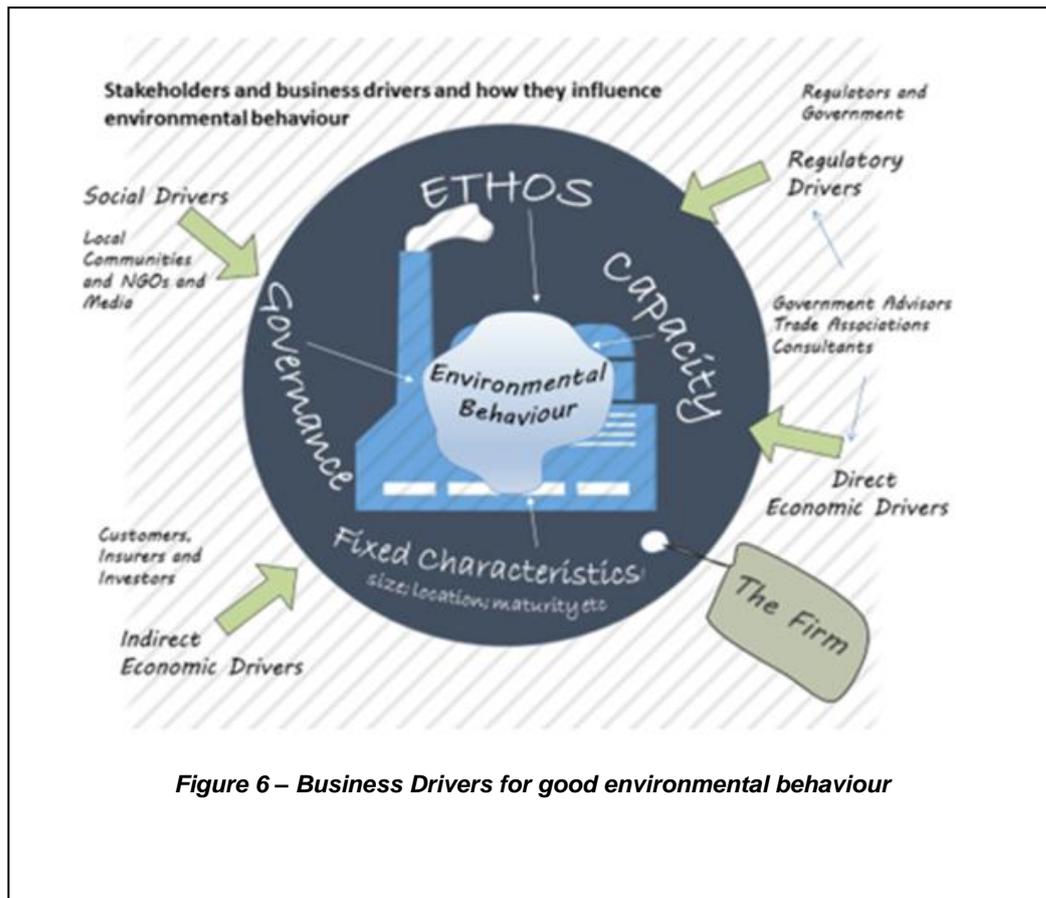
The Defra “Rapid Evidence Appraisals” (Defra , 2013) in particular REA 1 extends the messenger scope to include firms as well as individual behavioural responses. (But also see REAs on voluntary agreements and earned recognition). This model proposes that external business drivers for good environmental behaviour fall generally into four categories.

- **Deterrence Drivers** - basically command and control
- **Direct Economic Drivers** – Economic Instruments or market mechanisms
- **Indirect Economic Drivers** – Access to markets, Licences, “Quality Standards”
- **Social Drivers** - Peer pressure, name and shame, Public recognition/ endorsement

And they further suggest that “the way in which they actually influence the environmental behaviour of a firm will be influenced by internal factors (“enablers”) within the firm:

- Ethos
- Governance
- Capacity
- Fixed characteristics such as company size, location, sector etc.

(See figure 6 below)



Depending on the nature of these internal enablers in a particular firm they may amplify or insulate a company's response to external drivers.

Defra's Instrument Selection Policy (see figures 3, 14 and 20) and the IMPEL project on "complementary approaches" (see figure 18) make a similar, but slightly different analysis of business drivers and internal factors. These methods go further than just characterising businesses in this way but make suggestion of how this analysis can help you in choosing interventions. They are discussed more in chapter 5.

METHODS CONSIDERING BEHAVIOURAL ASPECTS

These systems essentially target people in the process which leads to harm. In this case by using behavioural insights from science, the interventions are designed to change this behaviour. They take into account that people sometimes act irrationally as well as rationally, people tend to perform better with a limited set of choices, tend to choose the well-known and obvious instead of uncertainty, tend to act on the small short term profit instead of the higher long term profit, act positively on social proof, authority, commitment, sympathies, etc. Also people can be influenced by designing an effective physical surrounding (Van Dorp, 2014).

Since the aim of the intervention is to effect behavioural change, there is a plethora of approaches that have been suggested, particularly in the health care field. Examples of interventions to tackle smoking, obesity, etc. are well documented and are mainly aimed at changing attitudes by advertising, peer pressure, etc. One of the best reviews of the

previous studies which have looked at identifying the main ways that individuals, communities and policy-makers can influence behaviour was done for the Cabinet Office (Cabinet Office, , 201?). Here they arranged the effects according to the acronym **MINDSPACE**.

Messenger	we are heavily influenced by who communicates information
Incentives	our responses to incentives are shaped by predictable mental shortcuts, such as strongly avoiding losses
Norms	we are strongly influenced by what others do
Defaults	we 'go with the flow' of pre-set options
Saliency	our attention is drawn to what is novel and seems relevant to us
Priming	our acts are often influenced by sub-conscious cues
Affect	our emotional associations can powerfully shape our actions
Commitments	we seek to be consistent with our public promises, and reciprocate acts
Ego	we act in ways that make us feel better about ourselves

In this report, they outline these nine robust influences on human behaviour and change. The principles are underpinned by considerable research from the fields of social psychology and behavioural economics. The elements described are those that operate largely, but not exclusively, on automatic effects. They illustrate some of the effects on behaviour, but crucially for us, do not deal with the effects of more traditional interventions that rely on legislation and regulation, particularly with regard to influencing *organisational* behaviour rather than *individual* behaviour.

The Scottish Government ISM Tool

The Scottish Government has developed an approach which recognises the importance of context in assessing how people's behaviours are influenced. It defines three levels as:-

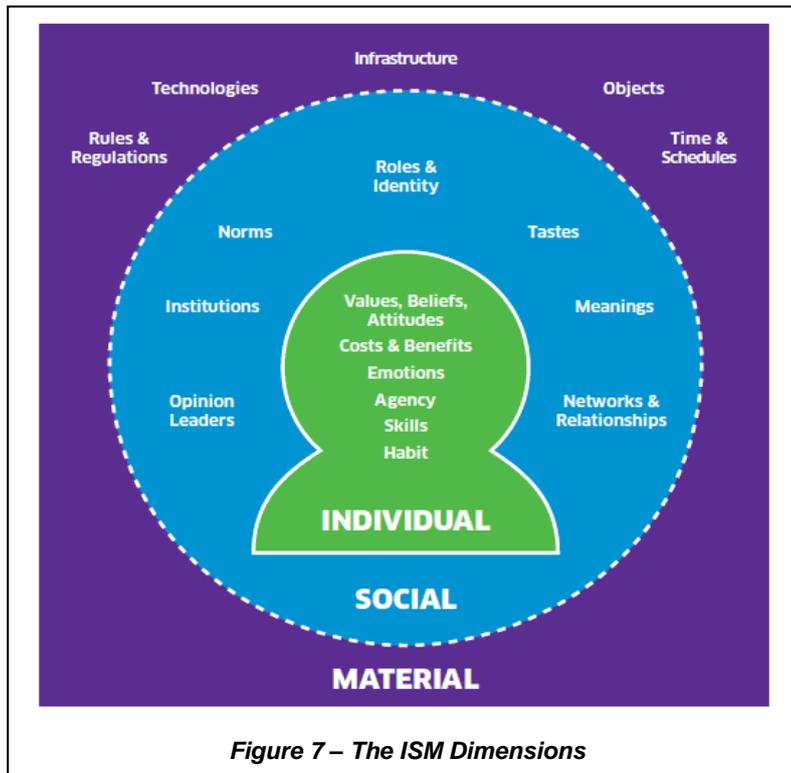
- Individual
- Social, and
- Material

The Report summarises the three contexts as:-

- **"The Individual context** focuses on people's values, attitudes and skills, together with other factors which drive our choices and behaviours.
- **The Social context** recognises that how other people behave and what society considers to be appropriate and desirable behaviour strongly influences how each of us acts.

- **The Material context** recognises that the world in which we live, i.e. the infrastructure and technologies, legislative and policy frameworks which exist, either work to promote, or constrain our behaviours.

Figure 7 summarises these ISM concepts.



One of the key principles of the ISM approach is that developing a package of interventions that targets all three contexts, is more likely to be successful in bringing about significant and long lasting change. The Scottish Government’s User and Technical guides to the ISM tool (Scottish Government Social Research, 2013) provides further information, whilst the case studies it utilises, show how the Scottish Government is putting ISM into practice in order to improve understanding of behaviours and strengthen and add to the delivery of existing policies.” It has a rigorous 12 step approach utilising a group of experts to characterise particular scenarios from a behavioural science perspective. However, the tool does not provide a list of potential interventions, nor says specifically how these should be developed or chosen according to circumstances. Rather it says in stage 9 that you should identify gaps (from the “policy mapping exercise” and that “some ideas will come naturally to the fore” “while others may require creative thinking”. So, the elusive last step of intervention design, intervention choice and packaging up interventions is left to those experts.

The European Union Food Information Council (EUFIC, 2014) similarly highlights a range of influences on individual behaviours. Their review sums up the area very well:

“In recent years there is much interest in theories of behaviour and models of behaviour change largely drawn from psychology and informed by economics and sociology. They consider the wide range of psychological, social, societal and contextual factors such as emotions, habits and routines. The theories of change support interventions by describing how behaviours develop and change over time. Behavioural models are designed to help us

understand behaviour and identify the underlying factors that influence it. An understanding of both aspects is needed to develop effective intervention strategies. Over 60 socio-psychological models and theories of behaviour have been identified, many of which have been used as the basis for designing and implementing health promotion programmes, with varying success. There is substantial evidence that the use of theory in designing and implementing behaviour change interventions improves the effectiveness of interventions. In the published studies, however, the details of the applied theory are often missing. As reviewed recently, only 44% of 34 randomised control trials in obese adults reported the theoretical basis of behavioural interventions. The most commonly applied were the Trans-theoretical Model and Social Cognitive Theory (explained below), although a third of the reviewed studies did not explain why a particular theory was used. The Theory of Planned Behaviour has also been effectively applied to physical activity and dietary interventions.

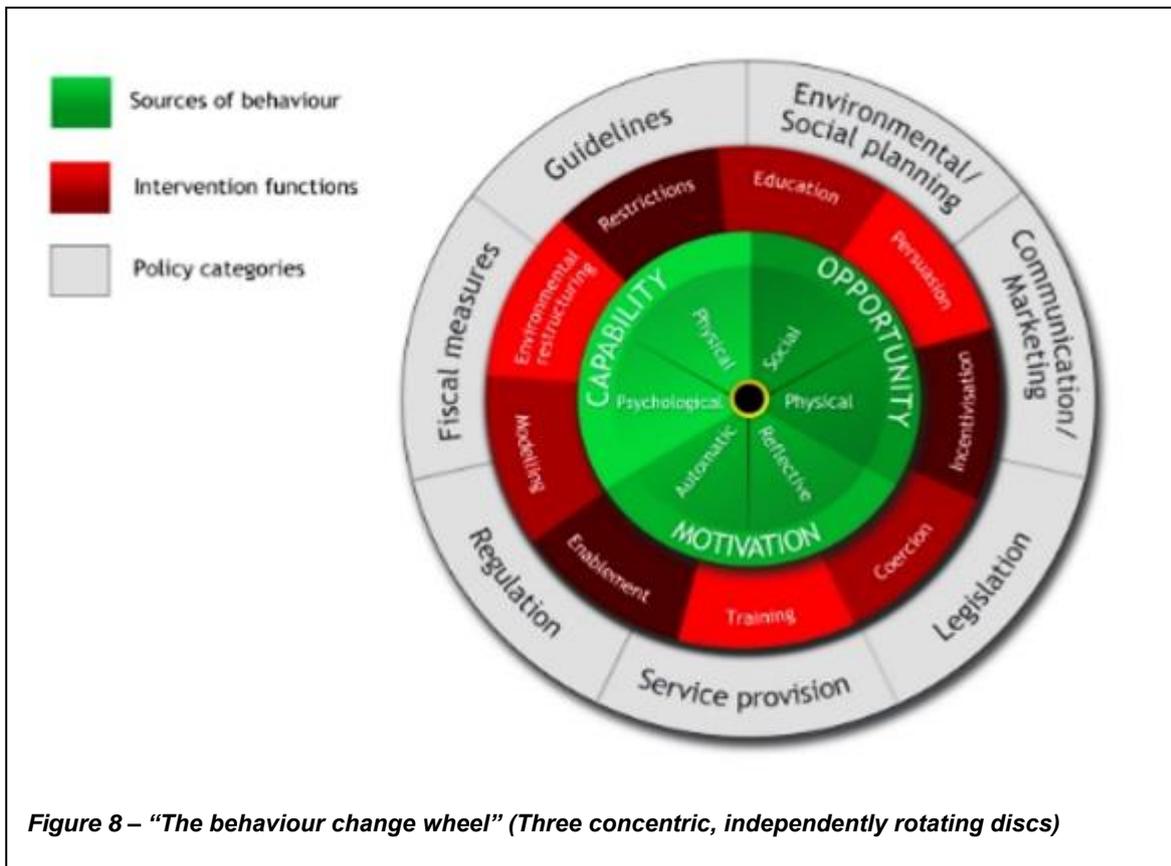
- Trans-theoretical Model (also referred to as the 'Stages of Change' model): segments the audience and tailors the intervention to their stage of change: pre-contemplation, contemplation, preparation, action, maintenance, and termination.
- Social Cognitive Theory: focuses on the role of observing and learning from others, and on positive and negative reinforcement of behaviour.
- Theory of Planned Behaviour: assumes that people's behaviour is determined by intention, and is predicted by attitudes, subjective norm (beliefs about whether other people approve or disapprove), and perceived behavioural control (beliefs about whether it is easy or difficult to do).

Models and theories identify techniques to change behaviour. Interventions often use several different behaviour change techniques. They range from providing information (for example, about the consequences of behaviour) to prompting the setting of specific goals and providing opportunities for social comparison. They can also include stress management, motivational interviewing and time management. It is not completely clear which techniques are effective under which conditions. Self-monitoring and other self-regulatory techniques (goal-setting, prompting, self-monitoring, providing feedback on performance, goal review) are consistently reported as effective behaviour change tools.

But they sum it up with a Quote – “There is a wide range of personal, social, and environmental factors that influence behaviour. Most can be assigned to three levels:-

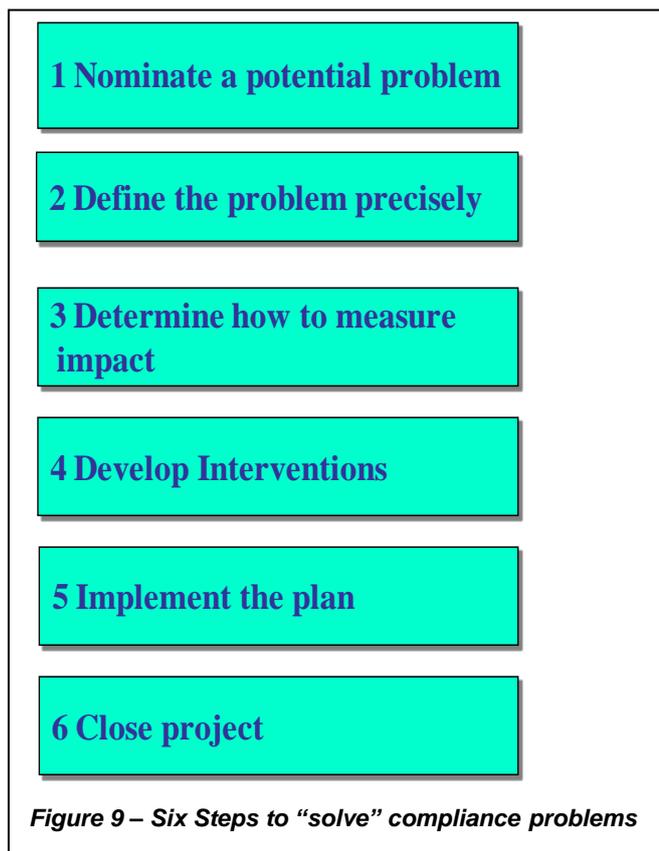
- Personal or individual: beliefs, knowledge, attitudes, skills, genetics
- Social: interaction with other people including friends, family and the community
- Environmental: the area in which an individual lives, e.g. school, work place, local shops and facilities, and wider factors including the economy (such as prices) and technology.”

So, although there are some differences in perspective in the sources discussed above, it seems that the process of designing a behaviour change intervention first involves understanding the target behaviour and selecting a broad approach, and then designing the specific behaviour change techniques to be used. The 'behaviour change wheel' (figure 8) has been developed as a guide for selecting appropriate interventions and an 'intervention design tool' is currently under development.



PROBLEM SOLVING: WHAT THE WHOLE "SYSTEM" LOOKS LIKE, SO YOU NEED TO “UNRAVEL THE KNOTS” AND “SABOTAGE THE VULNERABLE NODES”

Malcolm Sparrow in his book “The Regulatory Craft” (Sparrow M. K., 2000) makes a distinction between regular inspections and problem solving. He proposes a simple set of steps to solve these compliance problems. See figure 9 below.



The first step is to nominate the potential problems or problem areas. These problem areas should be external, nor solved by simply more inspections and cause social harm. The second step is to define this problem precisely, the third step is designing a measurement system which measures the impact of your solutions, the fourth step would be to develop interventions, the fifth step to implement the best solution and finally to stop the project.

These steps look simple enough, but actually are not. Problem solving, according to Sparrow, is relentlessly difficult. Unfortunately Sparrow only defines the steps, but does not explain clearly how to perform these steps, nor actually how to come up with interventions to address the problem.

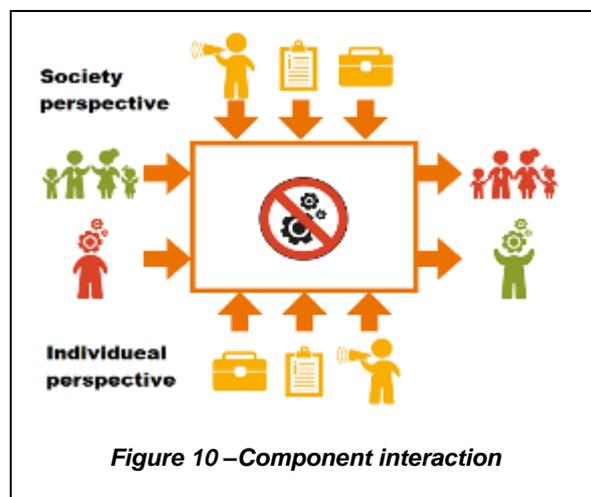
METHODS CONSIDERING THE NEEDS, TOOLS, PROCESSES OF PERPETRATOR AND SOCIETY

An interesting application of Malcolm Sparrow’s problem solving approach has been developed by Rob Van Dorp and used by the Inspectorate of Environment and Transport in the Netherlands (Dorp V. , 2014). It was developed for situations “when regulation and inspections simply do not work” and “a regulator has to go back to the drawing board to invent a new solution to a societal problem”.

Essentially this involves spending a lot of time on one of Sparrow’s key stages namely “defining the problem precisely” from the point of view of “society” (which includes environmental harm) and the point of view of the perpetrator (individual or company). And for each one you need to understand 4 components, namely:

- Unfulfilled Needs
- Tools
- Process
- Fulfilled needs

Figure 10 explains how the 2 points of view and the 4 components interact



A problem might be fly tipping in countryside.

