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# EFFECTIVE RISK MANAGEMENT OF RADIOACTIVE MATERIAL TRANSPORT IN THE COMMERCIAL RAIL ENVIRONMENT

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## ABSTRACT

As a wholly-owned subsidiary of the Nuclear Decommissioning Authority (NDA), Direct Rail Services (DRS) primary mission is to provide reliable nuclear rail services in support of the parent company's 120-year decommissioning strategy. Since DRS formed in 1995 the company has travelled over 5 million miles and safely transported Spent Fuel on behalf of the entire UK nuclear industry. Over the past 23 years DRS have developed and maintained an industry leading reputation for providing safe, secure, reliable, cost effective services within both nuclear and non-nuclear related markets.

As a rail company with a nuclear heritage DRS is an organisation that serves in two of the most highly regulated markets in the world. In order to operate DRS must conform to all the requirements of statutory regulatory bodies such as Office of Nuclear Regulation – Civil Nuclear Security (ONR-CNS), Department for Transport (DfT), Ministry of Defence (MOD) and Office of Road and Rail (ORR), and the NDA.

In the UK, the rail industry holds a reputation for operating with high levels of safety with the GB rail network considered to be one of the safest railways in Europe. To mirror this, the UK Nuclear Industry also demonstrates an impressive record having safely managed nuclear waste for over 50 years. This is underpinned by extensive experience within the industry as well as a strong safety culture.

However, although both industries implement a regimented approach to safety and risk management the different methods of risk estimation and agreed safety related decision making processes mean DRS must effectively balance both sets of priorities to manage expectations of governing bodies as well as nuclear industry and non-nuclear commercial customers.

Through assessment of the application of the 'as low as reasonably practicable' (ALARP) approach as well as other risk management tools DRS aim to produce a paper to identify the different attitudes to safety and risk management in the UK Rail and Nuclear industries. Case studies are provided to demonstrate how DRS draw these approaches together to form an appropriate and effective approach to risk management, with detail on how these methods could be applied by other nuclear transport providers operating in the global market.

## INTRODUCTION

DRS' business overlaps two different and traditionally separate, highly regulated safety critical domains: rail and nuclear. Because of the different nature of the risks in each sector, and their different histories and technologies, these two sectors have developed differing approaches to risk management and apply different risk acceptance criteria.

Given the nature of nuclear risks, and the scale of public concern about them, the nuclear industry views risk in a similar way to the government and considers the total risk exposure to individuals in prioritising its activity using notions of the 'tolerability' of risk. This approach is associated with government accountability and legislation. Rail companies in Great Britain however, have over twenty five years of experience of operating

in a fully commercial domain. This has led the industry to develop and clarify the clear and separate criteria for how a commercial entity in the industry takes decisions impacting safety as distinct from a regulator or the government, and a focus purely on ensuring that candidate measures reduce risk to a level that is as low as is reasonably practicable (ALARP), as is their legal duty.

Although Direct Rail Services (DRS) is a rail business, with its safety management system certified by the Office of the Rail and Road (ORR), it additionally applies the nuclear approach to risk acceptance criteria to its decision making and its business is shaped by the more demanding risk acceptance culture associated with the nuclear sector. This is despite the fact that its nuclear risks are clear and well contained within its business and its ONR-CNS licensed responsibilities are limited. The rail risk management framework, documented in the publication 'Taking Safe Decisions' [1], recognises that companies might choose to take a more demanding approach for risk acceptance for voluntary, commercial reasons. Taking this more demanding approach has indeed had more commercial benefits for DRS. It has challenged it to make its business more operationally resilient, and this has allowed it to carve out a niche in high reliability delivery services. DRS has also benefitted in the area of cyber security where because of its footprint in the nuclear industry it has been proactive in developing its information security management system and in managing its supply chain effectively, making tangible progress as an outlier in the UK railway industry in this regard.