So for the perpetrator the situation might be

- Unfulfilled Needs (lack of means to earn money by legitimate employment)
- Tools (e.g. transport to carry waste)
- Process (collection and disposal of waste)
- Fulfilled needs (making “easy money”)

And for Society these might be

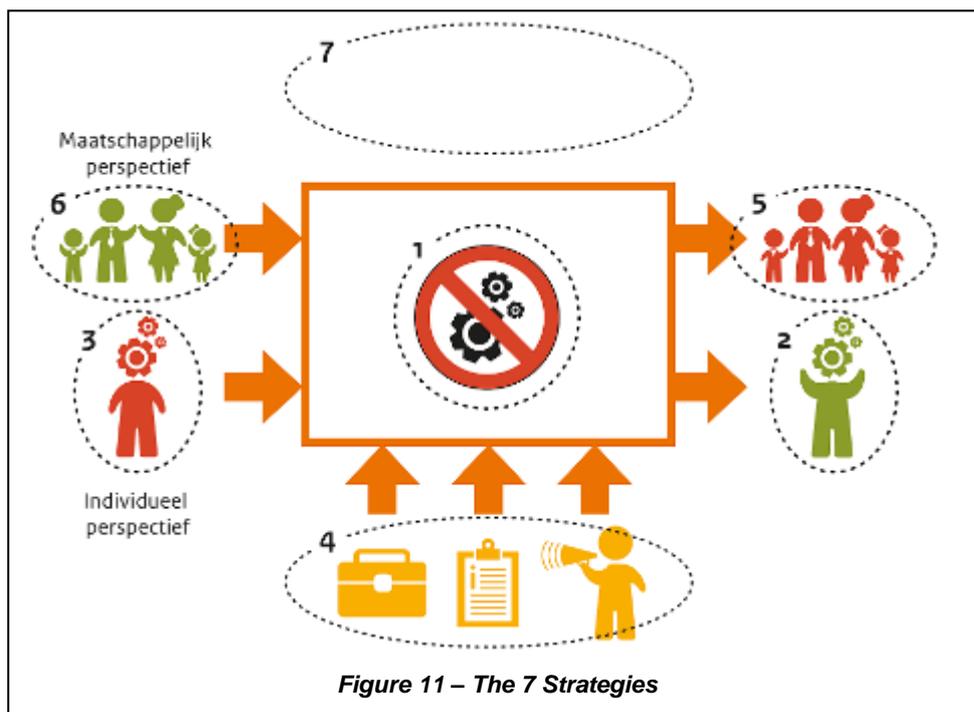
- Unfulfilled Needs (clean, safe countryside to walk in)

- Tools (transport to clean safe countryside)
- Process (spending leisure in countryside)
- Fulfilled needs (e.g. clean environment to live in: no waste)

In order to address these issues Van Dorp says there are typically 7 strategies as follows:

- Strategy 1: creating awareness to the actor of the harm his action creates to society
- Strategy 2: negatively compensate the profit (fulfilled needs) of the actor. (e.g. take away the proceeds of crime)
- Strategy 3: Filling the unfulfilled needs of the actor in another way. (E.g. pay him not to offend, give him a job etc.)
- Strategy 4: taking away the tools, information or support needed for the action (e.g. seize vehicle)
- Strategy 5: Compensating the harm to society. (e.g. provide alternative leisure facilities)
- Strategy 6: Changing the context of the action (e.g. make it non-profitable by ensuring legitimate waste business can run profitably)
- Strategy 7: Adding tools, information or support to stimulate desired behaviour.

The way in which the 7 strategies fit in to Van Dorp's model are shown in figure 11.



Van Dorp explains each of these strategies in more detail in his paper and he also recognises the value of using a chain of process approach and bowtie model (see figures 30 and 31) which we describe in chapter 7.

Once you have used the above approach for designing solutions you have a long list of possible solutions and Van Dorp recognises that making an optimal choice from this list is a separate process.

METHODS CONSIDERING THE OBJECTIVES YOU WANT TO ACHIEVE

The Ontario Ministry of Environment (White, 2013) has developed what they call “The Risk based compliance framework”. However a key first step in this is to understand and agree your objective. This is particularly important for them to help the dialogue between policy makers and regulators and it also helps when coming to evaluation. Figures 12 and 13 summarise the process. The overall compliance policy in Ontario (Ontario Ministry of the Environment., 2007) is about to be reviewed to updated and will incorporate the above framework.

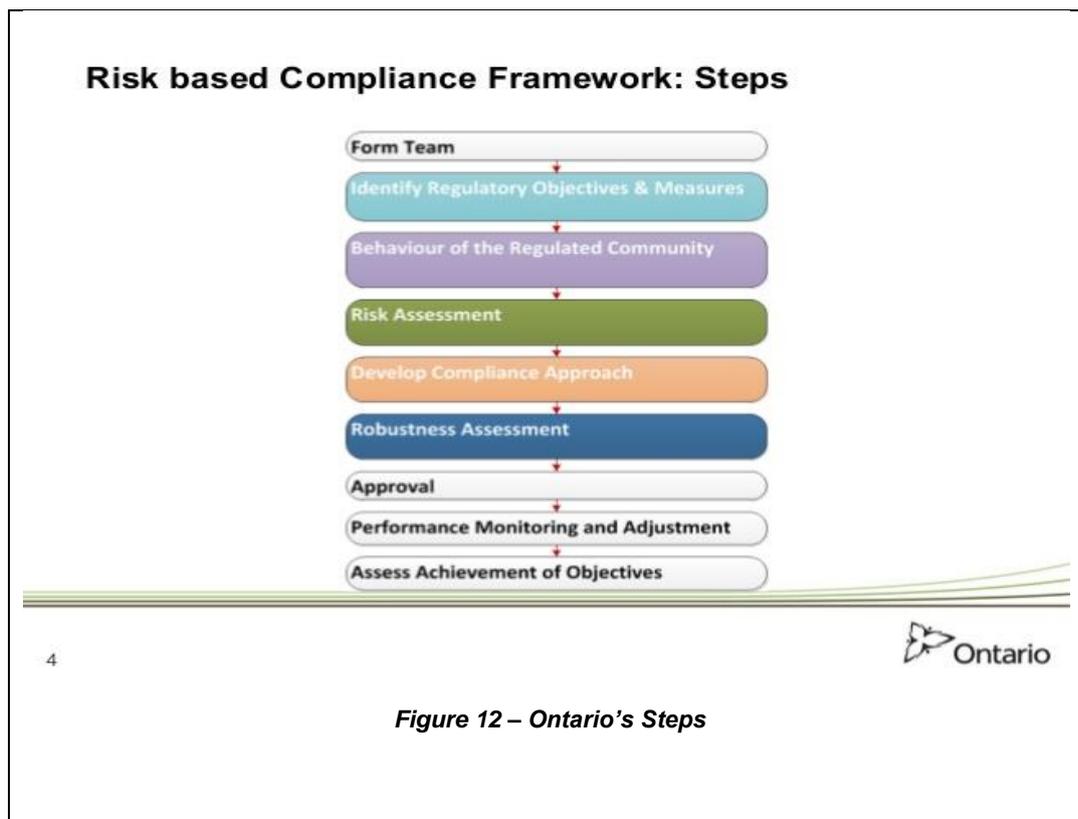


Figure 12 – Ontario’s Steps

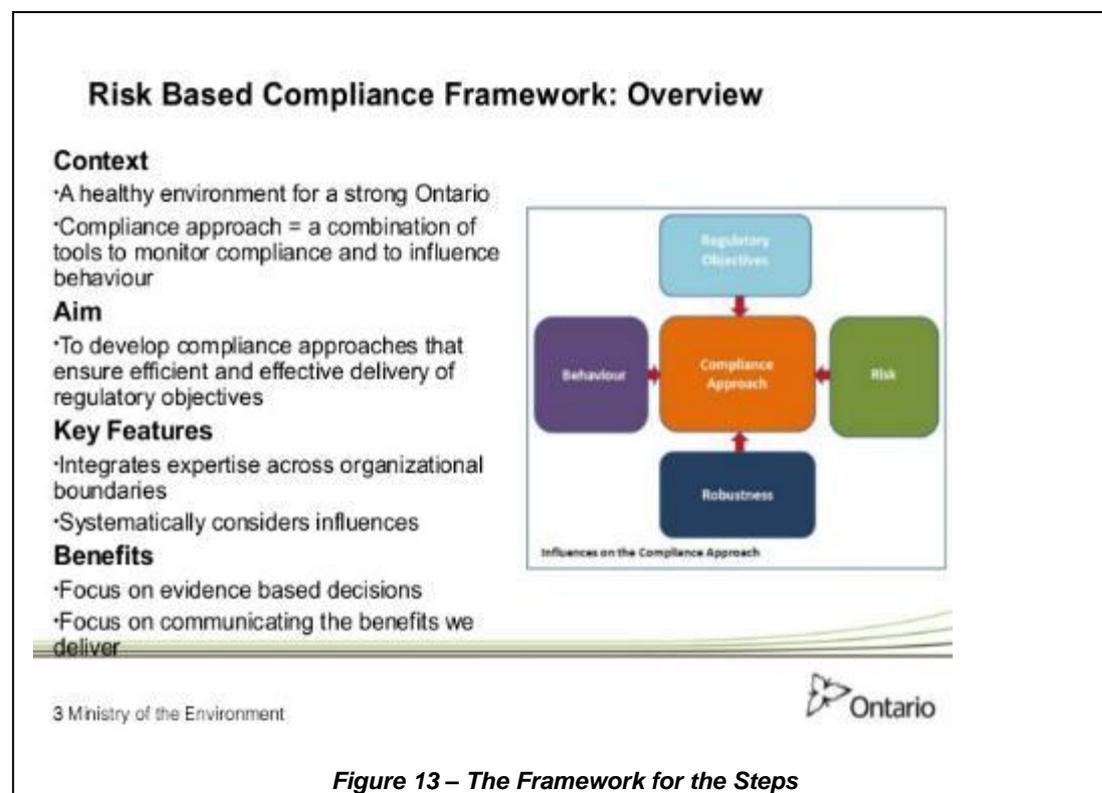


Figure 13 – The Framework for the Steps

4. INTERVENTIONS

There are a limited number of sources which describe the types of interventions used by regulators and policy makers in an environmental context. Some (but not many) of these include interventions which have been specifically designed and applied to waste crime¹. These are often not called “interventions” in the literature but go by names such as “complementary approaches”, “non-traditional approaches”, policy instruments”, “compliance promotion”, “non-compliance response” and so on. Some, but not all, of these offer a typology (which are generally similar) and classify interventions into types: regulatory, market based, behavioural and so on). A smaller number of sources provide information on where and how they have been applied or provide evaluation of their success.

Some regulators refer to some structured lists of interventions but these are mostly increasing degrees of regulation from supportive through to enforcement, based on risk.

CATEGORIES OF INTERVENTIONS

The key projects that have drawn up list of interventions and assembled them into categories are shown below. They all cover wider aspects of environmental regulation and none of them were specifically just for waste regulation.

- IMPEL project – Complementary Approaches (IMPEL, 2012) which lists about 25 interventions in 4 categories. These are included at appendix 2.
- SNIFFER project ER30 (SNIFFER, 2013) - a summary of the current better regulation evidence for 6 topic areas which includes a list of interventions in “topic guide 2”: These are included in appendix 3
- DEFRA Guidance on instrument selection (Defra, 2013), which lists 20 interventions as shown in figure 14.

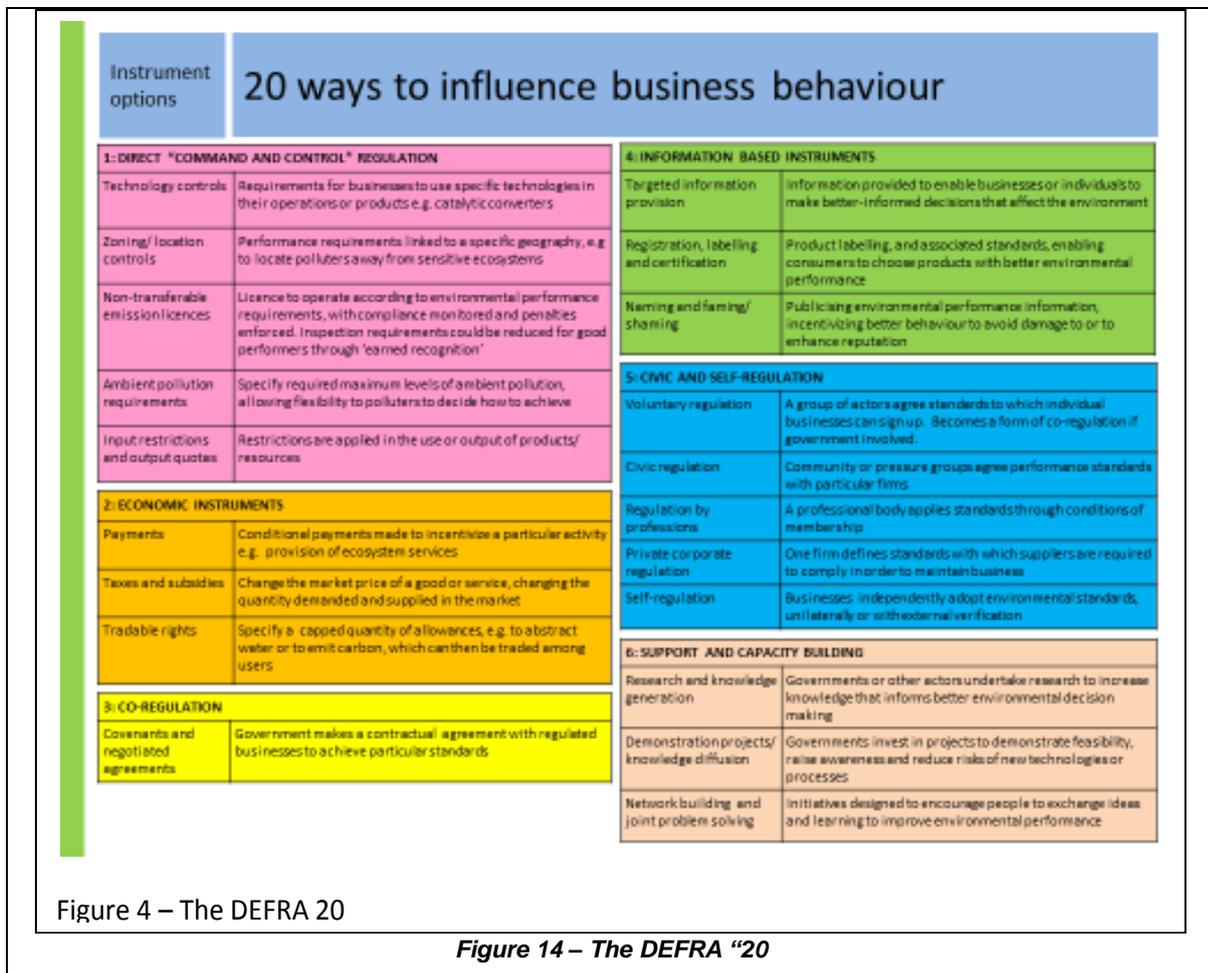
Each of these sources categorises them in similar but different ways. The Defra typology is typical. A useful description of how each intervention groups can be applied was developed by Cranfield University (Taylor, 2013) who worked on many of the above projects and is given in box 2 below.

Box 2. A typology of interventions

- **Direct regulation:** relatively certain outcome but potentially costly, need to be targeted according to risk e.g. Environmental Permitting regime, REACH
- **Economic instruments:** less certainty of outcome but greater flexibility for businesses to choose least cost options, may provide long-term certainty e.g. Landfill Tax
- **Information based approaches:** uptake dependent on customer/supply chain interest e.g. EU Ecolabel
- **Co-regulation:** can encourage rapid action, flexible to changing circumstances, but may struggle to capture small businesses e.g. Courtauld Commitment

¹ One useful source was. European Pathway to Zero Waste (2012). Novel Approaches to Waste Crime. Environment Agency

- **Self-regulation:** action motivated by financial, customer/supply-chain or reputational influences e.g. ISO14001
- **Support and capacity building:** impact may depend on credibility and trust.



Another typology for interventions was developed by the Scottish Government (The Serious Organised Crime Task Force , 2009) and called the "4Ds":

- Detection,
- Deterrence,
- Diversion and
- Disruption

Some interventions to tackle waste crime may involve just one environmental authority. Others may require extensive collaborations with other enforcement bodies, business representatives etc.

The "What Works Centre" for crime reduction at UCL (UCL, 2015) list 35 interventions and provides further information for each one in terms of:

- Impact on crime
- How it works
- Where it works

- How to do it
- What it costs

It would be very helpful if a similar menu of options could be developed for waste crime regulators along similar lines.

INTERVENTIONS USED FOR WASTE CRIME

As well as the examples listed in the sources mentioned above, some newer enforcement initiatives have been developed which may be particularly applicable to waste crime. For example:

Legislative amendments by speeding up prosecutions for rogue waste site operators, and introduction of fixed penalty notices for small scale fly-tipping in the UK (Defra, 2015).

Enhanced enforcement powers to help the regulators tackle waste crime and entrenched poor performance in the waste management industry (Defra, 2015). These include the following regulatory interventions:

- Suspend permits where an operator has failed to meet the conditions of an enforcement notice;
- Issue notices that include steps an operator must take to prevent the breach of a permit getting worse;
- Widen the regulators' ability to require the removal of waste from land.
- Fixed Penalty Notices for fly-tipping;
- Operator competence, including operator technical competence and the financial provision made by applicants for waste permits;

And in Scotland (SEPA , 2015) the new fixed and variable monetary penalties and enforcement undertakings will shortly be available.

Economics instruments aimed at improving waste management industry performance include landfill taxes and fees, incineration taxes and fees, pay-as-you-throw (PAYT) schemes, and producer responsibility schemes for specific waste streams (notably packaging, WEEE, ELV and batteries).

Powers to recharge for pollution works associated with the deposit of waste on land were included in the latest Defra consultation.

Actions to improve landowner awareness of potential liabilities related to waste operations were included in the latest Defra consultation.

Many kinds of interventions specifically related to waste crime which can be delivered at different points in the waste supply chain to help tackle waste crime. They can range from Site specific interventions focusing on one particular waste management site, or Operator specific, for example;

- interventions at pinch points in the waste supply chain (e.g. where waste is moved across borders);
- working with a particular waste sector or business representative bodies;
- working with end user representative bodies; and
- Lobbying for legislative and policy change at a national or European level.

As well as the regulatory and information based interventions mentioned above the latest Defra consultation (Defra, 2015) also proposes:

- Take physical steps to prevent further breaches by an operator of their permit;
- Take steps to remove a risk of serious pollution, whether or not a facility is under a permit;
- Options to address abandoned or orphaned waste management sites;

In the context of Waste Tyres, research by “EPOW” (Environment Agency, 2012) showed that financial gain was the strongest driver for waste tyre crime and illegal collection, storage and export. By targeting interventions at the point where the money changes hands, one of the key drivers can be Interventions mentioned in this study included:

- levying a charge early in the tyre’s life cycle, which removes the incentive to illegally collect as there is no money changing hands at point of waste collection. (A case study in Italy provided details of successful use of this approach)
- targeting the source of the illegal waste, the producers, rather than their normal approach of targeting the suspect fly-tipper (and gave an example of successful application in SEPA).
- use of “SmartWater” to help deter fly-tipping of waste. SmartWater incorporates state of the art forensic technology and each batch is forensically unique. It provides an invisible and permanent trace to the waste, meaning that if it is sprayed on individual batches of waste they can be traced back if disposed of illegally.

NOVEL INTERVENTIONS BEING APPLIED IN NORTHERN IRELAND AND IN ENGLAND

[Section to be completed after the promised information is provided by NIEA and EA.]

ADVERSARIAL REGULATORY INTERVENTIONS

Most of the interventions discussed above tend to assume some degree of rational or responsible behaviour in the regulatee. But particularly in waste crime, there is a very serious likelihood of violent criminal behaviour to and intimidation of, would be enforcement agents. Here there needs to be a realization that regulation is different and different rules and responses need to apply. The smart or expert response in these extreme cases must draw on front line security and policing skills and methods. It is primarily an adversarial situation, which needs access to another professional level of monitoring, deterrence and response, with appropriate training and protection of inspectors if intelligence led regulation is not to seem an oxymoron.

As well as first class intelligence and analysis, another useful technique learned from the military Special Forces and applied successfully elsewhere is “Red Teaming”. This is where experienced professionals are invited to act as the adversarial red team and react to and attempt to disrupt and circumvent proposed interventions on a no holds barred basis. Sometimes involving games theory, these responses however need to be deadly serious and there is every incentive to get the retaliation in first.

5. CHOOSING INTERVENTIONS

INTRODUCTION

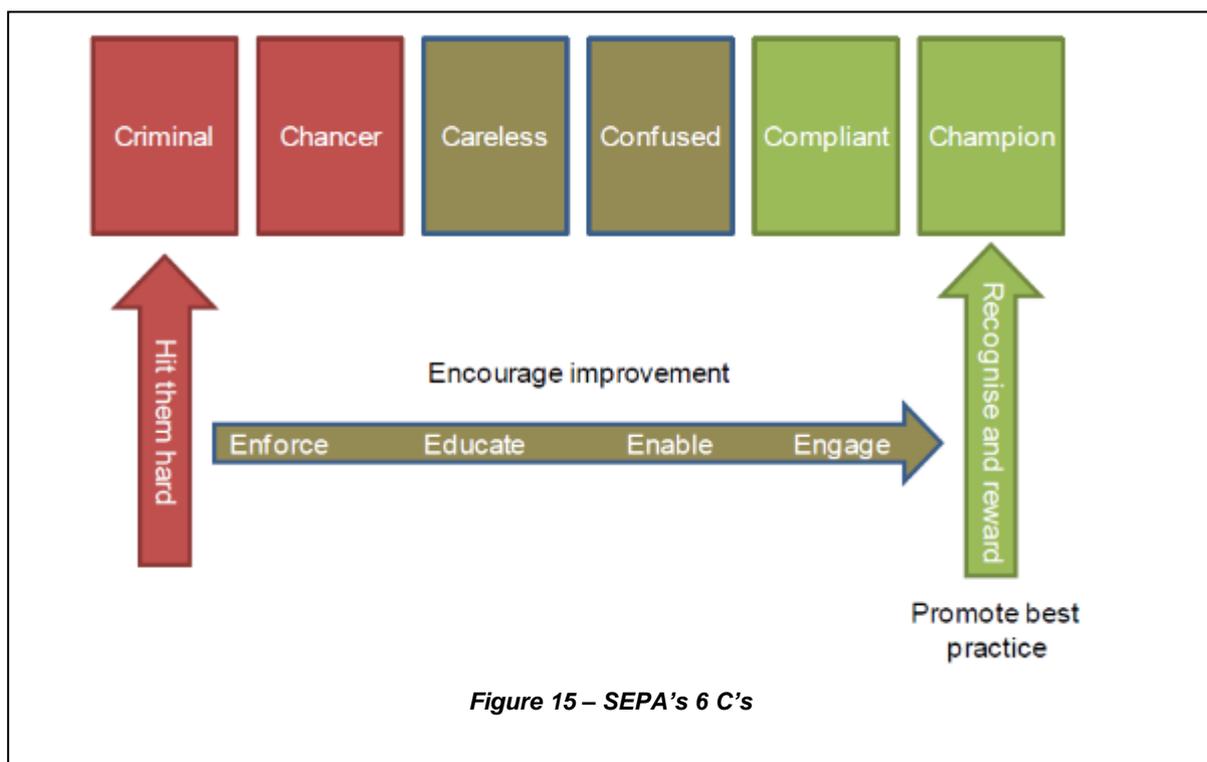
Most regulators have some risk based systems for allocating resources and some are now using other ways (as well as risk) to characterise the regulated and /or other organisations / individuals they wish to influence. Although some regulators have published such factors to take account of when choosing interventions, few have detailed methodologies let alone structured tools to direct the final choice.

Where regulators have referred to some structured lists of interventions these are mostly increasing degrees of regulation from supportive through to enforcement, based on risk and do not take account of the other relevant factors such as those summarised in table 1.

A review of models for choosing interventions is given in a recent IMPEL project report (IMPEL, 2015) While we do not intend to needlessly repeat the review, we have picked out a few of the most relevant models from that review and supplemented those by other systems we have examined separately for this literature review. In all cases the systems and guidance we found cover wider aspects of environmental regulation, not just for waste regulation.

RISK-BASED SYSTEMS TO SUPPORT SELECTION OF INTERVENTIONS

The Scottish Environmental Protection Agency has emphasized that a “one size fits all approach” is not necessarily the most effective when dealing with what, in reality, is a range of different individual and corporate entities with a range of attitudes, circumstances and mind-sets. They have proposed a way of categorizing this range as the 6 C’s and identified the influencing factors that might be expected to be most apposite. See figure 15.

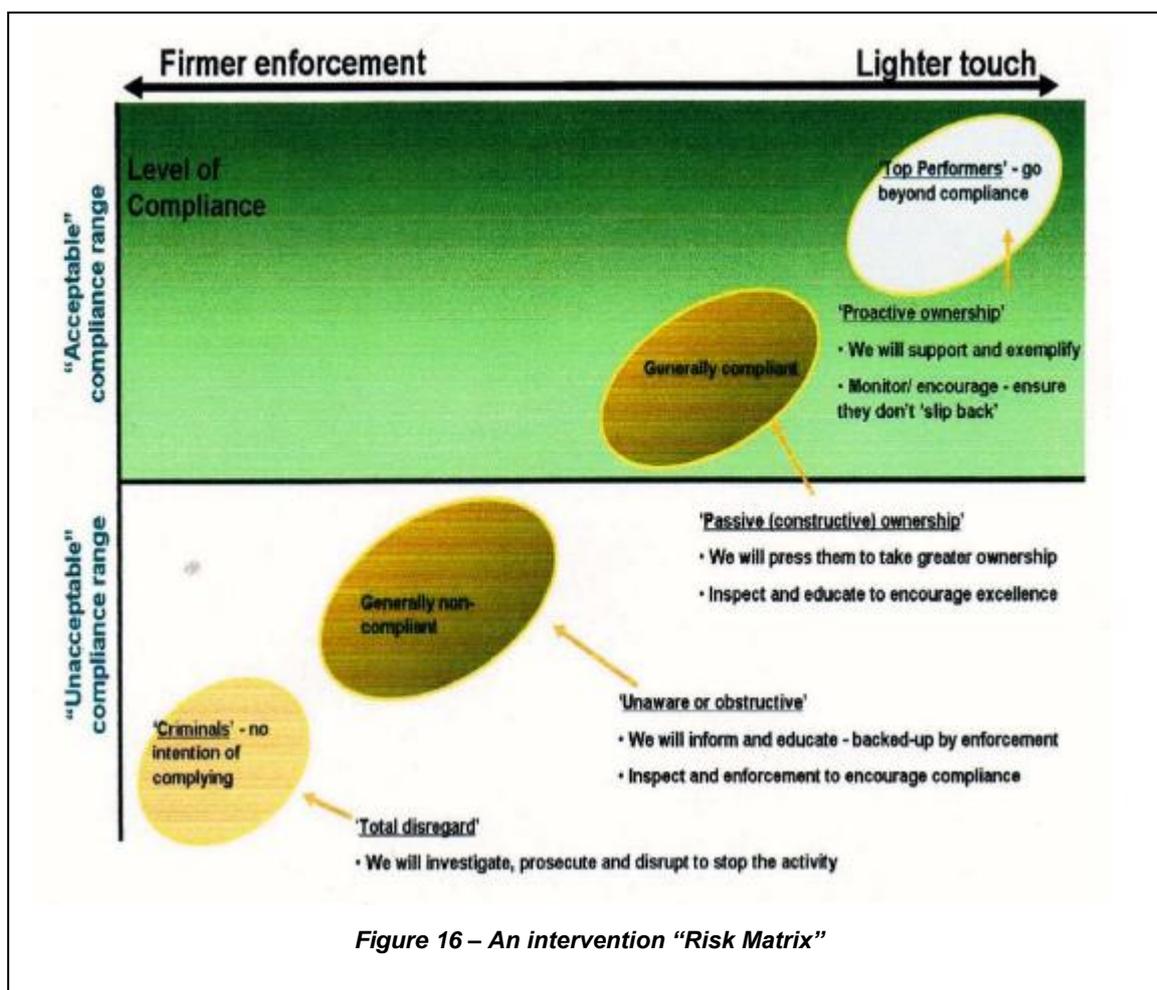


It further makes the point that SEPA requires a wider range “enforcement interventions”. Since then the Regulatory Reform (Scotland) Act 2014) has enabled the Scottish Ministers to give SEPA the power to impose fixed and variable monetary penalties and accept enforcement undertakings. These form part of the new environmental enforcement framework for Scotland that will enable more proportionate and flexible enforcement. They will help ensure that SEPA has the right tools to change the behaviour of those who continue to perform poorly or ignore their responsibilities, and will help tackle non-compliance at an earlier stage before it becomes entrenched. SEPA has just completed a final consultation on its updated enforcement policy and enforcement guidance (SEPA , 2015).

A similar approach in England and Wales considers 4 gradations of the “behaviour of the regulated organisation”. The model (shown in figure 16) identifies a number of interventions as follows:

- investigate and prosecute
- inform and educate
- inspect (either with enforcement to encourage compliance or with education to encourage excellence)
- support and exemplify
- monitor / encourage

These are then assigned to the target range from Top Performer to Criminal as in the SEPA spectrum.

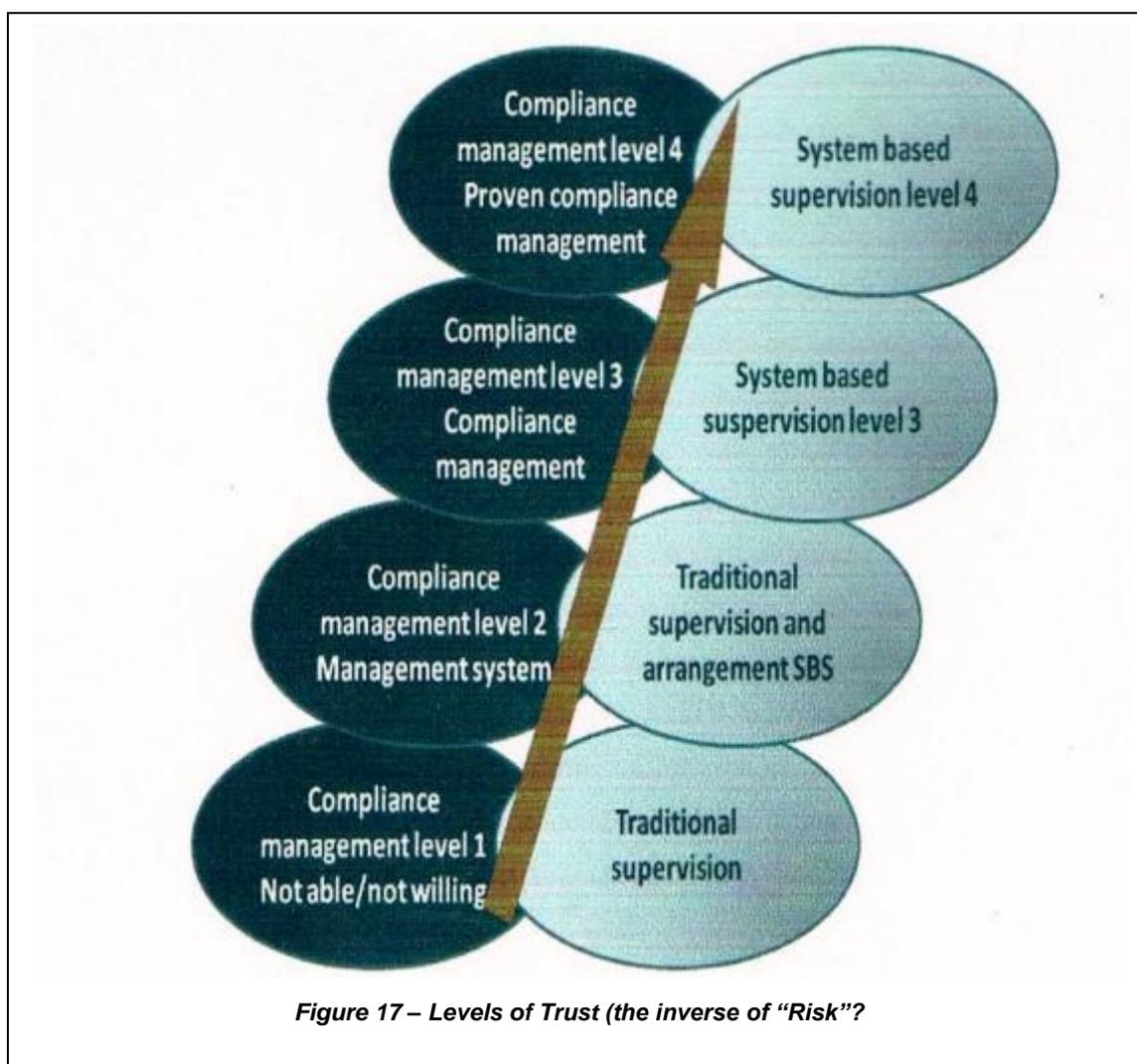


Other European Regulators have adopted this approach as in the Noord Brabant model (de Hass, 2011) in figure 17 which categorises its target communities on a “Level of Trust” basis with the intervention reflecting the care in monitoring needed.

Other systems for applying a risk based to inspections have been developed by IMPEL, but once again these are limited by an examination of the “attributes” of the target solely in risk terms and by limiting the solutions to regulatory rather than alternative interventions.

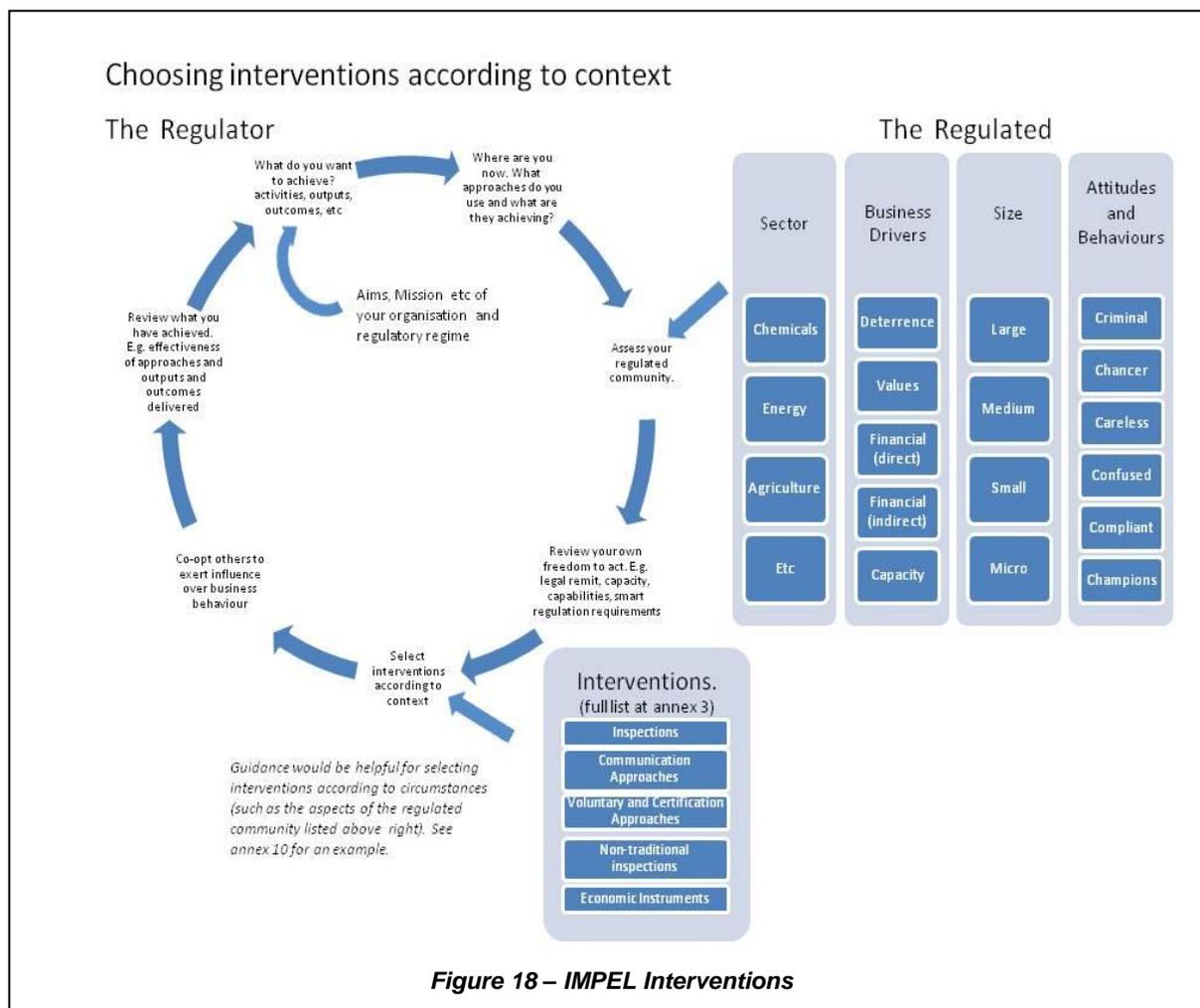
Examples are:

- Development of an easy and flexible risk assessment tool as a part of the planning of environmental inspections (“easyTools”).
- The “Doing the Right Things Project”. (IMPEL, 2015)

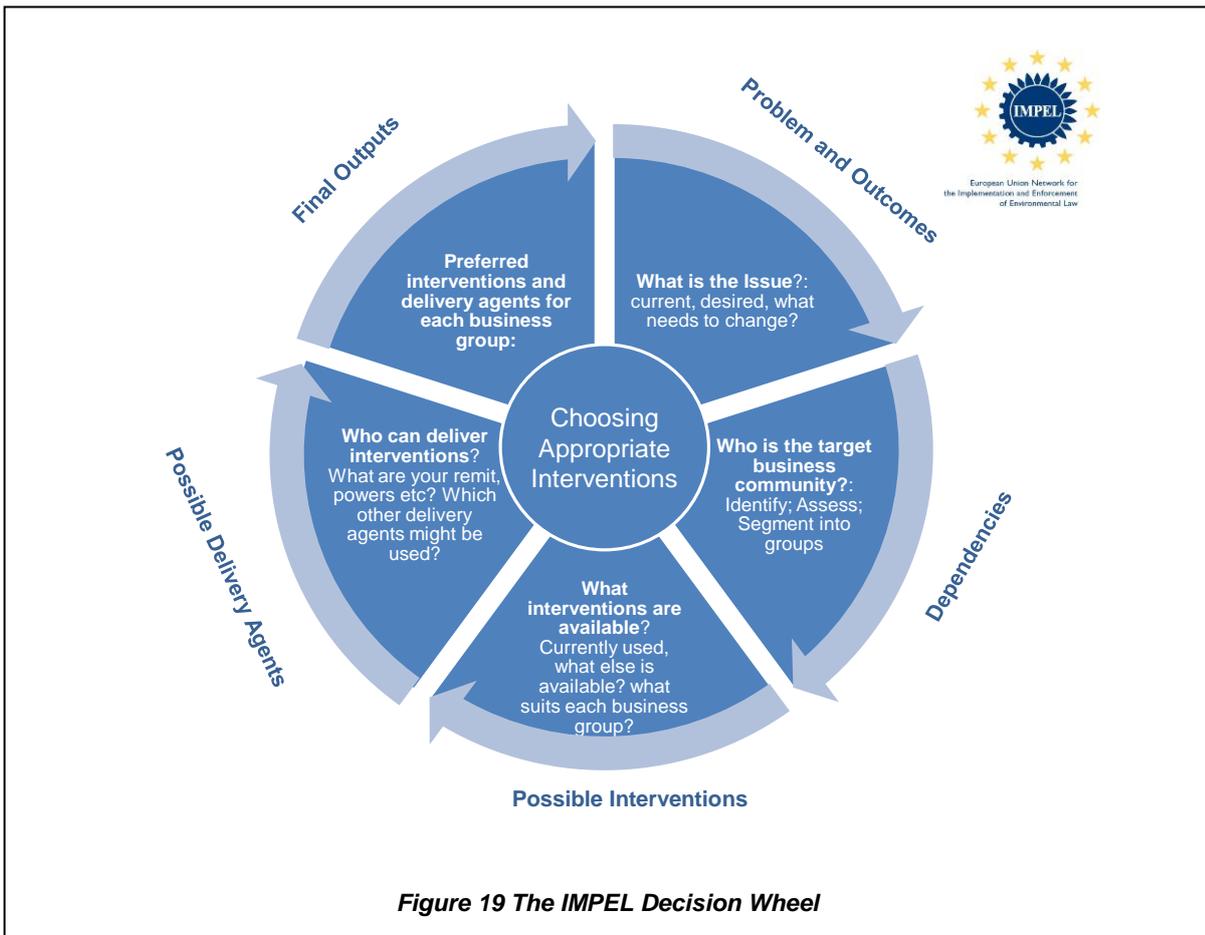


IMPEL PROJECTS ON “COMPLEMENTARY APPROACHES” AND “CHOOSING INTERVENTIONS”

As well as listing numerous interventions, these two IMPEL projects have attempted to explain the influencing factors or attributes that pertain to particular decision contexts. For example IMPEL project on “complementary approaches” (IMPEL, 2012) set out attributes related to the regulated as shown in figure 18 and set out a step by step process to help you choose appropriate interventions.



This IMPEL project also lists 25 or so interventions that have actually been applied by environmental regulators worldwide (not just those in the European IMPEL community) It provides a matrix in annex 9 which sets out what “business driver” each intervention aligns with to motivate improved environmental performance of business. The subsequent IMPEL project on choosing interventions (IMPEL, 2013) sets out a helpful process to identify the context and the kind of questions that need to be addressed when deciding the best solution for that issue. See figure 19.



Having recognised that there are a range of interventions and a range of different contexts, the latter IMPEL project recognised that what we need most of all is some guidance of applicability and strength of application. In other words a relationship is needed to be specified between the attributes, context and appropriateness of interventions. In phase 2 of that project they tested dependency analysis as a means of guiding intervention choice according to circumstances. In phase 3 they refined a particular dependency analysis tool (*iDEPEND*) to be specifically applicable to IMPEL’s needs and IMPEL have subsequently bought a licence and made that tool available to all IMPEL members.

Further information on dependency analysis and (*iDEPEND*) is given in chapter 7 and appendix 1.

In these days there is always another consideration and that is cost effectiveness with scarce resources – value for money. This has been extensively developed in the economic literature and a much used tool is the classic Multi Criteria decision making approach which is discussed in chapter 7.

DEFRA'S DRAFT INSTRUMENT SELECTION GUIDANCE FOR POLICY MAKERS AND REGULATORS

This guidance (Defra, 2013) is designed to help policy makers and regulators think of ways to influence business behaviour to achieve environmental objectives. It lists 20 different ways to influence business behaviour which are each described and compared. It includes step-by-step discussion questions to help think through options. There are cross-cutting themes to help think through effective implementation and it provides links to examples and more detailed sources. Figure 14 in chapter 4 above lists 20 interventions, figure 20 below indicates where each class of intervention might be used and figure 3 in chapter 2 shows how interventions can influence business behaviour and which actors / stakeholders can exert that influence.