## DIFFERENCES BETWEEN RAIL AND NUCLEAR SECTORS

**Table 1. Comparison of Nuclear Power Station and Nuclear Rail Transportation**

| Nuclear Power Station | Nuclear Rail Transportation |
|---|---|
| Complex | Simple |
| Tightly coupled | Open |
| Catastrophic potential | Serious but limited potential |
| Negligible residual risk | Tangible residual risk |

In any industrial sector, the approach that is taken to risk management, including its methods, techniques and culture are attuned to the specific nature of its operations and technology. In this regard, in Great Britain, the nuclear sector and the rail sector have a number of important differences. One difference is that since privatisation of the railway network in 1994 rail has operated in a commercial environment. Despite the re-nationalisation of Network Rail in 2014 train operation is broadly undertaken by private companies who, given that their safety management systems are certified by the national regulator, are trusted to operate the railways in a way which is safe and does not unduly concern the public. Companies in the nuclear sector however tend to have a much stronger degree of government level accountability and oversight. The nuclear industry is charged with managing risk in an environment where there is a significant public interest and concern regardless of how low the level of risk is.

This first distinction is an important one which impacts the other differences in the sectors. In the nuclear sector the operations can be characterised in a number of ways. Sites are generally distinct and separate with a high degree of security from outside influence and protection from external factors. Systems are highly engineered, and the workforce who interact with them are highly trained and operate in a controlled environment with supervision where necessary. This environment lends itself well to robust analysis and monitoring of risks using good quantitative models of risk. It is therefore not surprising that the nuclear sector has pioneered techniques such as risk monitors and living probabilistic risk assessment [2]. In this environment, residual risks can be managed to a very low level and good evidence produced to demonstrate this and build assurance.

The rail sector is very different. At one level of abstraction the national rail network can be considered as one system, however it is delivered by a multiplicity of different organisations. The network is a mixture or old and new, with some infrastructure dating back to the Victorian era so infrastructure is in constant need of upgrade. Management of risk at the interfaces between systems and organisations can therefore become complicated. In addition the system is open to the elements, with risk affected by rainfall, snow and extreme heat, and there is very significant interaction with the public. Most fatalities on the railway occur as a result of members of the public interacting with the railway to intentionally cause themselves harm, or when inebriated [3]. The less controlled and defined nature of the system makes it more difficult to undertake quantitative approaches similar to those in the nuclear sector, although significant attempts have been made and are used [4,5,6]. Rail in Great Britain has sought to apply such techniques at least since the train collision at Clapham Junction in 1988, and commitment to data and reporting are arguably one of the reasons why the railway in Great Britain regularly has the best safety performance of any major railway in Europe. Regardless, this different environment creates a different culture, where a certain level of residual risk must be accepted and monitored.

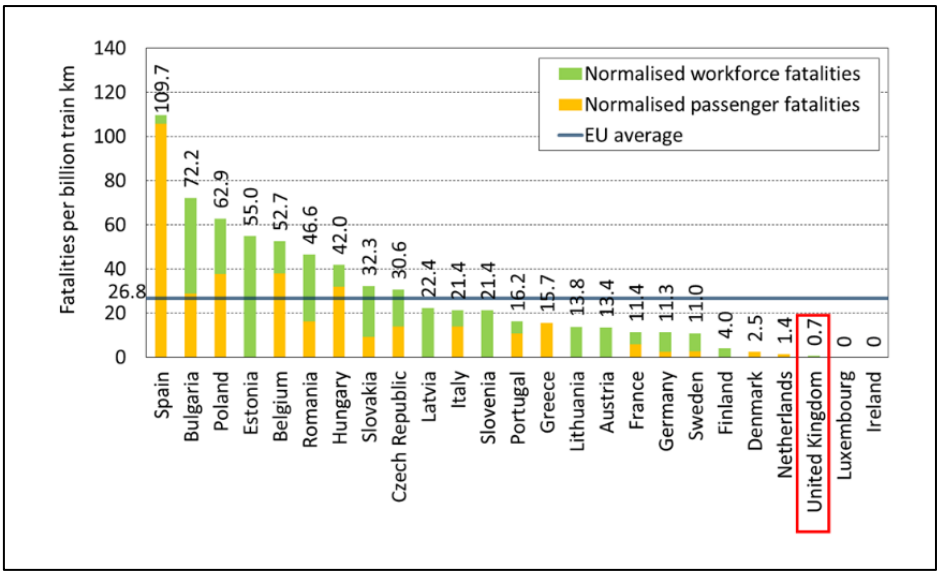


**Figure 1. EU Fatalities per Billion Train KM (source RSSB)**

**Figure 2. DRS Spent Fuel Transportation and Intermodal Freight Service**

## NUCLEAR INDUSTRY APPROPACH TO A RISK LEVEL AS LOW AS IS REASONABLY PRACTICABLE (ALARP)

In the UK, operators must seek the regulator's permission to commence activities where the level of individual and/or societal risk is deemed potentially intolerable, or where regulatory attention is expected by the public.