The main types of instrument					
Type of instrument used or supported	Ways government can influence business behaviour	Types of risk to target	Effectiveness	Costs and efficiency	Industry suitability
1: DIRECT "COMMAND AND CONTROL" REGULATION	Require businesses to comply with rules, enforced with sanctions.	Target at highest impact risks. H	Relatively high, if enforced.	Relatively costly to government and business. Typically less flexible for businesses.	Widely used. Enforcement more difficult for multiple small businesses.
2: ECONOMIC INSTRUMENTS	Change economic incentives for businesses.	Can be targeted at major risks. M	Relatively high, outcome less certain than direct regulation.	Can be costly to businesses and government. Allow greater flexibility to businesses.	Widely used. Typically target specific products or emissions (e.g. waste to landfill, water use).
3: CO-REGULATION	Negotiate with a group of businesses to agree targets to be achieved.	Typically targeted at lower risks. M/L	More likely to be effective if participation provides business advantage (e.g. reduced costs, more sales).	Typically lower cost to government than direct regulation but can still be costly for businesses. Afford greater flexibility.	Easier where industry has capacity to coordinate own activities. Large businesses typically easier to engage than small businesses.
4: INFORMATION BASED INSTRUMENTS	Provide better information to customers and other stakeholders.	Typically targeted at lower risks. M/L	Less certain; dependent on environmental concern of customers/ consumers.	Lower cost to government.	Customers / consumers need to prefer products with better environmental performance.
5: CIVIC AND SELF-REGULATION	Promote or reinforce other social influences on good environmental performance.	Typically supported by government for lower risks. Can be useful for exploring new or poorly understood problems. M/L	More likely to be effective where better environmental performance provides business advantage (e.g. reduced costs, more sales).	Typically zero/ low cost to government but can still be costly for businesses. Afford greater flexibility.	Dependent on presence/ strength of influence of external stakeholders.
6: SUPPORT AND CAPACITY BUILDING	Improve knowledge and skills of businesses to promote better practices or better technology.	Typically target R&D resources at highest priority risks. H	Difficult to predict and measure, with some failures likely.	Costs can be significant e.g. for demonstration projects.	Used for many industries.

Find out more: [SNIFFER30: 2 - Choose and Design Interventions](#)

Figure 20 – DEFRA's Instrument Selection Guide

THE ENVIRONMENT AGENCY'S "TOOLKIT FOR HIGH RISK SITES".

The Environment Agency has a toolkit for high risk sites developed by their "Evidence Delivery" section. This gives examples and case studies. High Risk sites are usually those with D, E or F OPRA scores for example. There is no published information on this, but the Environment Agency have promised to provide information on the method to SEPA.

ENVIRONMENT AGENCY'S INTERVENTIONS STRATEGY AT HINKLEY POINT

In 2013, as part of the 3rd phase of the above IMPEL project the Environment Agency tested out the *iDEPEND* tool to help develop an interventions strategy for the waste disposal aspects of the nuclear new-build project at Hinkley point. A facilitated workshop was used to utilise the experience and views of a number of EA staff and a representative of the power company. Dependency analysis models were built that indicated which aspects (dependencies) were preventing achievement of the goal of compliance. The team then considered what the most likely interventions to address those dependencies were. The dependency model was run again to give an updated forecast of how this would improve the chances of achieving compliance.

An example of the “before interventions” and “after interventions” model outputs are shown in figures 21 and 22. Please note these plots were produced for illustrative purposes for the IMPEL triennial conference in 2013 and are not meant to represent actual circumstances.

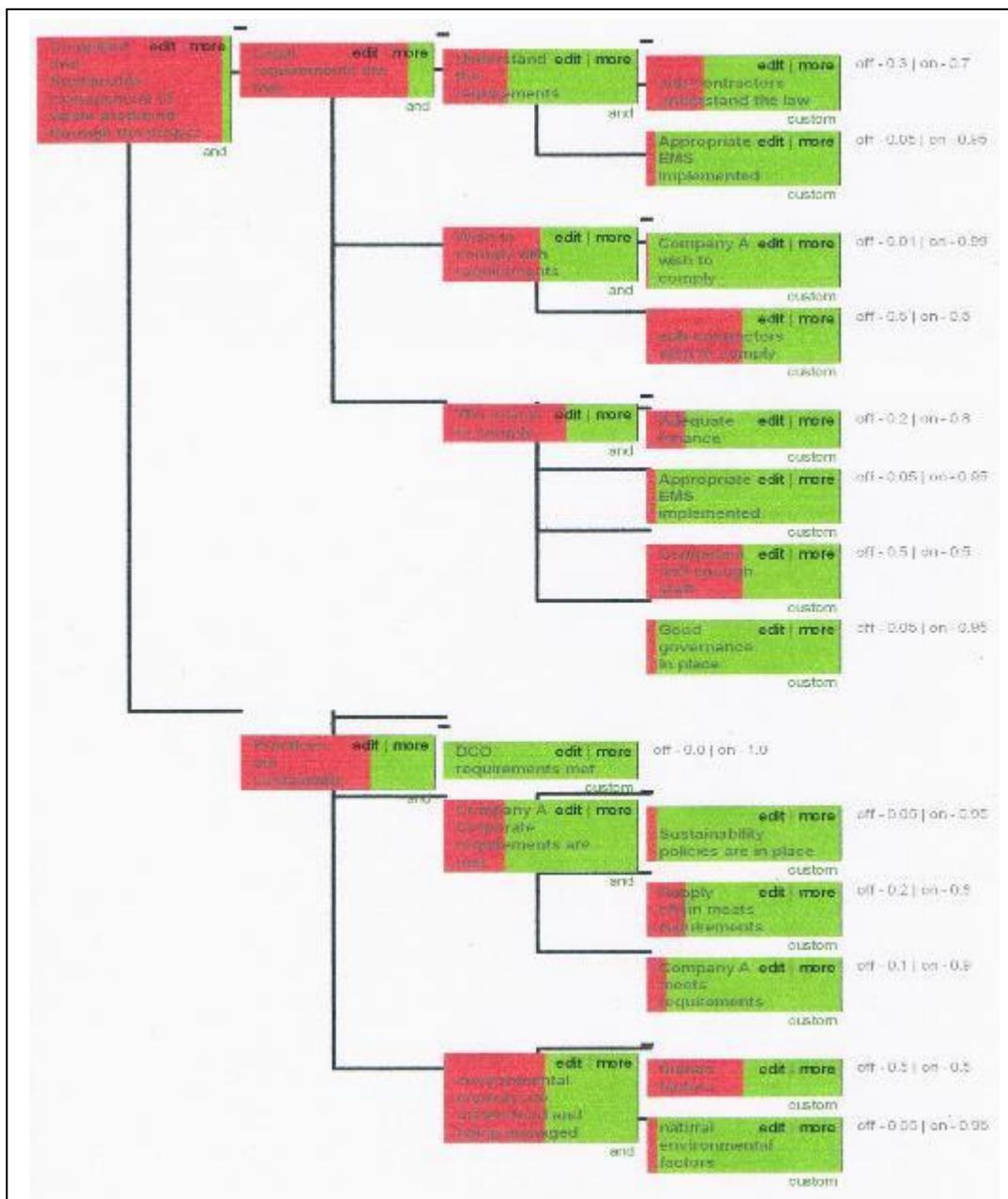


Figure 21. Example model on *iDEPEND* without interventions. Showing low likelihood (in green) of achieving the objective

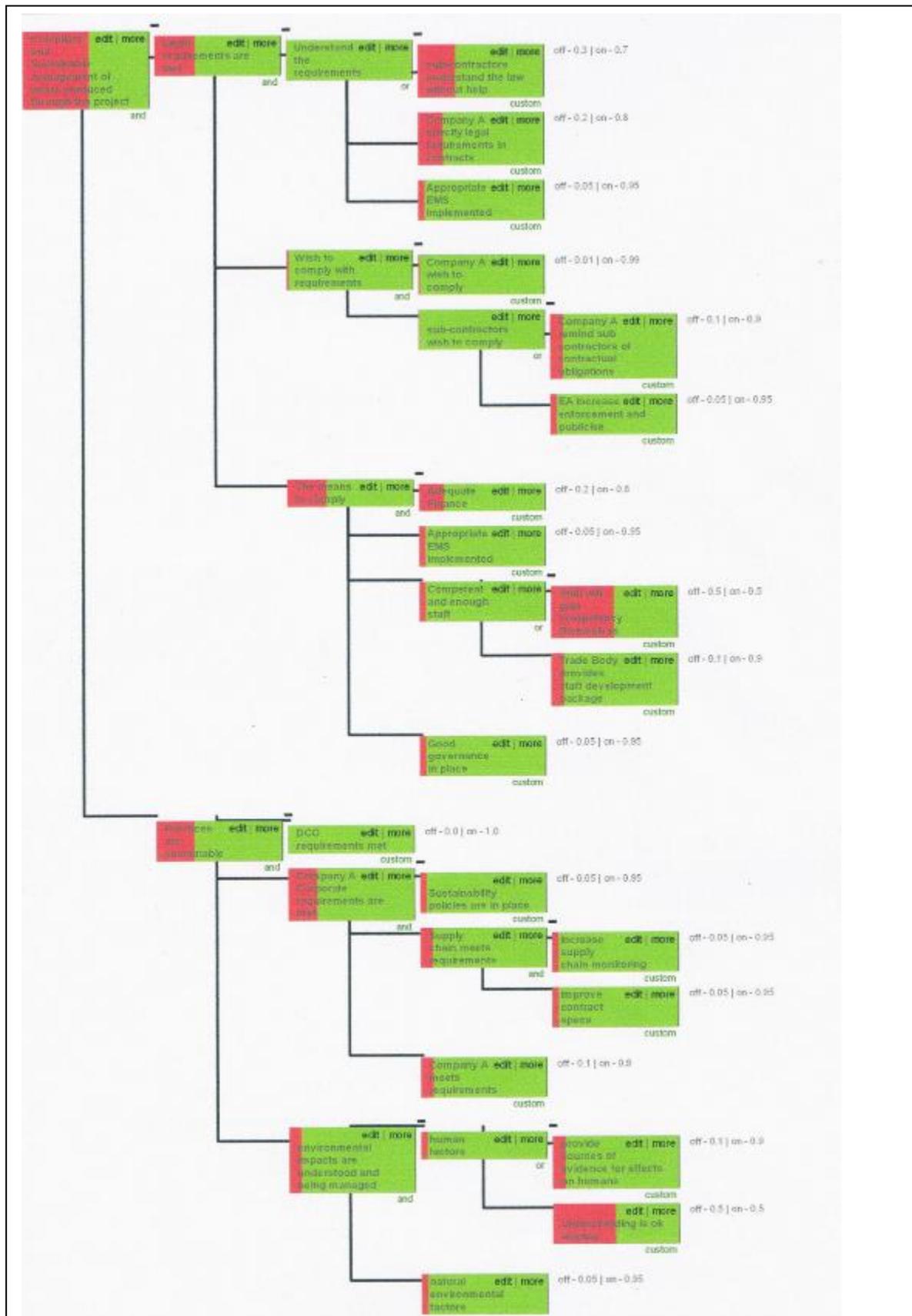


Figure.22 - Example model on iDEPEND with interventions. Showing higher likelihood (in green) of achieving the objective

6. STRATEGIES FOR MANAGING COMPLIANCE AND PREVENTING HARM

As discussed above, there are a number of interventions that can be used to manage compliance and prevent harm and there are some systems and tools which help you decide on what is/are the best intervention(s) for particular circumstances. However, in practice it seems that environment ministries and regulators rarely have detailed tools and guidance for this specific purposes. Nevertheless many regulators do have some higher level “compliance policies” which contain elements of the above. Some good well developed examples of these are discussed below.

VICTORIA ENVIRONMENT PROTECTION AUTHORITY IN AUSTRALIA

Victoria EPA’s Compliance and Enforcement Policy sets out a regulatory model and regulatory approach. The EPA undertakes a range of activities to achieve compliance in what they call “a balanced regulatory approach with a mix of compulsory and voluntary methods”. These are broken down into 5 categories of interventions, 4 of which are to encourage / support compliance to prevent offences and harm occurring as well as the enforcement category to address non-compliance. It is summarised in the Figure 23.



However there does not appear to be a structured decision making process for choosing an intervention or bundle of interventions for particular circumstances.

Once an offence has occurred then there is a more structured approach to enforcement action according to the culpability of the offender and harm to the environment. However, there is no mention of a higher level strategic decision making process to put in place a range of measures to reducing incentives for offending or by addressing the vulnerabilities which led to the offence in the first place.

BRITISH COLUMBIA MINISTRY OF ENVIRONMENT IN CANADA

The Ministry first developed a Compliance Management Framework (British Columbia Ministry of Environment , 2007) about 10 years ago, and it has since been reviewed and elaborated and in 2014 the Ministry published quite a comprehensive policy and procedure which includes a number of “tools for addressing non-compliance” and a list and description of such tools is provided (British Columbia Ministry of Environment , 2014).

The aim of the policy is expressed as “use of a variety of compliance tools, giving consideration to using the most appropriate tool necessary to obtain compliance, and when required, to promote general deterrence”. A non-compliance decision matrix is provided to help that process and is shown in figure 24. This does go some way towards supporting a regulators decision over choice of interventions and includes the choice of pro-active tools to prevent non-compliance and environmental harm.

In practice though “choices made for dealing with compliance management are somewhat affected by the capacity you have: resources available and sometimes the particular experience and skill you have and changes in organisation and changes in leadership” and “in any guidance about choices that we make we don’t want to be too prescriptive and take away discretion from officers. To be able to choose most appropriate action is often a subtle issue requiring officer understanding of the case in question” (Marty Roberts, 2016).

		ESCALATING ENVIRONMENTAL, HUMAN HEALTH OR SAFETY (ACTUAL OR POTENTIAL)				
		LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
DIMINISHING LIKELIHOOD OF COMPLIANCE (COMPLIANCE HISTORY/WILLINGNESS AND CAPACITY TO COMPLY)	CATEGORY A (HIGH)	ADVISORY	ADVISORY - WARNING	WARNING - ORDER - ADMIN SANCTION - AP	ORDER - ADMIN SANCTION - AP - INVESTIGATION	
	CATEGORY B	ADVISORY - WARNING	WARNING - AP	ADMIN SANCTION - AP - INVESTIGATION		
	CATEGORY C	WARNING - AP	WARNING - ORDER			
	CATEGORY D	WARNING - ORDER - ADMIN SANCTION - AP	ADMIN SANCTION - AP - INVESTIGATION			
	CATEGORY E (LOW)	ORDER - ADMIN SANCTION - AP - INVESTIGATION				

Note: An investigation is always necessary prior to issuance of a ticket, recommendation of formal charges or use of restorative justice. Therefore these tools are not shown on the matrix. Depending on the outcome, an investigation could also contribute in the issuance of a warning, administrative sanction or penalty, or an order.

Figure 24 – Levels and Categories BC

REGULATORY APPROACHES AT LOW RISK SITES (SNIFFER ER13)

Although this SNIFFER project was aimed a low-risk sites it does more than support intervention choice. It also helpfully addresses a way of assessing the intensity of the recommended intervention as a function of the ability of the regulatees to respond (figure 25).

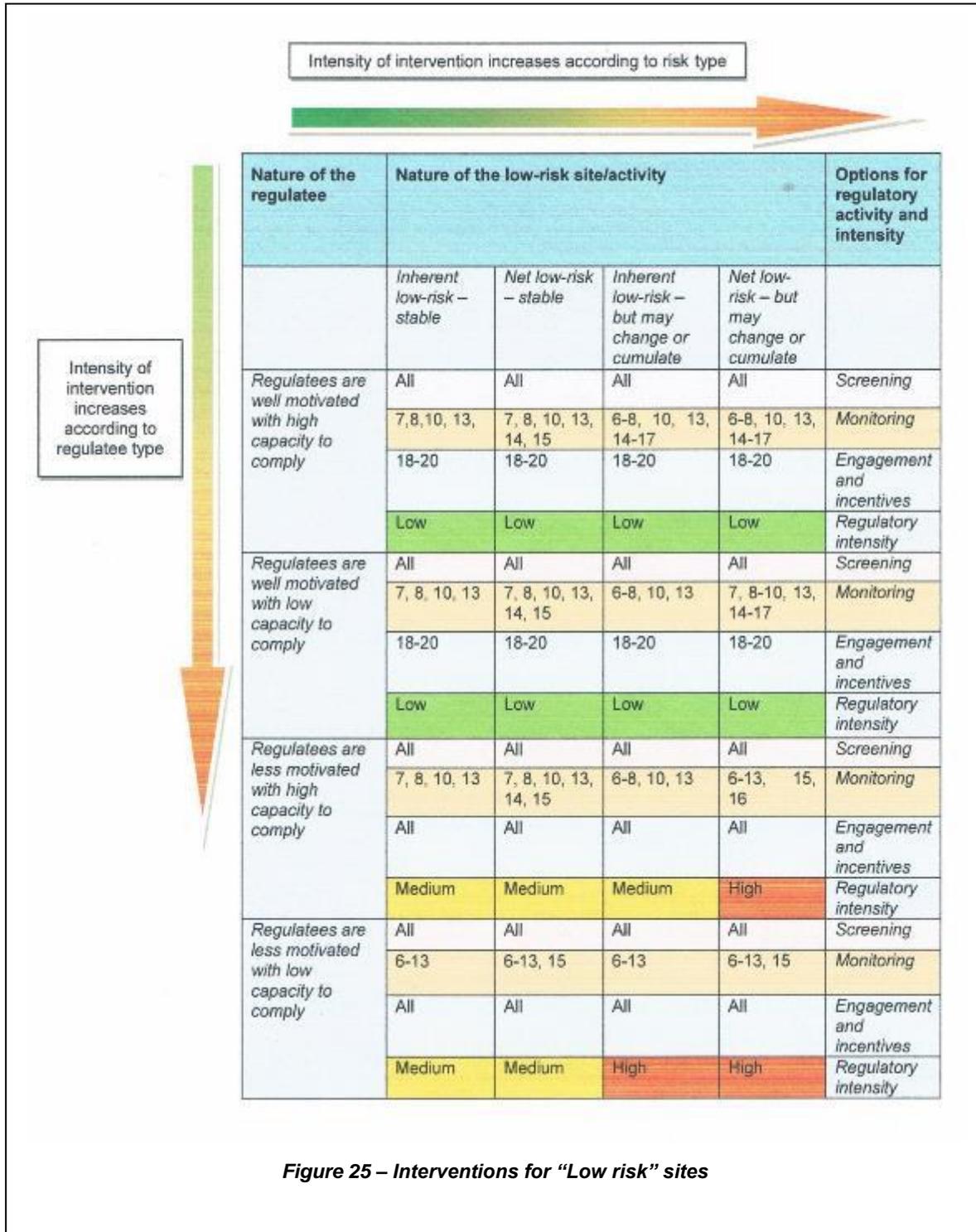
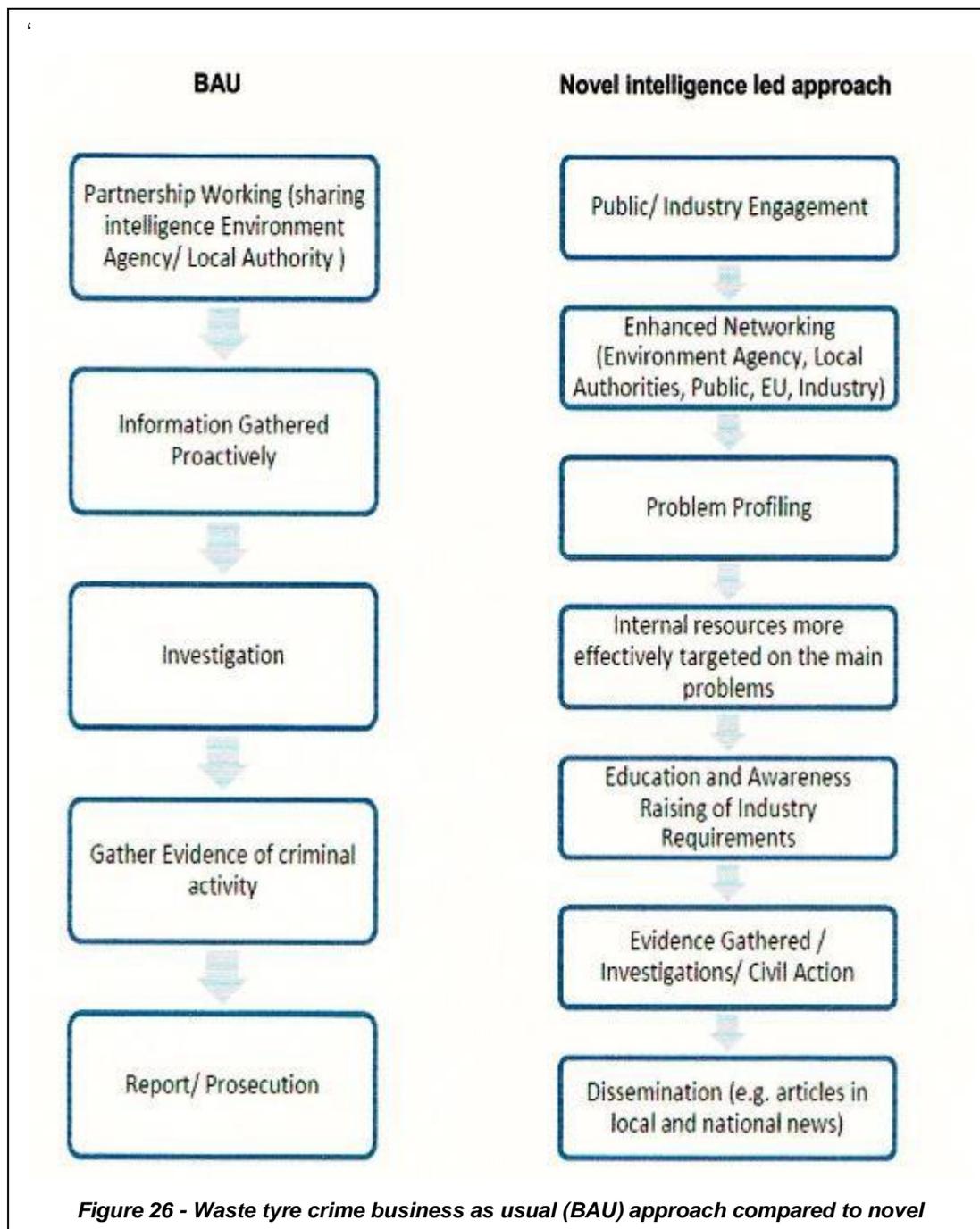


Figure 25 – Interventions for “Low risk” sites

INTELLIGENCE LED APPROACHES

The European Pathway to Zero Waste project (Environment Agency, 2012) developed a novel intelligence led approach for waste tyre crime as shown in figure 26. They also developed and tested some novel interventions specifically for waste which are listed in chapter 4.



7. DECISION MAKING AND DECISION SUPPORT TOOLS

There are a number of interventions that can be used to manage compliance and prevent harm and there are some systems and tools which help you decide on what interventions to use in different circumstances and how to build a framework of interventions and actors to address specific problems in a structured way.

But then it another problem entirely to estimate whether any one tool or combination of tools is might be most successful and even more complicated to assimilate a combination of tools which are just right for each particular scenario. These later stages are where you might need decision support tools to help you in the several different types of decisions you need to make for example:

- How to act? (what interventions to use)
- Where to act? (which are the targets for each intervention)
- where to use new interventions
- when to use other actors

For the purposes of this review we are not examining here the decision making on things like

- what do you want to achieve?
- how much resource to apply
- prioritisation of resources on one site / activity / area compared to another,

Most of the decision-making systems in the literature examined might be applicable to wider business decision-making of a regulator or government department. They address issues such as resource needs or cost benefits of policies or priority of (say) addressing any one particular non-compliance / harm scenario compared to another. Few of them address the different types of decision-making needed for this project, in particular decisions about:

- the objectives you wish to achieve (e.g. compliance and/or environmental outcomes);
- the people / organisations contributing to the non/achievement of objective
- the target of any interventions (deciding who is/are the target(s) maybe advised by waste flow intelligence and deciding what factors/issues related to the target are relevant (behavioural, regulatory, economic etc.) maybe advised by incentives for illegal and legal behaviour);
- the actors who might deliver the interventions (which is a factor of things like their powers, capabilities, resources and willingness to act); and finally
- the specific interventions and the actors who will deliver them.

The exceptions are problem solving techniques (Dorp V. , 2014) and dependency analysis (Giddens).

This staged approach to decision making and the multifactorial element of each is more like problem solving and so you need to consider some problem solving techniques. For example Rob Van Dorp in his paper makes reference to Prisma analysis, historical analysis. And process analysis.

MULTI-CRITERIA ANALYSIS AND MULTI-CRITERIA DECISION ANALYSIS

A widely used approach to deciding between different options is to set a number of selection criteria and assign notional scoring of extent to which agreed essential attributes meet these criteria. SEPA has trialled such a technique in a recent report. A literature review of such techniques was done by CREW as a precursor to choosing a software tool to carry out the trial. This is such a useful overview, that we have quoted much of their comments below.

“Every decision we take requires the balancing of multiple factors (i.e. criteria). Advantages of using multi-criteria analysis (MCA) over informal judgement unsupported by analysis includes: the group’s choice of objectives and criteria are open to analysis and to change if decided later they were inappropriate; the scores and weights are explicit and developed based on tried and tested techniques; the scores and weights used provide an audit trail; a wide range of experts can contribute; and it provides a means of communication within the decision making body and with wider communities (UK Government, 2009). Decision analysis has been suggested to be “a formalisation of common sense for decision problems that are too complex for informal use of common sense” (Keeney, 1982).

MCA differs from cost benefit assessment (CBA) in that CBA seeks to value the expected impacts of an option in monetary terms, which are based on well-developed economic theory of valuations based on willingness to pay or accept. MCA generates preferences between options (also called alternatives) by reference to an explicit set of objectives and a corresponding set of established measurable criteria to assess how well these objectives have been met. They can be used to identify a single most preferred option, rank options, to short list a limited number of options for subsequent detailed assessment or to identify acceptable and unacceptable options. There are a wide range of MCA techniques since there are different types of decisions that are addressed, the time, data and analytical skills available to support the analysis may differ, and the administrative culture and requirements of the decision-making organisation can vary. Criteria for selecting a particular MCA technique can include: ease of use; software availability, where needed; internal consistency and logical soundness; transparency; data requirements consistent with the importance of the issue being considered; realistic time and manpower requirements for the analysis process; and ability to provide an audit trail (UK Government, 2009).

Multi-criteria decision analysis, or MCDA for short, is a form of MCA that has found a wide range of applications in both public and private sector organisations. MCDA is an approach and a set of techniques with the aim to provide an ordering of options. One of the primary aims of MCDA approaches is to enable decision makers to learn about the problem faced, and the priorities, values and objectives of those involved and to organise and synthesize information so that they can make decisions and minimise post-decision regret by taking into account all of the important factors. MCDA is “an umbrella term to describe a collection of formal approaches which seek to take account of multiple criteria in helping individuals or groups explore decisions that matter” (Belton, 2002) dispel three myths about MCDA: that it will provide the ‘right’ answer; it provides ‘objective’ analysis which relieves decision makers of the responsibility of taking difficult decision; and it takes the pain out of decision making. MCDA is an aid to decision making that provides a process that aims to “integrate objective measurements with value judgements” and “make explicit and manage subjectivity” (Belton, 2002) The primary aim of MCDA is to enable decision makers to learn about the problem faced, and the priorities, values and objectives of those involved to help identify a preferred

approach and solution (Belton and Stewart, 2002). The main stages in MCDA are identification of the issue or problem, problem structuring, building the model, then using the model to inform and challenge thinking, and finally to determine a plan of action (Belton and Stewart, 2002). In their book Belton and Stewart (2002) highlighted that the traditional way of using MCDA techniques in isolation needed to be improved and MCDA to be seen in a more integrated way e.g. greater integration with other problem structuring and decision evaluation methods.

There are three broad categories of approaches to MCDA: value measurement models; goal, aspiration or reference level models; and outranking models (Belton and Stewart, 2002). Value measurement models are based on developing numerical scores for each criterion and aggregating these to identify preferred options. In goal, aspiration and reference level models the process tries to identify options that are likely to result in these goals or aspirations which have been identified for each of the criteria. Outranking models compare pairwise alternatives based on each criterion to assess the overall strength of one alternative course of action over another. Belton and Stewart (Belton, 2002) stress that if MCDA is to have a real impact on practical decision making then analysts need to gain expertise in the wider process that includes problem structuring. Decision making occurs at the border of several disciplines and uses concepts and methods from psychology, economics, decision analysis, biology, ecological science, engineering, management science, facilitation and negotiation analysis. The value of decision analysis is in challenging initial gut feelings.

- **STRENGTHS:** MCDA has been demonstrated to improve decision making than more traditional meetings. It is widely used in government and commercial settings.
- **WEAKNESSES:** There is a range of techniques for scoring and weighting the criteria. Computer software is required to carry out the mathematical calculations, and participants need to have confidence it is representing their input transparently.

The Multi-criteria Mapping 'process' is based around a software application that is well designed and supported. A free trial (60 days) can be started in less than two minutes. The web based application contains a worked example and pop-up help boxes at each stage of the process. A detailed PDF manual is available (via FAQ page) that sets out the values and aims, as well as guiding a facilitator/interviewer through setting up and carrying a Multi-criteria Mapping 'process'.

What does a Multi-criteria mapping 'process' involve? The overarching purpose is to represent as authentically as possible a range of different appraisals, conducted from diverse perspectives, concerning the best ways to achieve some broadly shared focal goal. In other words, the aim of Multi-criteria mapping is to explore the ways in which different pictures of strategic choices change, depending on the view that is taken –not to prescribe a particular 'best choice'. One consequence of this 'heuristic' approach is that (unlike some other multi-criteria analysis techniques), the qualitative information elicited in a Multi-criteria Mapping engagement is (if anything) more important than the quantitative information.

The Multi-criteria mapping process involves five basic steps: select options;

- define criteria;
- assess scores;
- assign weights; and

- review ranks.

It is important the participant is in the driving seat and facilitators and interviewers ensure they are open, sensitive and neutral.

There are three main parts to a Multi-criteria Mapping process. These are planning and designing the appraisal, carrying out the interviews/engagements with participants, and analysis and reporting back. Interviews/engagements are arranged with the identified participants, either individually or in small homogeneous groups (2-3 hours per interview/engagement). The aim of the structure is to enable consistent and fair comparison of the options across all the perspectives of the participants.

- Planning and designing an appraisal - defining the focal goal and core options, and recruiting participants are all interdependent.
- Interviews/engagements - the interviewer/facilitator guides participants through: selection options; define criteria; assess scores; assign weights; and review ranks of options.
- Analysis and reporting back - the interviewer/facilitator then reviews and analyses the qualitative and quantitative information collected from each of the engagements/interviews.

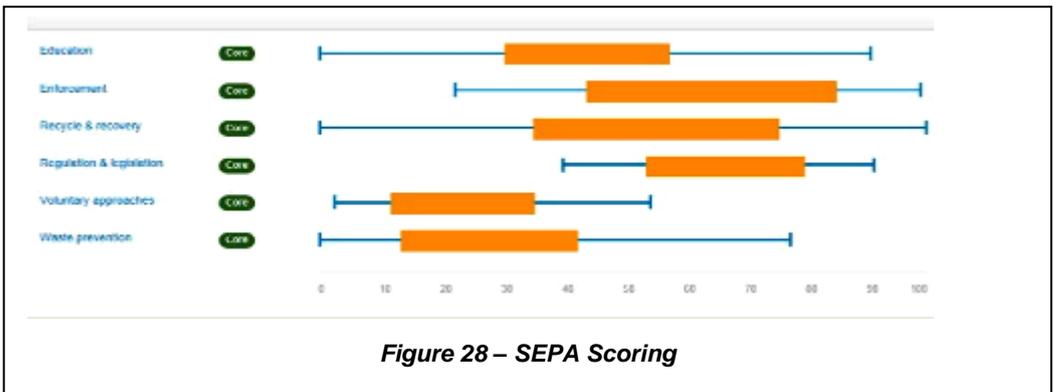
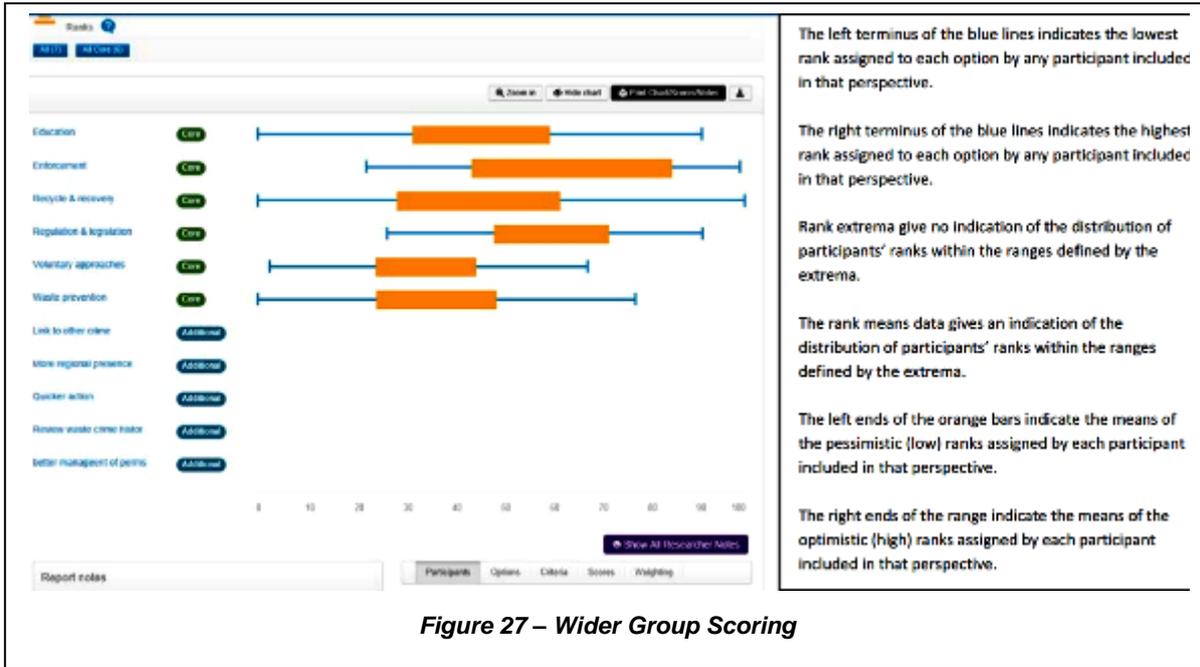
Information on the Multi-criteria mapping 'process' and web based application can be found here <http://www.multicriteriamapping.com/>"

The report prepared very recently for SEPA (SEPA, 2015) documented a trial of Multi-criteria mapping (MCM) process and software, using MCM to assess the most effective interventions for combating or reducing waste related crime. One of the key findings (see exec summary on page 1) is: "*Multi-criteria mapping will be trialled by SEPA in collaboration with the EU LIFE SMART Waste Project (LIFE 13 ENV/UK/00549) Smarter Regulation of Waste in Europe, and this will be reported separately.*"

The main messages from the analysis are:

- A) Enforcement is still seen as the most effective type of intervention.
- B) Novel, intelligence based approaches should be considered.
- C) There are divergent views on the value of waste prevention, recycling and recovery measures. Participant comments shed light on the reasoning behind this dissimilarity and suggest that there is scepticism about the likelihood of reducing waste crime practices currently in operation.
- D) People in SEPA may not be focusing on costs when considering how to assess effectiveness of measures. This will have implications for the type of data collected and an understanding of this could help to overcome some of the barriers to better data collection in the organisation.

Figures 27 and 28 below demonstrate the outputs of using MCM in this context.



MULTI CRITERIA/ ATTRIBUTE UTILITY TECHNIQUES

It has been pointed out, and Keeney (1992) subsequently elaborated, that decisions are made to realise objectives, but that objectives often conflict. How to deal with that conflict is the subject of multi-criteria decision analysis. The approach is particularly attractive because it accommodates consequences that are both uncertain and appraised differently depending on the criteria considered.)

Keeney's Axiomatic Foundations of Decision Analysis

Keeney articulates 4 sets of axioms of decision analysis (Keeney 1992) as below:

Axiom 1 - Generation of Alternatives. At least two alternatives can be specified.

- **Identification of Consequences.** Possible consequences of each alternative can be identified.

Axiom 2 Quantification of Judgment. The relative likelihoods (i.e. probabilities) of each possible consequence that could result from each alternative can be specified.

Axiom 3 Quantification of Preferences. The relative desirability (i.e. utility) for all possible consequences of any alternative can be specified.

Axiom 4 Comparison of alternatives. If two alternatives would each result in the same two possible consequences, the alternative yielding the higher chance of the preferred consequence is preferred.

UTILITY AND ECONOMICS

Some more direct analyses of regulatory behaviour have even suggested that the only real way of influencing the players is to address the economics of compliance.

Braithwaite (Braithwaite) suggests a Utility Function which cynically postulates that the only decision made is balancing the certain cost (saved?) of compliance, versus the likelihood of cost of sanction.

$$U > p \times D$$

(U= cost of Compliance, p the probability, and D the downside the cost, of getting caught)

MULTI ATTRIBUTE RANKING

An early example of this methodology applied to regulatory interventions specifically, is the Compliance Theory approach developed from the OPRA (Operator Performance/ Risk Assessment) model (Slater D. H., 2000). Here the attributes are grouped into two orthogonal sets relating to the controls available to the regulator and the responsive behaviour of the regulatee community. These factors are then rated (on a scale of 1-5) and weighted as shown below:-

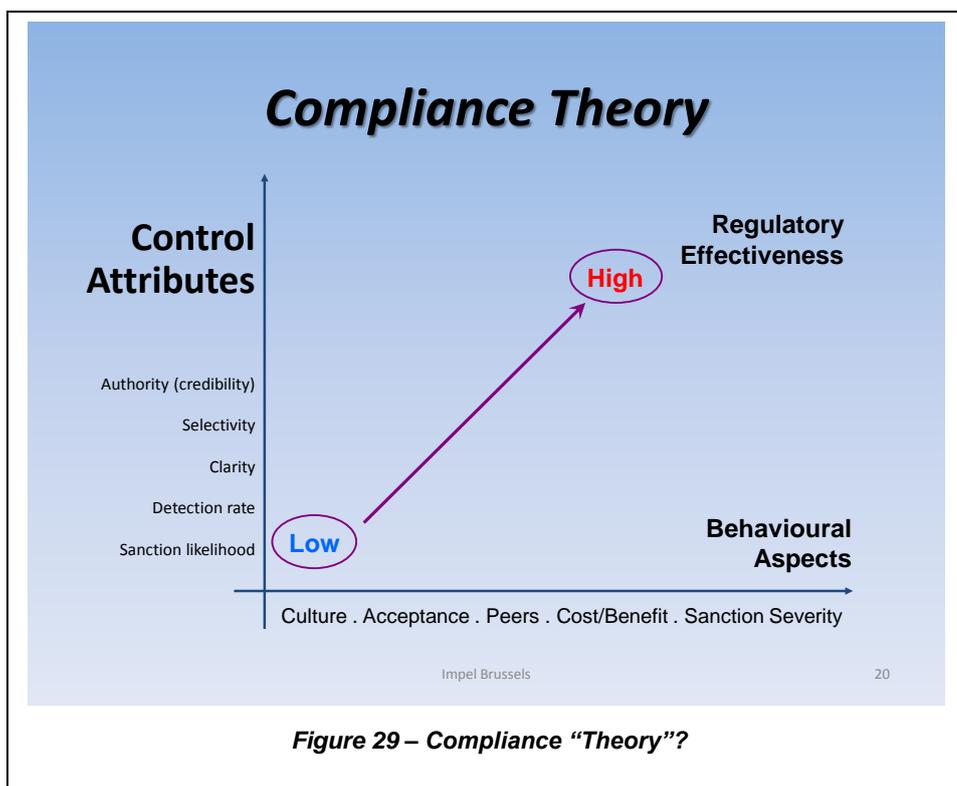
1. **Control dimension** (Credibility of Enforcement?)
 - 1.1 **Authority** - Quality of the rule maker (Perceived?) = (1-5) x 10
 - 1.2 **Sanction Likelihood** - (Probability of penalty) = (1-5) x 4
 - 1.3 **Detection rate** - (probability of being found out) = (1-5) x 3
 - 1.4 **Clarity** - (Practicality of regulations) = (1-5) x 2
 - 1.5 **Selectivity** - (Effectiveness and focus of inspection) = (1-5) x 1

2. **Behavioural aspects**
 - 2.1 **Culture** - (Innate willingness to comply) = (1-5) x 10
 - 2.2 **Sanction - Severity** (impact on viability, reputation) = (1-5) x 4
 - 2.3 **Cost benefit** - (Advantages vs. Disadvantages) = (1-5) x 3
 - 2.4 **Peer Pressure** - (Disapproval of non-compliance) = (1-5) x 2
 - 2.5 **Acceptance** - (Recognition of need, legitimacy) = (1-5) x 1

Plot Sum (1.1-1.5) divided by 10 **on y – axis**

Plot Sum(2.1-2.5) divided by 10 **on x – axis**

The resulting effectiveness is read from a Graph as shown in figure 29 (analogous to risk ranking).



Similar approaches can be seen in the identification and ranking of attributes in the Dutch T11 approach (Dorp V. , 2014) and the EBRD “Chain of Factors” (EBRD, 1994) and an attempt to organise and utilise their effectiveness was proposed along similar lines (Slater D. H., 2000)..