The concepts of ALARP and tolerability of risk are integrated into regulatory judgement by a framework established following a Public Inquiry [7] into the tolerability of risks from new nuclear power stations. The resulting framework [8] was enhanced by later work [9] and defines tolerability.

The framework incorporates a set of numerical targets that regulators use to aid their judgement when considering whether hazards are being adequately controlled, and risks reduced ALARP. More specifically, the targets guide regulators to where additional safety measures should be considered by the operator. Two types of targets are considered. Basic Safety Objectives (BSOs), mark the start of the broadly acceptable region for societal and individual risks. Basic Safety Limits (BSLs) are a minimum standard that the operator must meet. It is regulatory policy that a new (facility or) activity should at least meet the BSLs. However, in making a judgement where BSLs are met, regulators may consider that risks have not been reduced ALARP and insist on further safety measures. By the same logic, existing facilities, which may have been designed and constructed to earlier safety standards, or deteriorated over time, may exceed BSL, but be considered to have reduced risks ALARP – this situation may arise where suitable safety technology is not available, but not where reasonably practicable measures to reduce risk should be taken.

In making a decision, regulators will also consider whether additional safety measures would be 'grossly disproportionate' – for which there is no legal definition or established calculation. This term originates from a court judgement [10]. Evidence provided by the HSE Director General during the 1987 Sizewell B public enquiry can be used as a starting point and suggests that gross disproportion is a factor of up to 3 for individual workers (who accept their risk through their employment relationship). For the public, gross disproportion depends on the level of risk, but also on societal expectations that may undergo significant generational changes. Where risks are low (consequence and likelihood) a factor of about 2 was suggested. For higher risks, a factor of 10. This implies that a factor of 10 for risks in the vicinity of BSL is unlikely to be acceptable and. For hazards with very significant consequences, the factor may be larger still.

## RAIL INDUSTRY APPROPACH TO A RISK LEVEL AS LOW AS IS REASONABLY PRACTICABLE (ALARP)

In the GB railway, significant work has been undertaken to clarify the meaning and interpretation of the legal duty for companies to reduce risk to a level that is as low as is reasonably practicable. This was deemed necessary, as the railway industry saw that risk acceptance criteria that were developed for regulatory purposes and decision making by bodies for which the government was accountable were becoming used in the commercial rail sector. This was problematic as such approaches could not be practically applied to their decision making and were adding confusion and driving risk aversion [11] so, in terms of the mandatory responsibilities of companies for safety risk investment and management, the rail network specifically and pointedly drew a distinction between the way it interpreted its duties and the way that these duties were practically applied in other sectors where the government held the primary accountability. The rail approach was the described in the document Taking Safe Decisions which was first published in 2008 [1].

In summary, determination of whether an action is reasonably practicable involves balancing its risks, costs and benefits. The principle was set out in a Court of Appeal judgment in the case of Edwards [10]:

…a computation must be made…in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and

that, if it be shown that there is a gross disproportion between them – the risk being insignificant to the sacrifice – the defendants discharge the onus on them.