The EBRD Compliance ‘chain’ of factors are:

- **A** uthority – Quality of the rule maker
- **B** ehaviour – Tendencies in groups and individuals
- **C** ontrols – Effect of supervision and enforcement
- **D** istortions – Inequities within systems
- **E** xternal Events – Impact of other demands or drivers

These attributes are then ranked as in the Table below

Table 1. Illustrative A2E priority ranking

Factor	Priority Groups	Preferred Response	Priority (= Marginal Cost)
<i>Authority</i>	Loyal/Disloyal	Negotiation	Low-Med
	Informed/Uninformed	Education	Low
<i>Behaviour</i>	Compliant/Non-compliant	Advertising	Low-Med
<i>Control</i>	Deterred/Undeterred	More/less tolerance	Med-High
<i>Distortions</i>	Prepared/Unprepared	Public/private initiatives	Med

And similarly the Dutch T11 attributes have been scored as below:-

The eleven Dutch dimensions are:

- Spontaneous compliance dimensions (absence of enforcement)
 - T1 – Knowledge of rules (familiarity of Target Group)
 - T2 – Cost benefit considerations (advantages and disadvantages of compliance)
 - T3 – Level of acceptance (in Target Group)
 - T4 – Normative commitment (innate discipline)
 - T5 – Informal control (loss of market, reputation etc. if caught)
- Control dimensions
 - T6 – Informal report probability (whistle-blowing)
 - T7 – Control probability (inspection frequency)
 - T8 – Decision probability (detection likelihood)
 - T9 – Selectivity (ability of regulator to pinpoint offenders)
- Sanctions dimensions
 - T10 – Sanction probability (likelihood of penalty)
 - T11 – Sanction security (type and scale of sanction)
- T Factors evaluated either by:
 - Strength/weakness evaluation by expert group
 - Extensive Target Group survey – scoring 1 – 5 for each “T”

(Source – Dick Ruimschotel and Burt Klaasen, Ministry of Justice, The Hague)

Most of these approaches have thus evolved into techniques which identify, weight and summarise semi-quantitatively (often graphically) how the values and importance of these different factors should be reflected in the decision taken.

In the past, these multi attribute methods have been mainly used for scoping decisions, for example on business strategy, or policy options, or both; and have been addressed primarily in the economics field and a number of variations of this approach have been formalised (Acronym-ed); and tools are available commercially to carry out these Multi Attribute (or Criteria) Utility Rankings as decision aids.

The Ministry of Defence uses such an (MCDA) (CATALYZE) approach for procurement processes (Equity 3), but historically the most extensive utilisation has been in trying to rate, rank and probe, alternative sites and technologies for the disposal of Radioactive Waste (e.g. Battelle’s MAUD (Battelle), multi-attribute utility decision tool).

The literature records a number of issues with the techniques, for example the MOD feels that major expenditure items such as aircraft carriers fared badly due to an “unrevealed” bias against large expenditures. This inability to model subtle and interdependent influences and the problems of tweaking and updating models as better data becomes available, is also an issue. But the main criticism is generally that they are inevitably totally subjective and highly dependent on the quality and experience of contributing experts. In software terms this is the classic “Garbage in, Garbage out” scenario.

The most important challenge then is to obtain sufficient justification and validation of the extent of various influences and the values of the weights and decision criteria chosen.

Thus most of these approaches rely on a facilitated group session to assign and justify from experience, the models and data employed in these empirical approaches

The problems arise when there is insufficient or unreliable data on which to base the ranking process. This requires making decisions under uncertainty, a process that “real” (human) intelligence has had to adapt to. In the past, these decisions, for example on business strategy, or policy options, or both, have been addressed primarily in the economics field where utility theory and cost effectiveness are typical tools for choosing preferred outcomes.

Similarly the scoring of options is very subjective, making it difficult to get consistency of application between different user groups.

A number of these Multi Attribute (or Criteria) Decision Analysis Techniques (MCDA) are available as software packages which can be used to facilitate and record the outcomes of these group sessions and shown in the Table below.

Software	Supported MCDA Methods	Pairwise Comparison	Sensitivity Analysis	Group Evaluation	Web-based	
1000Minds	PAPRIKA	Yes	Yes	Yes	Yes	[5]
Ahoona	WSM , Utility	No	No	Yes	Yes	[11] 1
Altova MetaTeam	WSM	No	No	Yes	Yes	[cit ati on ne ed ed]
Analytica		No	Yes	No	Yes	[5]
Criterium DecisionPlus	AHP , SMART	Yes	Yes	No	No	[cit ati on ne ed ed]
D-Sight	PROMETHEE , UTILITY	Yes	Yes	Yes	Yes	[5]
DecideIT	MAUT	Yes	Yes	Yes	Yes	[5]
Decision Lens	AHP , ANP	Yes	Yes	Yes	Yes	[cit ati on ne ed ed]
Super Decisions	AHP , Analytic Network Process	Yes	Yes	No	Yes	[12] [1] 2]
Expert Choice	AHP	Yes	Yes	Yes	Yes	[5]

Software	Supported MCDA Methods	Pairwise Comparison	Sensitivity Analysis	Group Evaluation	Web-based	
Hiview3	Equity 3	No	Yes	Yes	No	[5]
Intelligent Decision System	Evidential Reasoning Approach , Bayesian Inference , Dempster–Shafer theory , Utility	Yes	Yes	Yes	Available on request	[5]
Logical Decisions	AHP	Yes	Yes	Yes	No	[5]
M-MACBETH	MACBETH	Yes	Yes	Yes	No	[10] [11] [3]
PriEsT	AHP	Yes	Yes	No	No	[14] 1
WISED	MACBETH	Yes	Yes	Yes	Yes	[10] [11] [5]

MACBETH is an interactive approach that requires only qualitative judgements about differences to help a decision maker or a decision-advising group quantify the relative attractiveness of options. It employs an initial, interactive, questioning procedure that compares two elements at a time, requesting only a qualitative preference judgement.

The Catalyze products, Hiview and Equity are both based on the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) approach to multi-criteria decision analysis, the subject of Keeney and Raiffa's 1976 classic book. In that book, the authors extended the axioms of decision theory, which lead to the expected utility model, to provide for consequences characterised by multiple criteria

It is particularly suited and useful in choosing between costed options on a project and the pictorial presentation of relationships between attributes (HIVIEW) and the automatic processing of scoring and automatic assignment of weights makes it very helpful in facilitating group sessions.

This process is much the same for all these multi-criteria applications; they nearly all use the simple additive model.

That is - Scores are multiplied by weights and the products summed.

In other words, the scores assigned to the consequence of an option on all the criteria are multiplied by the respective weights assigned to the criteria and those products summed across all the criteria.

MORE INTELLIGENT CHOICES

One of the options in the above Table, (**Intelligent Decisions System**), however, introduces a more structured way of deriving and including “evidence” of the importance of the various factors involved. This **Evidential Reasoning Approach** utilises two important ideas, which

give a mathematically sound way to deal with uncertainty, using, not plain stochastic statistical probabilities, but Bayesian “conditional” probabilities. This has been developed further into the Dempster Schaefer approach now widely used to reconcile multisensory real time information into most probable or reliable estimates of reality. Software packages that can be used include Genie, iDepend and Tesla.

Of these, we have found the Open Group’s Dependency Modelling approach (al., 2012) the most useful for aiding decision making on the sensitivity of achieving successful outcomes of a range of similar situations. It is also well suited to facilitating the kind of expert group session, traditionally employed for these studies.

This methodology has been demonstrated developed and applied successfully in the recent IMPEL Project (al. C. B., 2014). We are not aware of any other studies which have utilised Dependency modelling in regulatory applications.

BAYESIAN LOGIC AND IDEPEND

Choosing between these possible interventions requires an objective and transparent way of predicting their effectiveness in particular applications (not just an overall ranking of attributes!). But because of the uncertainty there needs to be some indication of the confidence we have in any ranking of alternative options. Thus a “probability” of outcome is a more honest appraisal than a ranking order. Further the use of Bayesian “conditional probability” approach would allow the formal utilisation of any evidence we have of the factors influencing the overall effectiveness in particular cases.

“Businesses and governments must often assess and manage risk in areas where there is little or no direct historical data to draw upon, or where relevant data is difficult to identify. For example, the Barings Bank collapse in 1995 was not due to credit or market risk, where banks have sufficient data for prediction and mitigation of risk, but rather it was due to what is now called operational risk – the results of failures in everyday operational processes. The challenges are similarly acute when the source of the risk is novel: terrorist attacks, ecological disasters, major project failures, and more general failures of novel systems, market-places and business models.”

(Fenton and Neil - MANAGING RISK IN THE MODERN WORLD - A Knowledge Transfer Report from the London Mathematical Society and the Knowledge Transfer Network for Industrial Mathematics (Neil, 2010))

In these situations pragmatism is perhaps more important than perfection. It is also necessary to have the perspicacity to contextualise/correct perception. It is particularly appropriate where value for scarce resource deployment needs to be transparent and justified. In Risk, as in most areas, you get what you pay for; but often the most important insights can be discerned at a fraction of the cost of full computational commitment. Perfection as the enemy of the good is a recurrent theme in academia, this paper presents a just enough, just in time development of a powerful, but less intimidating (to the non-mathematician) methodology, which gives value in effectiveness in the teeth of imperfection.

WHAT IS DEPENDENCY MODELLING

Dependency Modelling (DM) is thus a practitioners’ practical implementation / development of Bayesian Networks – a methodology for understanding, communicating and measuring

the **risks** to an **endeavour**. Here **endeavour** means any of a wide variety of entities. It could be an enterprise, venture, undertaking, government, campaign, machine, system or process. It might be the security of an establishment; the success of a military campaign; the effectiveness of a communications system; the reliability of a supply chain or the preservation of a reputation. It could in fact be anything for which a suitable model can be built.

HOW IT WORKS - RISK AND GOALS

In DM terms, Risk has meaning only in relation to goals. A goal is typically the achievement or maintenance of some state of affairs and forms the basis for the evaluation of risk. In DM terms, an important measure of risk is as follows.

Risk is a measure of the chance that achieving the goal depends on things we cannot control, predict or perhaps even understand.

The user of the methodology first specifies a goal or purpose of the endeavour. He does this in a special way. Goals are abstract. For example we probably don't want an access control system for its own sake, but we may want to keep out the bad guys. The access control system is just a set-up introduced to help achieve the goal. We must not confuse ticking a box saying we've got an access control system with the achievement of our goal.

So our goal is an abstract, ideal state of affairs – in this case to keep out the bad guys. What is actually achieved may fall short of this, so we specify two or more possible outcomes or 'states' - such as 'failure and success', or 'failure, partial success and total success'. In state terms, our goal is that the outcome will turn out to be in the best 'state'.

The achievement of our goal will depend upon various entities. For instance the effectiveness of a communication system might depend upon the correct functioning of certain equipment, the availability of electrical power, the availability of sufficiently skilled personnel and so forth. Each of these dependencies is also an entity rather like our goal: it too is abstract and can be in any of several states. Each such dependency in turn has its own set of dependencies, and so forth.

In this way an abstract model is constructed graphically on a screen. The model has a tree-like structure, but one in which branches are allowed to re-merge whenever a common dependency between two branches occurs.

The user stops adding further dependencies whenever he or she feels it appropriate, determined by the depth of insight required. The dependencies at the point where he stops are referred to as 'givens' or 'uncontrollables' because the user is in effect accepting them as they are. These uncontrollables are on the boundary of the model where much of the risk creeps in.

The diagram forms among other things a graphical language to discuss and clarify issues concerned with risk.

TYPES OF DEPENDENCY RELATIONSHIP

The user also specifies the nature of each dependency. The relationship between an element and its immediate dependencies is a statistical one that can be described with a high degree of granularity. However there are two very simple relationships that occur with sufficient frequency to merit special attention.

For example the communication system mentioned earlier would require every single one of its dependencies to function in order for the goal to be achieved. We describe this as an AND relationship (because it requires this AND this AND this).

By contrast there are dependency relationships satisfied if even one dependency functions properly. An example is the availability of electrical power which depends on the correct functioning of either a generator OR a standby battery, either of which would suffice alone. This latter type we call an OR relationship.

Clearly **AND**-relationships increase risk while **OR**-relationships reduce it.

Importantly, these are just two, albeit common examples from a huge number of possible statistical relationships that can be specified in the model and which crucially are not limited to Boolean or even to binary values..

This 'top down' specification in terms of goals and requirements is more natural and satisfying than the alternative 'bottom up' method of trying to think what can go wrong. The latter is hampered by having far too many possible starting points. By systematically expanding a tree from root to branches, important dependencies are less likely to be missed.

The method also differs greatly from Fault-Tree Analysis (FTA) inasmuch as DM deals in goals and handles a rich set of statistical dependency relationships while FTA looks for failures and is limited to Boolean relationships. Anything that FTA could uncover is exposed by DM, but the converse is not true.

OUTPUTS

When the model is constructed it is possible to make a number of automatic statistical inferences such as:

- ⤴ the likelihood of achieving the goal;
- ⤴ the most likely causes for success or failure to achieve the goal;
- ⤴ those elements which are most critical to the goal;
- ⤴ the cost-effectiveness of each countermeasure;
- ⤴ the sensitivity of the likelihood to the accuracy of the statistics each of the uncontrollables;
- ⤴ those uncontrollables whose statistics are relatively unimportant since they are of low sensitivity.

If we paraphrase our earlier definition of Risk as *the sensitivity of the probability of achieving the goal to the statistics of each uncontrollable*, then this is a quantity that can be precisely measured and plotted, say as a bar chart, thereby clearly attributing the risk due to each uncontrollable in the model. Of course other measures of risk - such as Probability X Consequence - can also be automatically evaluated using the method, but is less intuitively satisfying.

Moreover risk, however measured, can be reduced by making a goal less dependent on any uncontrollable by for example introducing an OR relationship. By changing the model we can illustrate changes to risk and to the likelihood of achieving a goal.

It is not necessary to know the statistics of insensitive dependencies very accurately since the outcome is less dependent on them. By contrast those dependencies to which the outcome is highly dependent are the main sources of risk and they are automatically uncovered, and they are the ones that show the highest risk using our definition.

The *iDEPEND* software thus:

- **enables the quantitative “mind mapping” of these critical “dependencies”** to where they become “outside our control” and subject to the effects of the wider time/ space environment.
- It is **built on a proven methodology (Bayesian belief nets)**, which allows the status probabilities of these uncontrollables, to be estimated and inputted.
- Individual models can be linked across organisations and displayed as dynamic risk models.
- The tool is as easy to use/ modify/ update as a simple drag and drop visual display, through a web portal, producing, quantitatively rigorous reports on probabilities, sensitivities, etc. and the models can be left “live” as part of wider intersystem.

The way in which the IMPEL members wanted to use *iDEPEND* was to start with an objective that was something the regulator wanted to achieve such as full compliance or river quality meets “good” quality status. However, the tool can just as well be used with an objective of “intervention x is successful”. Models can then be built which show the circumstances (dependencies) that are needed for that intervention to work. If this is repeated for a suite of interventions, to create set of “templates” (one for each intervention as demonstrated in figure 33 in chapter 8). Then intervention choice can be supported by regulators estimating the extent to which those dependencies are met for their given scenario.

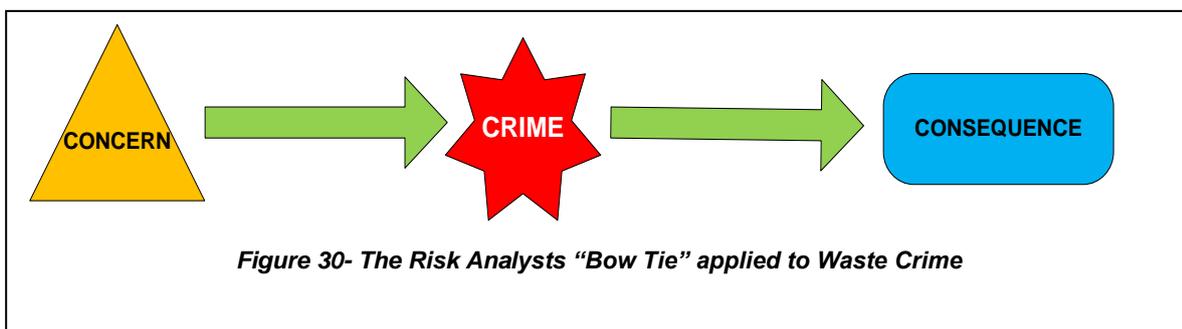
THE BOW-TIE AND BARRIERS APPROACH

Van Dorp explains that “The first approach to design an effective solution is to analyse the process which leads to harm, analyse which filters are in place to avoid the harm and then to analyse where filters can be added (filters like technical solutions, inspections, regulation) to reduce the chance of harm.

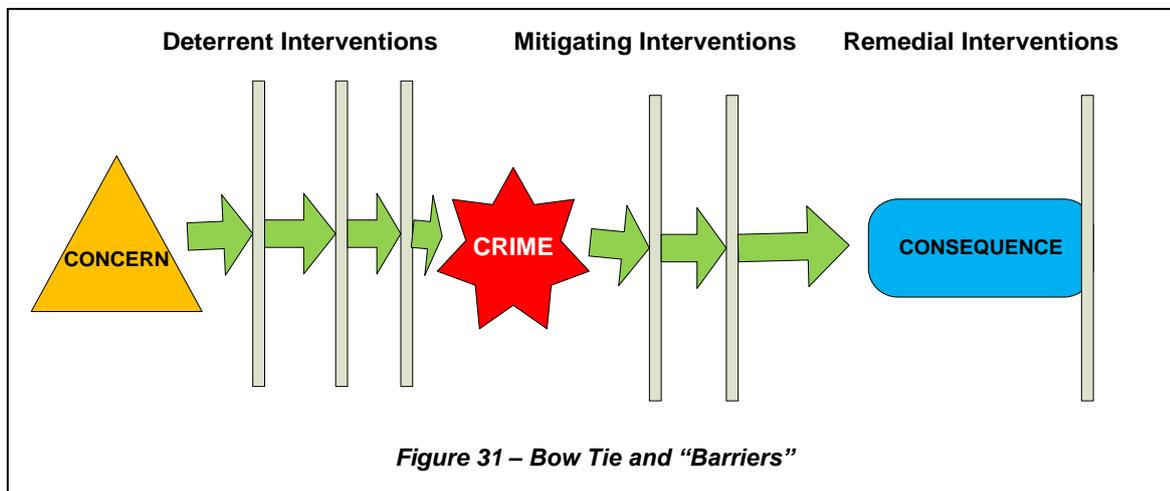
This filters can be added to avoid the action which leads to harm altogether (for example fire proof material to avoid fire) or can be added after the event to reduce the harm to an acceptable level (for example smoke alerts to detect a smouldering fire so it can be put out before it escalates into a full fire)”

Useful analysing tools that can be used in this process are the bowtie model or Prisma analyses.

This can help us organise different components into an overall framework. One obvious choice would be to follow the sequence of activities as they develop in a waste crime scenario. This is where an entity of interest (A Concern) commits a violation (A Crime) which has implications for the wider community (A Consequence). This can be shown as the line in a “Bow Tie” – a popular risk assessment Tool a shown in figure 30.



The sequencing allows us to realise the point at which different interventions have to occur to be effective. Deterrence is effective before the crime (the Knot) whereas detection and sanctions can only be used, unfortunately after the crime and often the consequences. Other interventions like stop and search though could ensure that although there is a violation, the consequences can be avoided or mitigated.



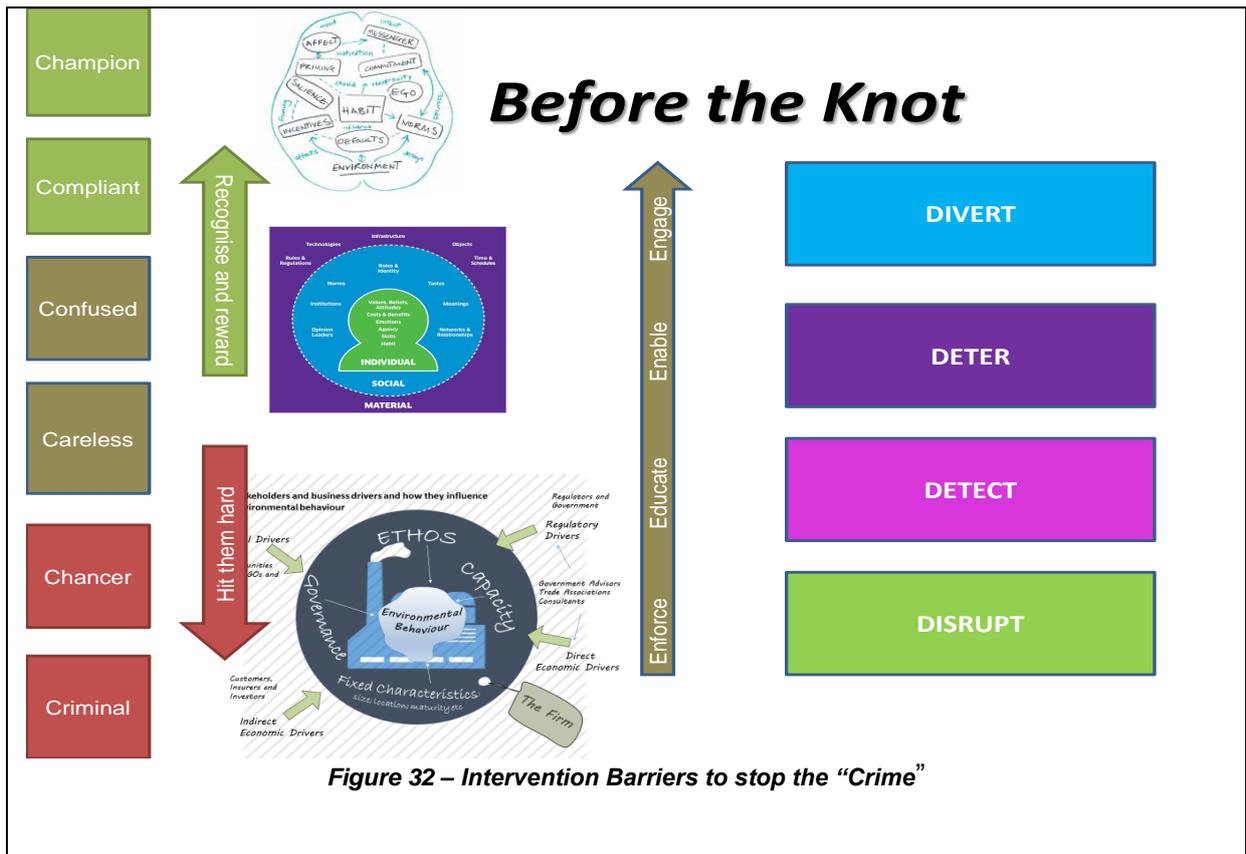
The possible or potential interventions can then be shown on the Bow Tie as Barriers to the sequence progressing (see figure 31). This is how they are used in Risk studies where these Barriers are used to represent protection systems (Alarms, Cut outs, Procedures, etc.)

So, on the **LEFT HAND SIDE** we can concentrate on educating the “controlling mind”.

Here the approaches like the ISM (Individual, Social and Material) categorisation enables us to assess and target individuals, peer groups and Businesses to try and develop a culture which recognises personal, social and material win-wins.

The **RIGHT HAND SIDE** is then all about ensuring that the criminals are apprehended preferably in the process of, before harm is done in disposals. This relies more on interventions such as Intelligence, Interception and Monitoring to demonstrate presence and a high likelihood of being caught.

Figure 32 demonstrates how the various methods discussed in this literature review could be used to identify barrier interventions before a crime and enforcement interventions after the crime.



8. CONCLUSIONS: SELECTION OF INTERVENTIONS ACCORDING TO THE SPECIFIC OF THE SITUATION

From the literature review we can see that there are a number of ways that we can organise the sum of the learnings from the theoretical analyses and practical experiences. It is clear that decisions on interventions require consideration of a number of factors, in particular:

- The “target” of the intended interventions;
- The factors that affect the “behaviour” of the target need to be identified (e.g. ISM, Mindscape, external drivers on business and internal factors etc.);
- The “attributes” of the regulations, regulatory effectiveness and economic sanctions that are important in determining the success outcomes (table of 11). Perceived equity and clarity of the legislation and outcome desired (transparency) is also important and are too often assumed attributes;
- The identification and characterisation of actors who can deliver interventions;
- And finally there is a range of interventions that can and have been attempted to achieve the particular objectives of the policy makers and regulators.

So the challenge is to choose the most effective intervention from a menu of “options” to deal with a particular “case” that has a number of different, but key “attributes”. Bearing in mind this is the real world with no guarantees, this decision has to be made against a background of considerable uncertainty.

One of the conclusions that immediately stands out is that it would be very helpful to start recording and analysing experience of interventions and provide an analysis for regulators along the lines of the UCL “What Works” website for general criminal applications.

We can sum up previous attempts at providing techniques / tools) to aid this decision making as an evolution from qualitative “guesses” (instinct/intuition / experience) to more formal justification by empirical or semi empirical “methods”, to formal mathematical treatments. These include

- Risk Plots – (OPRA,) where probability of outcome is assessed against normally log–log plots of reliability of operator versus the seriousness of potential consequences
- Multi attribute scoring techniques, either ranking alone or rankings and weightings (such has MCDA Table) summed to give a “score” for a particular option.
- More formal mathematical treatments which allow the calculation of the probability of successful outcome (achievement of objective) as a function of reliability evidence of an influence and the probability of its effectiveness if present.

Of these last techniques, the Bayesian and the Dempster Schafer approaches are (very similar and) the most established and well documented in applicability.

Generic Bayesian software tools abound (GENIE, UNINET and AGENA are probably some of the best known) and similarly for Dempster Shafer. But it appears that the two most suitable for regulatory decision making are the Bayesian Belief Net software - iDEPEND used in European environmental regulation by IMPEL, and by the Defence Academy) and the Dempster Schafer derivative TESLA (by Quintessa which is used in Nuclear Waste decisions).

None of the sources examined appear to have covered all the above stages, rather they usually consider just one or two aspects.

Table 1 is an attempt to represent how each of the 20 or so methods/tools that we have examined can take account of each of the 10 or so factors that seem to be relevant in choosing interventions. It also indicates which were specifically developed for waste crime.

Most systems only take account of about 3 or less of the factors. The systems which tick the most number of boxes are *iDEPEND* and the problem solving approach developed by Rob Van Dorp. However, neither have been specifically developed for or used for waste crime

But the *iDEPEND* approach of developing a set of “models” (pre-prepared templates), for predicting the expected effectiveness of a range of possible interventions (from a menu) in a range of applications, which can be utilised by field inspectors who do not need to know the detailed maths behind the probability estimates output, seems the most potentially helpful approach in this regard.

As a further benefit the “Evidence” and results of applications can then be recorded to calibrate the probability estimates used in the Templates. These can also be presented in a table in a similar way to the what works website for general criminal applications (UCL, 2015).

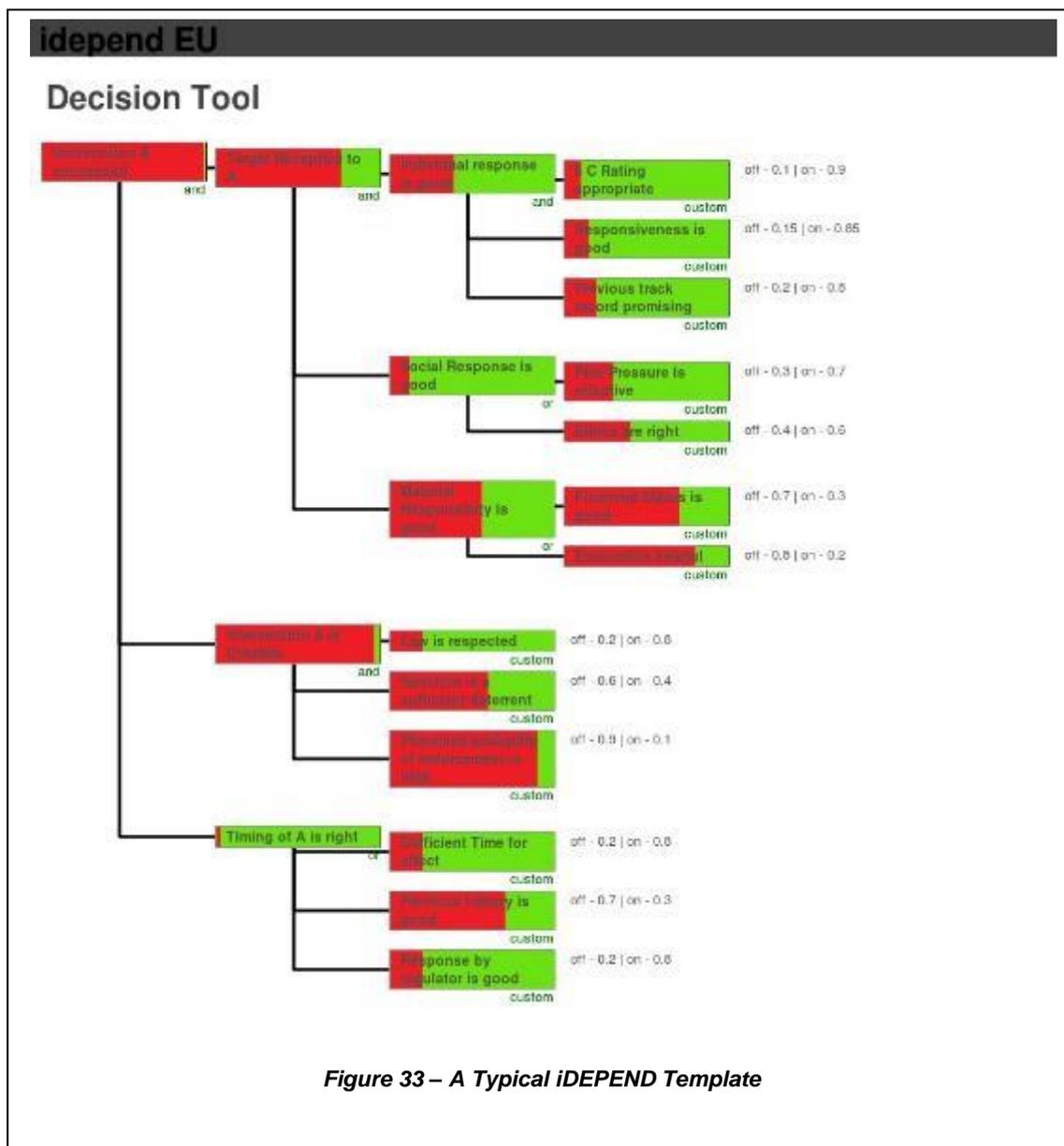


Figure 33 – A Typical *iDEPEND* Template

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APPENDIX 1. – DEPENDENCY MODELLING

CONTEXT

As an academic subject, risk is subject to the same pressures and ambitions to demonstrate intellectual depth and mathematical rigour to impress (face down) the competitive chorus of “peer” review. This need for this academic machismo tends to dismiss merely useful approaches in the hope (promise?) of more benefits from the full development/ implementation/ resolution of the glimpse of promise so far achieved.

Nowhere is this more applicable than in the pursuit of unravelling the mysteries of Risk.

In the 60’s and 70’s the goal was to develop fully quantified probabilistic predictions of the likelihood, modes and “effects” of failures of complete, large engineered systems from nuclear power plants to offshore platforms. As well as sophisticated Boolean logic trees, very detailed modelling of consequential spreading of (“Heavy”) vapour clouds from accidental releases consumed even more computational effort than the prediction of its likelihood (which always seemed to be 1 in a million?).

Although very impressive for the Regulators and planning inquiries, decision makers, faced with the responsibility of operating real plants in real locations with real people, found little practical help for day to day tactical decisions and responses. A classic consequence was the brave but misguided response at 3 Mile Island, trying to correct what they thought was happening, but in reality exacerbating the actual situation, with disastrous consequences. This is not a one off; the historical record is littered with well-meaning operators doing the wrong thing for the right reasons from Flixborough, through Bhopal, to Chernobyl.

This inability to see the wood from the “(Fault?) Trees”, implies that the insight and awareness needed by managers is not getting through, or being utilised. This has led increasingly to reliance on qualitative standards (ISO 31000), systems and processes (“Enterprise Wide”), rather than numerical assessments, which, if still affordable, tend to be part of detailed design commissioned and filed for compliance, rather than operational purposes

Today’s systems and systems of systems are even more complex and interdependent and this gulf grows wider. Academic approaches have again stressed the need for in depth, “state of the art” mathematical modelling (mash ups?) with high performance processing of large scale data sets using powerful algorithms, not easily understandable to the non-academic.

The result is that decision makers have again retreated to a reliance on more primitive but comprehensible analogies (e.g. –Renn’s Greek Mythology (Renn) from the Blackett Review (Blackett)) to get the insights they desperately need to manage responsibly today’s infrastructure. Thus the inability of the Banks to deliver the kind of risk management required is at least understandable, if not forgivable.

This note argues that there is a middle way; and that a more pragmatic, practical (non-academic), approach, focussed on the application rather than the publication, can give most of the usefulness for a fraction of the effort. This has long been recognised from the earlier logic tree debates as the “Expected Value of Perfect Knowledge” (EVPK); which questioned

the extra benefits obtainable from increased rigour and computational detail. This just enough, just in time approach strikes a resonance in today's resource challenged times. Thus, just as in practice, the main insights and usefulness of the full Fault and Event tree approach, can be obtained with a simplified Bow Tie and Barriers approach (described below) – increasingly utilised now across the board; there are other more efficient and effective ways of dealing with complex interactions than crude brute force computation. A little pre-thought and positioning can go a long way.

The “Imperfect” Knowledge Approach.

There are well established ways of addressing situations where there is insufficient definition, data or history to generate predictive models of likely system behaviour. One of these suffers so much from the layman's reaction to its perceived “too difficult to understand” aura, (the preserve of a secretive mathematical clique?), that its very name precludes its further discussion in practical management circles. Nevertheless it is a powerful and potentially very useful approach which deserves further examination. To do this sensibly we have developed an approach which attempts to retain the rigour while dispelling the mathematical mysteries of Bayesian Nets. We can think of it as the new “Bow Ties” and Barriers” analogue, in, that we can get all the insights (quantitatively) without worrying about the math.

The Bayesian Net approach is summed up succinctly and powerfully by Fenton and Neil, in their KTN paper - MANAGING RISK IN THE MODERN WORLD 3 Applications of Bayesian Networks.

***“Even though we may have little or no historical data, there is often an abundance of expert (but subjective) judgement, as well as diverse information and data on indirectly related risks. These are the types of situation that can be successfully addressed using Bayesian Networks (BNs), even when classical, data-driven approaches to risk assessment are not possible. BNs describe “webs” of causes and effects, using a graphical framework that provides for the rigorous quantification of risks and the clear communication of results. They can combine historical data with expert judgement. During the last decade, researchers have incorporated BN techniques into -----the development of decision support systems in a diverse set of application domains, including medical diagnosis, safety assessment, forensics, procurement, equipment fault diagnosis and software quality. -----
----- . As a result, BN methods are beginning to penetrate mainstream business practice. Recent commercial case studies provide evidence of impressive returns on investment from these techniques. Both the practice and research of BNs are mushrooming.”***

This “top down”, just in time”, just enough” development attempts to provide a vehicle for enabling the promise to be realised by overcoming the perception of “too difficult to use” for the benefits expected. The approach is called –“**Dependency Modelling**”.

As with the Bow Tie, the analysis appears non-technical (certainly non mathematical) to the user(s).The advance over the now numerous Bayesian Network applications and packages

available is the intuitive and familiar interface which is essentially mind mapping! If we can get the same “Value” from this apparently simplified approach, why would we need to venture further into the computational labyrinths, which seem to have bedevilled and bogged down the full realisation of the power and potential contribution of the method?

The outputs however are the same as in the full applications as employed by for example Microsoft, Pharmaceuticals, etc. (See Appendix.). The quantum leap however lies in its ability to input real time behaviours and get instant system response So at the risk of drawing criticism from the academics as to the lack of rigour and mathematical detail in its description, we give below an outline of the method, which although not “Perfect” to the purist, nevertheless provides real Value to those responsible for managing in today’s turbulent times.²

WHAT IS DEPENDENCY MODELLING

Dependency Modelling (DM) is thus a practitioners’ practical implementation / development of Bayesian Networks – a methodology for understanding, communicating and measuring the **risks** to an **endeavour**. Here **endeavour** means any of a wide variety of entities. It could be an enterprise, venture, undertaking, government, campaign, machine, system or process. It might be the security of an establishment; the success of a military campaign; the effectiveness of a communications system; the reliability of a supply chain or the preservation of a reputation. It could in fact be anything for which a suitable model can be built.

IN SUMMARY - DEPENDENCY MODELLING

We need to make a distinction between allocating resources and how to regulate.

You allocate resources on the basis of risk.

Then having decided that you ask “how do we go about regulating with those resources?” Strategies must be developed as to how inspectors should go about the task of intervening in the affairs of regulated organisations to ensure compliance and enforcement—a question regarding which there is little consensus.”

Then you have various tools to deploy in interventions depending on the problem and almost all problems have more than one possible intervention, so the question “does the hammer work” is strangely meaningless. It is like asking in disease control, “does the scalpel work?” “it all depends!”

A dependency model is based on goals and objectives, and the prerequisites to satisfy these. In other words it is a top down approach working from goals to requirements. This is in strong contrast with other methodologies which focus on faults, disasters and failures.

² (A DM software solution is available to test at <http://idepend.heroku.com>)

There are a number of advantages in the top down approach, not least being that it is easier and more intuitive to think of goals and requirements.

This systematic approach enables the direct linking of the *Goal* in a cascading manner to those needs (dependencies) essential to deliver the goal. This approach using **iDEPEND** to drive this framework then allows the assessment of sensitivities to achieving the goal.

There are a large number of advantages of building a dependency model, such as:

- It forms a language to discuss risk with other people.
- It forces us to understand and articulate what we are trying to achieve.
- It allows us to analyse the risk of not achieving it and what that is dependent on (the dependencies).
- It allows us to model the effects of interventions on achieving goals
- Any misunderstandings we have are made visible to ourselves and others, and are thereby more likely to be uncovered. .

A simple example:

Suppose we want to visit friends who live several hundred miles away. Our goal is a successful visit, and we're going to limit our analysis just to the journey. The issues we're concerned with here are possible last minute cancellation by either party, or possible travel problems. So the success of our journey will depend on, for example:

- a car that works properly
- the availability of fuel
- the state of the traffic
- possible road closures
- ourselves avoiding being taken sick at the last moment
- our friends avoiding being taken sick at the last moment

We will call these the **dependencies** of our goal. (To extend the terminology, a goal is the **dependent** of its dependencies.) Now we need to ask ourselves "what do we want from our model?" One thing must surely be to calculate the chances we will achieve the goal i.e. the probability that a successful trip is achieved.

APPENDIX 2. COMPLEMENTARY APPROACHES TO ENVIRONMENTAL INSPECTIONS.

More detail on each approach is provided in section 4 of the IMPEL report. (IMPEL, 2012)

Non-traditional environmental inspection approaches*

- Sharing of inspections by different regulators and/or sharing by national and local regulators
- Promotion of supply chain management so that customers demand compliance.
- Engagement with companies at a senior level rather than just regulating individual sites.
- Shared Stewardship: This includes sharing intelligence with other regulators and using shared knowledge, commitment and actions of individuals' organisations and communities and all levels of government as a whole.
- Catchment walks to spot what issues are rather than looking for issues on sites.

Communication approaches

- Advice and guidance given by regulator to operators, by various means such as web-based written materials or meetings.
- Use of third parties such as trade associations, suppliers or vendors to provide advice and guidance to aid compliance
- Publishing of performance ratings of emissions, compliance rates, etc.
- Enabling public participation. As well as the communication of compliance / emissions etc. this can also include the provision of access to justice.
- Using communication to the public to increase / maintain the regulators credibility which improves its ability to influence companies' compliance.

* Note regarding some forms of Inspection which are covered under RMCEI definition

The following types of inspection are considered novel by some parties, but they are actually included in the definition of inspection under RMCEI (see annex 2). Therefore the following examples are not included as examples of complementary approaches for the purposes of this project.

- Inspection activities by third parties such as accredited technical surveillance organisations who report to inspection authorities
- Measurements by certified third parties of waste, water pollution, air emissions etc. and reporting to inspection authorities.
- Using remote emission monitoring and/or CCTV to monitor compliance
- Requirements for operators to install continuous measuring devices at the operators' installations and send results automatically to the inspectorate and/or the internet.
- Targeted inspections in sectoral areas following national decisions on priorities.

Certification and voluntary approaches

- Self-certification and reporting of compliance by operators
- Use of trade associations to provide a compliance assurance service to its members.
- Voluntary agreements or other voluntary approaches. These can be incentivised by recognition and publication of membership of such schemes and of environmental performance of member companies.
- System Based Supervision (or “self-management supervision”). A company adopts compliance management processes to ensure that particular environmental outcomes are achieved.
- Promote / incentivise companies to set up their own “24 hour complaints line” to encourage direct and quicker responses by companies to incidents and complaints.
- Voluntary Environmental Auditing by companies
- Use of Environmental Volunteers
- Use of Eco Management and Audit Scheme (EMAS)

Economic Approaches

- Trading Schemes.
- Taxes.
- Charging Schemes
- Offset schemes. Expenditure eligible for environmental projects can be deducted from charges.
- Subsidies or loans or fiscal incentives for capital spend to go beyond compliance or for implementing Environmental Management Systems in SMEs.
- “Green Credit”: Use environmental performance as a factor in loan decisions by banks.
- Remove export licence from companies with serious environmental violations.
- Green securities scheme mandates environmental disclosure for listed companies.