Comparison of the risk associated with an action and its cost, as implied by the Edwards judgement, is not simple because risk and cost are not measured in the same units so the risk is translated into a financial value using the industry 'Value of preventing a fatality' (VPF) and is currently approximately £2 million per statistical fatality averted. This figure was originally developed from studies of what a selection of members of the public said that they would be willing to pay for reduction in risk levels. Given this a proportionate approach would be to mandate expenditure of resources up to, and only up to, that level, but this does not sit comfortably with the judgment in the Edwards case, which requires expenditure, to be incurred unless it is 'grossly disproportionate' to the safety benefit. 'Taking Safe Decisions' sought to provide guidance to help determine under what circumstances and to what degree additional expenditure might be necessary. In summary this was that, as it was for the responsible party to prove that a measure was not reasonably practicable, they needed to err on the side of caution in making this judgement. Where significant uncertainties exist in the estimation of risk, as might be the case where the potential consequences in the risk assessment relate to the occurrence of major train accidents, this might mean expenditure significantly above the level implied by the VPF is warranted. But it pointedly does not include intangibles like 'societal concern' and it does not include 'individual risk' as this is about the totality of risk exposure to an individual and not about the change under analysis – the 'measure' using the terminology of Justice Edwards judgement. It also does not use blanket multipliers as this was not seen as an evidence-based approach.

R2P2 [9] and other guidance documents had suggested that additional expenditure above and beyond the VPF might be justified on the basis of 'societal concern' or the degree of 'individual risk'. The industry found this guidance confusing. There was no clear legal argument for the use of either factor to shift the balance in the ALARP judgement in this way. Taking Safe Decisions reconciled these documents by setting out a framework for how private companies undertake safety related decisions, their considerations in each case and how the decisions relate [12].

## Rationalising the two ALARP Approaches

The important point to remember is that the precise interpretation of gross disproportion has not been tested in the courts, and the judgement by Lord Justice Edwards, from 1949, incomplete thought it is, still stands as the definitive case law. Therefore neither approach is right or wrong. The interpretation of ALARP has in fact evolved to the needs and demands of each sector in different ways. However, despite their respective complexity, the two approaches described are clearly different. In order to help explain why different parties looked at risk acceptance and ALARP differently, the research in support of Taking Safe Decisions produced a framework to show how the different approaches aligned (figure 3). This framework postulates that, as described above for the rail approach, ALARP criteria are distinct from any more demanding criteria that might be imposed by government under certain circumstances and it is based on a rational and deterministic assessment of risks and costs only. However, companies might choose voluntarily to go beyond their strict legal duty for commercial reasons.

The framework also recognises that companies which are within the public sector and for which government is directly accountable, might choose to mandate more demanding measures based on their own view on the acceptability of risk. However such decisions require additional funding to implement and this needs to be found with the support of government. There are precedents in the rail industry for this approach such as when the Train Protection and Warning System was implemented via legislation. This was in response to raised levels of public concern following the accident at Ladbroke Grove in 1999 [13]. The installation of the system was not considered ALARP by the industry companies so the government legislated to make it happen and provided the necessary funds. This approach is consistent with the Nuclear interpretation of ALARP. In particular the concept of BSOs and BSLs as tools for regulatory permissioning that are complementary to company led ALARP judgement fits perfectly within the model. As a government run sector, additional safety

measures can be implemented – as long as the government is prepared to pay for them and as DRS is owned by a government body governmental and commercial decision making is broadly in alignment.

The net result is that DRS operates in an environment where a lower level of residual risk is consistently demanded and where risk acceptance culture is therefore materially different.