APPENDIX 3 CATALOGUE OF INTERVENTIONS AND LINKS TO EVIDENCE ON EACH³

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
Regulatory interventions			
Permitting	<p>“Permits” set requirements which can include requirements on emissions and or on the “techniques” or “measures” required of the regulated. There can often be a hierarchy of permits such as “registration, standard permits and bespoke permits.</p> <p>Requirements that set specific limits to the amount of pollutants that can be released into the environment which typically relate to industrial operations. The purpose of emission regulations is to improve environmental quality.</p>	The integrated pollution prevention and control (IPPC) Directive was introduced in 1996. It was found to have a positive impact on eco-efficiency in the dairy industry in the UK.	http://www.sciencedirect.com/science/article/pii/S0959652604002732#
General binding rules	For certain classes or operation there are general binding rules that all relevant businesses must comply with. These can be included in permits or may be set out in statute.	<p>Evidence suggests that vehicle emission standards contributed towards a dramatic reduction in air pollution in Texas during the 1999 – 2012 period.</p> <p>The intervention was successful as it applied to all new vehicles and mandated a minimum standard for emissions.</p>	http://www.tceq.state.tx.us/assets/public/implementation/air/am/committees/pmt_set/20120425/20120425-kite.pdf
Inspections	<p>“Environmental inspection” is an activity which entails, as appropriate:</p> <p>(a) checking and promoting the compliance of controlled installations with relevant environmental requirements set out in Community legislation as transposed into national legislation or applied in the national legal order (referred to hereinafter as</p>	A study in the US examined how third party inspections coupled with insurance protection can encourage businesses to reduce their risks from accidents and disasters. It found that relying on decentralized market-based incentive mechanisms to supplement performance-based regulations for promoting industrial safety can be an effective	http://grace.wharton.upenn.edu/risk/downloads/01-05-HK.pdf

³ Source: SNIFFER (2013) Towards a *regulatory evidence portal*. Six topic area summaries on principles of better environmental regulation. <http://www.sniffer.org.uk/knowledge-hubs/environmental-regulation/better-regulation/towards-regulatory-evidence-portal/>. Follow the link on this web-page to “Topic Area 2” (Choose and Design Interventions).

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
	<p>'EC legal requirements');</p> <p>(b) monitoring the impact of controlled installations on the environment to determine whether further inspection or enforcement action (including issuing, modification or revocation of any authorisation, permit or licence) is required to secure compliance with EC legal requirements;</p> <p>(c) the carrying out of activities for the above purposes.</p> <p>The above is a truncated definition. The full definition of environmental inspections is on page 43 of the European Commission Official Journal L 118 of 27.4.2001 in the Recommendation 2001/331/EC of the European Parliament and of the Council of 4 April 2001 providing for minimum criteria for environmental inspections in the Member States [Official Journal L 118 of 27.4.2001]</p>	<p>means to reduce regulatory burden and improve compliance.</p>	
Enforcement	<p>This includes a number of options that regulators can use to require them to take action to ensure that an infringement does not occur or to bring them back into compliance. It can also include penalties to deter the non-compliant company from further non-compliance, as well as to deter others.</p>	<p>Empirical analysis suggests that the benefit of enforcement actions can extend beyond the organisation subject to enforcement. On the margin, the impact of a fine can lead to widespread reductions in violations in the short term (one year). The result is obtained through the regulator's enhanced reputation; the deterrence impact on other organisations is almost the same as on the sanctioned organisation.</p>	<p>http://www.sciencedirect.com/science/article/pii/S0095069605000380</p>
Planning control	<p>This is the process that regulates the development and use of the land to ensure that changes to the physical environment, buildings and land, are appropriate for their purposes and location. The purpose of planning control is to protect amenities and the</p>	<p>Designating land for conservation has been a central tenet of countryside policy in the UK. A recent study has found that while they remain broadly fit for purpose and good value for money,</p>	<p>http://www.sciencedirect.com/science/article/pii/S0264837709000921</p>

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
	environment in the public interest. It is not designed to protect the interests of one person over another.	they will have to become more embedded in land use strategies which are more responsive to changing social needs and environmental conditions to remain relevant.	
Environmental liability	Environmental liability is based on the “polluter pays” principle. The liable party is the operator conducting the specified dangerous activities, and he is liable for environmental damage arising from these activities. Where such damage occurs, the operator must take appropriate remedial action. In certain cases, it may not be possible to identify the operator, or the operator may fail to take remedial action. In these instances, the competent authority may complete the necessary preventative or remedial measures. The purpose of environmental liability is to (1) provide a clear incentive for operators to take appropriate preventative measures, and (2) ensure that the cost of remedial action is borne by the appropriate party (or parties).	A study of 8000 U.S. facilities examined the effectiveness of state hazardous waste regulations and policies in promoting compliance. It found that adopting strict liability decreased serious violations (although it positively correlated with the overall probability of violation).	http://www.springerlink.com/content/w304416712070338/
Product controls	Regulations of equipment, or product standards, are normative requirements that a product must attain to be considered as ‘legal’. They do not relate to how the products are manufactured, distributed or distributed. The standards are validated by specified test methods. The purpose of product standards is to protect consumers or the environment by ensuring a minimum level of acceptable standard.	Product standards can have positive and negative economic impacts. A UK study analysed the potential competition impacts of product standards and concluded that care is required due to the potential of businesses to behave strategically in response to their introduction, and that standards can have asymmetric impacts on businesses operating in the market.	http://www.offt.gov.uk/shared_offt/economic_research/offt1030.pdf
Registration, labelling and certification	Typically, information describing the environmental performance of the businesses delivering a product or service is made available to consumers using a product label, enabling consumers to choose products with better environmental performance. The approach may encourage businesses to gain certification to enhance their	ENERGYSTAR is a voluntary energy efficiency labelling programme operated by the U.S. Department of Energy and the Environmental Protection Agency. Since its inception in 1992 it has become a leading international brand for energy	http://www.sciencedirect.com/science/article/pii/S0301421508001092 (Also Gouldson et al., 2008).

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
	reputation, and relies on consumers buying on the basis of better environmental performance	efficient products. It has played a role in the development of local, national and international energy programmes and resulted in significant energy savings.	
Economic and market-based interventions			
Tradable permits	Achieve reductions in pollution or use of resources in the most effective way through the provision of market incentives to trade. A limited number of permits for a specified activity, such as emission of a pollutant, are auctioned or granted to operators in a sector. The operators may then trade permits with each other to find the most efficient mechanism to meet regulatory objectives. These are most commonly used for emissions of aerial pollutants, such as sulphur dioxide from industrial operations.	<p>The US acid rain programme successfully employed emissions permits to reduce sulphur emissions from power plants. The programme was very successful, exceeding the target at a cost much lower than predicted.</p> <p>Its success was due to the fact that it simplified the scheme through the use of cap and trade⁴; it was nationwide, providing plenty of scope for abatement; and there was no requirement for government to approve transactions.</p>	http://www.oecdbookshop.org/oecd/display.asp?lang=EN&sf1=identifiers&st1=972004071p1
Environmental taxes	Change prices and thus the behaviour of producers and consumers, and also raise revenues. Effective when the tax is sufficiently high to stimulate measures to abate pollution levels, that is, when the cost of the tax is sufficiently high that abatement measures are economically justified.	The UK landfill tax, introduced in 1996, has been used to reduce waste going to landfill. Evaluations of its success have been mixed. While it has changed business behaviour in general, the impact on SME behaviour has been less pronounced.	http://www.tandfonline.com/doi/abs/10.1080/0964056032000138436
Environmental charges	Cover (in part or in full) the costs of environmental services and abatement measures such as waste water treatment and waste	The Environment Agency has a charging scheme that covers waste carriers, brokers and dealers of	http://www.environment-agency.gov.uk/business/reg

⁴ Cap and trade: An overall absolute cap, target, or envelope of emissions per time unit and geographical area (which may be global, as in the case of greenhouse gases) is fixed. This cap is then allocated to various parties who can then trade. 'Cap and trade' ensures that the overall target is achieved.

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
	disposal. Differentiation of charges can help to refine the change in behaviour by consumer or company.	waste, producer responsibility, waste exemptions and environmental permits. The types of environmental permit vary from those with standard rules to bespoke complex permits covering a wide range of activities (e.g. complex chemical plants, large sewage works, and nuclear power stations).	ulation/38805.aspx
Environmental subsidies and incentives	These are used to (1) stimulate development of new technologies to help create new markets for environmental goods and services (including technologies); (2) encourage changes in consumer behaviour through green purchasing schemes; and (3) temporarily support achieving high levels of environmental protection by companies.	Johansson, M. (2006). Are Carrots as Good as Sticks? Ex-Ante Efficiency of Swedish Environmental Subsidy Programme. <i>European Environment</i> 16, 89-107 (2006)	http://onlinelibrary.wiley.com/doi/10.1002/eet.409/abstract

Voluntary interventions

Unilateral commitments	Environmental improvement programmes set up by companies and communicated to their stakeholders, such as employees, shareholders and clients. The content of the commitments, the definition of environmental targets as well as the provisions governing compliance are determined by the company itself. Monitoring and dispute resolution may be delegated to a third party to strengthen the credibility and environmental effectiveness of the commitment.	Marks and Spencer's 'Plan A'. This includes 180 commitments to achieve in 5 years to 2015 to combat climate change, reduce waste, use sustainable raw materials, trade ethically and help their customers to lead healthier lifestyles.	http://plana.marksandspencer.com/about
Negotiated agreements	Contracts between competent authorities and industry which contain a target (such as a specified pollution abatement objective) and a time schedule to achieve it. The competent authority agreement generally consists of not introducing a new piece of legislation unless the voluntary action fails to meet the agreed target.	Negotiated agreements on industrial energy efficiency were successfully employed in Denmark to reduce CO2 emissions in industry. The agreements covered companies with energy-intensive production processes, and involved a three-year agreement with the Danish Energy	http://search.oecd.org/officialdocuments/displaydocumentpdf/?doclanguage=en&copte=env/epoc/wpnep(2002)13/final

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
Public voluntary programmes	<p>Participating companies agree to standards (related to their performance, their technology or their management) which have been developed by competent authorities such as environmental agencies. The scheme defines the conditions of individual membership, the provisions to be complied with by the companies, the monitoring criteria and the evaluation of the results.</p> <p>Economic benefits in the form of research and development subsidies, technical assistance, and reputation (for example, by being permitted to use an environmental logo) can be provided by the competent authority.</p>	<p>Agency. The agreements were legally binding and provided for a tax rebate for companies that met the terms of the agreement. The agreements had a positive impact on the companies' behaviour and their expected effects were realised. However the administrative costs for the companies and competent authority were relatively high compared to the implementation of taxes and subsidies.</p> <p>The Courtauld Commitment. This is an agreement to reduce food and packaging waste which WRAP is responsible for. It covers over 40 food retailers, manufacturers and suppliers in the UK.</p> <p>Sam, A. and Innes, R. (2004). Voluntary Pollution Reductions and the enforcement of Environmental Law: An Empirical Study of the 33/50 Program; Research Paper 2004-08, Univ. of AZ.</p> <p>Study of empirical determinants and effects of businesses' participation in EPA's 33/50 voluntary pollution reduction program. Authors study bi-directional links between participation and enforcement, effects of implied boycotts, and potential regulatory pre-emption and incentives. Findings include that pollutant reductions were prompted by a firm's likelihood of becoming a boycott target and/or being subject to environmental interest group lobbying for tighter regulatory standards.</p>	<p>See WRAP Web pages on the Courtauld Commitment which include fact sheets, case studies and evaluation reports.</p> <p>http://www.wrap.org.uk/content/courtauld-commitment-1</p> <p>http://cals.arizona.edu/arec/pubs/researchpapers/2004-08samannes.pdf</p>

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
Requiring companies to set up their own 24-hour complaint lines	Requirement for companies responsible for emissions to set up and publicise a system for recording complaints. The regulator then publishes a list of companies with the most complaints, incentivising them to improve their environmental performance.	In Victoria, Australia, the regulator has introduced a requirement for companies responsible for emissions must publish a toll-free number and system to record complaints. The regulator then publishes the top ten companies with the most complaints, incentivising them to improve their environmental performance.	<p>IMPEL (2012) Exploring the Use and Effectiveness of Complementary Approaches to Inspection for Ensuring Compliance.</p> <p>http://impel.eu/wp-content/uploads/2012/09/R_EPORT-FINAL-Exploring-Complementary-Approaches-May-2012-adpt.pdf</p>
Private corporate regulation	Voluntary agreements organised by the private sector. Therefore, the private sector operates and participates in all elements of the agreements without any public sector intervention or risk of government sanction.	Waitrose, the UK based supermarket, has been involved in Corporate Social Responsibility initiatives for several years. Good practice from the implementation of ‘corporate social responsibility’ in the supply chain has engendered improvements in supply chain responsibility. This has increased the sourcing of products with higher associated environmental and ethical standards.	<p>http://www.emeraldinsight.com/journals.htm?issn=1359-8546&volume=14&issue=4&articleid=1798850&show=abstract</p>
Information and communication-based interventions			
Advice and guidance given by regulator to operators (can include both compliance assistance and technical	Delivery of advice and guidance which can include general compliance assistance and/or technical assistance (e.g. on new requirements of law/permit, reasons for non-compliance and means to achieve compliance). It can be delivered by various means (e.g. internet (web site), written materials, and meetings).	<p>This is in widespread use.</p> <p>Local authorities in the Netherlands work with SMEs to improve their environmental performance. Becoming a ‘strategic partner’ in this way has been found to help both partners take a practical step-by-step approach to tackle mutual barriers and successfully execute cleaner production projects.</p>	<p>See section 4 of IMPEL (2012) Exploring the Use and Effectiveness of Complementary Approaches to Inspection for Ensuring Compliance.</p> <p>http://impel.eu/wp-content/uploads/2012/09/R_EPORT-FINAL-Exploring-</p>

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
assistance)			Complementary-Approaches-May-2012-adpt.pdf http://www.sciencedirect.com/science/article/pii/S0959652699000840
Advice and guidance given by third parties (e.g. trade associations, suppliers, or customers)	Third parties, such as trade associations, suppliers or vendors, can provide advice and guidance – although the regulator would need to have some assurance that these bodies are trustworthy and have the necessary expertise to provide advice and guidance. One important aspect of such advice and guidance is to “sell economic advantage”.	The provision of on-site technical assistance (by a third party) for reducing the use of toxic material was found to encourage companies in Massachusetts, US, to reduce toxics use by 9.4%.	http://www.mass.gov/envirota/publications/pdf/effectiveness_study_executive_summary.pdf
Earned recognition	The rationale of earned recognition is that businesses that prove to be proactive and reliable in their environmental performance can be inspected less frequently. There should be mutual benefits, where earned recognition could be presented by a business as a sign of quality or responsibility to their consumers, while regulators benefit from having to undertake fewer inspections.	A Defra study undertaken to assess whether membership of a Farm Assurance Scheme affects compliance with animal welfare legislation and code found that certified enterprises could reliably be inspected less frequently than enterprises that are not certified.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16613#Description
Naming and shaming	Publishing emission performance ratings, compliance rates, etc., of regulated businesses.	An incentive-based pollution control programme has been introduced in China. The environmental performance of businesses is rated from best to worst using five colours, and the ratings are disseminated to the public through the media. Publishing the information has increased compliance with environmental regulations.	http://www.sciencedirect.com/science/article/pii/S0301479704000337

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
Enabling public participation (this can include providing access to justice)	The power of civil liability is deliberately supported by publicising information on emissions and compliance that could be used by non-government agencies to take action.	<p>This is used in the US, where the power of civil liability is deliberately supported by publicising information of emissions and compliance that could be used by non-government agencies to take action. This is especially effective when there is a large local interest in environmental issues.</p> <p>In British Columbia, Canada, the Ministry requires some companies to fund citizen oversight for some large projects.</p>	<p>IMPEL (2012) Exploring the Use and Effectiveness of Complementary Approaches to Inspection for Ensuring Compliance.</p> <p>http://impel.eu/wp-content/uploads/2012/09/REPORT-FINAL-Exploring-Complementary-Approaches-May-2012-adpt.pdf</p>
Requiring companies to advertise enforcement actions taken against them	Requiring businesses to advertise enforcement actions so as to increase the impact on the behaviour of the business concerned – as well as putting other businesses, who are likely to experience the same if they do not comply, ‘on notice’.	<p>In Scotland, SEPA and the Scottish Government are considering and consulting on a new instrument, which is being called a ‘publicity order’.</p> <p>Research evidence suggests that publicity around enforcement action can be a significant deterrent for legitimate businesses. In some cases, this may be more of a deterrent than a monetary penalty. However, for other companies, publicity may be ineffective due to counter publicity.</p>	<p>http://jel.oxfordjournals.org/content/17/2/161.full.pdf</p>
Other interventions			
Sharing of inspections by different regulators, including intelligence-led, joined up	<p>One example of this is joining up with other government regulators, where appropriate, to have more integrated approaches. Such approaches can have significant efficiency benefits for the regulators and they can reduce the burdens on the regulated.</p> <p>Although, in practice, integrated approaches can be difficult to organise. Careful organisation is required, particularly when many different organisations are involved and consideration is needed on</p>	<p>Sweden’s Network between Supervisory Bodies.</p> <p>Scotland’s Environmental and Rural Services (SEARS).</p> <p>In Greece, the Environment and Health regulators have taken this approach.</p> <p>It is in widespread use in the Netherlands and, to</p>	<p>IMPEL project on complementary approaches</p> <p>The IMPEL project on “Common Regulatory Frameworks”</p>

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
approaches between regulators	the appropriate balance between super inspectors (inspectors with knowledge across media) and specialists (media- or sector-specific) to maintain the quality and effectiveness of inspections.	some extent, in other countries (e.g. Poland).	
Requiring or encouraging companies to have environmental management systems (EMSs)	Businesses are encouraged to adopt environmental management systems. This can be undertaken by providing incentives (e.g. reduced inspections and charges) or by providing support in the form of funding for training and/or other costs associated with setting up an EMS.	<p>A European study found that adopting an accredited certified EMS in several EU member states improved site environmental management activities, leading to lower average emission levels.</p> <p>In Denmark, the Danish Government provide direct subsidies to businesses to prepare them to make the transition to an environmental management system.</p> <p>In the UK, the Environment Agency is trialling third party assurance schemes with a range of business sectors (30 of the best sites over 9 sectors). It will review these trials in 2013 and consider which can be taken forward</p>	<p>http://remas.academe.co.uk/content/results.htm</p> <p>Farmer A. (2007). Handbook of Environmental Protection and Enforcement. Earthscan.</p> <p>See page 25 of Defra Red Tape Challenge - Environment Theme Implementation Plan, September 2012.</p> <p>http://www.defra.gov.uk/publications/files/pb13819-red-tape-environment.pdf</p>
Promotion of supply-chain management so that customers demand compliance	Promoting and supporting the use of supply-chain pressure as a means of improving environmental performance whereby customers are exerting pressure on business who supply to other businesses. This could be done by enabling the sharing of “green specifications” and “green contract terms” that are used by the public sector so that private companies find it easier to set up those requirements for themselves. It can also involve encouraging and advising larger businesses on activities to support smaller businesses.	An empirical study from the US demonstrated how private contracts (focusing on supply-chain contracting) regulate firm behaviour to promote positive environmental outcomes. The private standards reduce market externalities by translating a complex mix of social, economic and legal incentives for environmental protection into private contractual requirements.	http://www.law.virginia.edu/pdf/workshops/0607/vandenbergh.pdf
Engagement with companies at a	Gaining commitment to environmental compliance at the highest level in a business. Regulators have adopted a variety of approaches to gain this commitment, including account	Early positive outcomes have been reported from account management approaches adopted by the Environment Agency, namely closer relationships	Environment Agency (2011). Effectiveness of Regulation: Literature Review and

Intervention	Description	Example of where it has worked and why	Link(s) to evaluations or other evidence
senior level, rather than just regulating individual sites	management, director level signoff, and targeted training and communication.	enabling solutions to be identified before wider problems occur, enhanced consistency across sites, and improved efficiencies on both sides. There is some concern that this type of boardroom level intervention can lead to actual or perceived regulatory capture and also about the considerable demands placed on limited senior staff resources.	Analysis. Report - SC090028 http://cdn.environment-agency.gov.uk/scho0911bubh-e-e.pdf
Shared stewardship	This includes sharing intelligence with other regulators and using shared knowledge and commitment, and the actions of individuals, organisations, communities, and all levels of government as a whole.	This is common in Canada. For example, in British Colombia, the environment ministry commits resources to “ <i>instilling a sense of shared stewardship</i> ” which they believe “ <i>assists in increasing voluntary compliance rates and in motivating the public to report non-compliance.</i> ” There are a lot of stewardship groups, such as water conservation groups, that encourage wise water resource use. There is also an “eco-justice” group which finds data and information, and publicises it with the aim of influencing corporate behaviour.	IMPEL (2012). Exploring the Use and Effectiveness of Complementary Approaches to Inspection for Ensuring Compliance. http://impel.eu/wp-content/uploads/2012/09/REPORT-FINAL-Exploring-Complementary-Approaches-May-2012-adpt.pdf
Catchment walks to spot what the issues are, rather than looking for issues on site	Regulatory staff walking along water courses in priority catchments to gather information on the causes of diffuse pollution and identify breaches of the rules.	In Scotland, SEPA staff have walked over 5,600 km of water courses in priority catchments to gather information on the causes of diffuse pollution, and have identified over 5,000 breaches of the diffuse pollution General Binding Rules (GBRs). These relate mostly to the storage and application of fertiliser, keeping of livestock and cultivation of land. “Land managers’ understanding of the causes and impacts of diffuse pollution is increasing, and this will help with the development of practical solutions that protect and improve water quality.”	SEPA (2012). Progress on delivering better environmental regulation. http://www.sepa.org.uk/about_us/publications/better_regulation.aspx