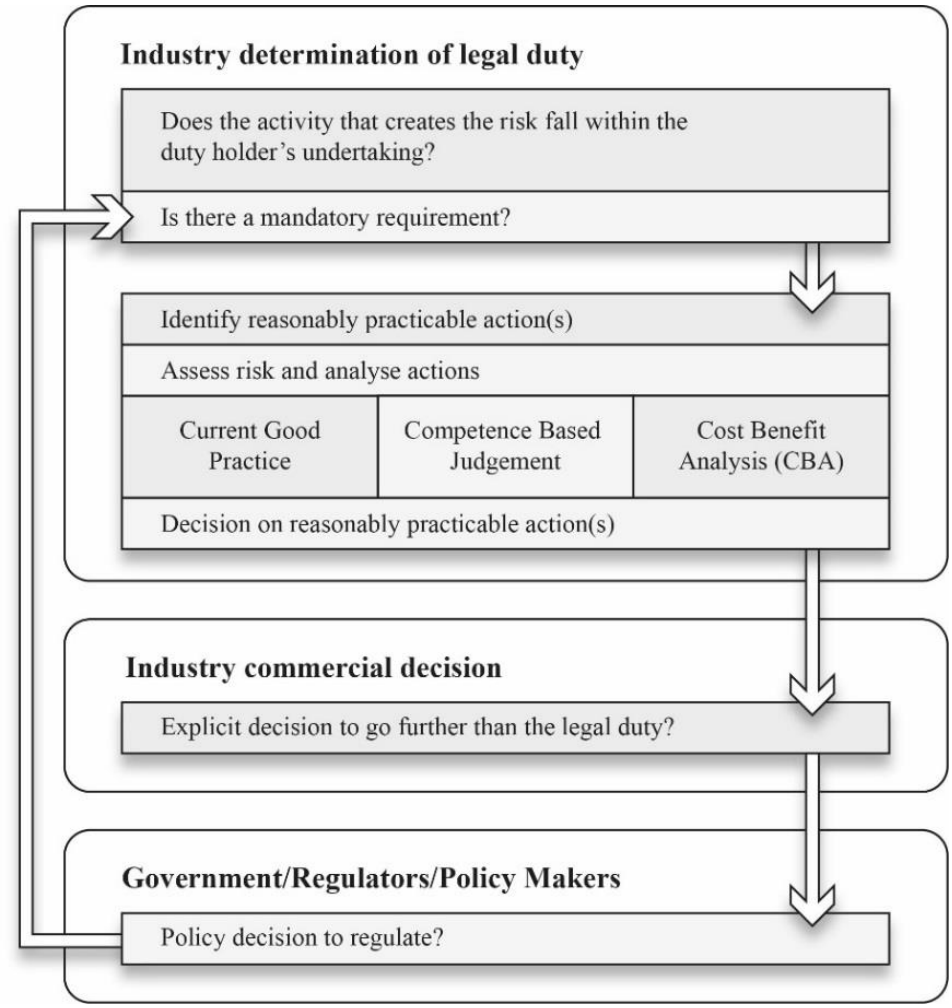


**Figure 3. Different Types of Decision and their Relationship to Legal Duties**

## CASE STUDY 1 – CYBER SECURITY

All industrial sectors in the modern era, are being transformed by digital and communications technology. This requires new partnerships between national governments and the various organisations and suppliers that have the technological capability to deliver the new systems and services. In this environment the threat of malicious tampering with industrial systems, from a range of potential actors, is increasingly high on the agenda. This is particularly the case for critical national infrastructure like that operated and maintained in the Rail and the Nuclear sectors. Significant legislative requirements now exist in particular the regulations on the Security of Network and Information Systems 2018 [14]. 'Operators of essential services' are required to develop a strategy and policies to understand and manage their cyber security risk. Security measures need to consider:

- Detecting attacks,
- Developing security monitoring,
- Raising staff awareness and training;

- Reporting incidents as soon as they happen;
- Having systems in place to ensure that they can recover quickly after any event, with the capability to respond and restore systems.

Broadly the approach in rail is one that recognises that the sector needs to go through a journey of culture change, encompassing its awareness of security threats, and the behaviours of people throughout the whole process of design, build, operation and maintenance. Such a change takes time. A cyber assessment framework has been put in place for self-assessment of capability, and it is expected that enforcement of the regulation will gradually become stronger over time.

However, given its footprint in the nuclear domain, where such threats have been understood and considered in risk management for many years, DRS has already made significant progress with its approach to dealing with such risks.

Managing risk is core to the DRS' mission to be a world leader in safe, secure and reliable nuclear rail logistics in support of the NDA mission. All DRS staff play a role in identifying, reporting and managing risks.

The consequences of a successful cyber-attack will most likely bring major damage to the company through regulatory, reputational and financial implications, and given DRS' ownership structure this damage could easily be extended to the nuclear industry as whole. To mitigate the occurrence of this risk DRS looks to implement a strong information security culture within its organisation as well as resilient security systems. These systems are designed to go further than requirements mandated by a rail company in recognition of the obligations placed upon the nuclear industry.

Due to DRS' involvement in operating Radioactive Material (RAM) transports DRS stewardship of Sensitive Nuclear Information (SNI) is of vital importance. DRS have an adverse appetite for security breaches that could result in the compromise of sensitive sites and material. As a nuclear regulated business, the company has accredited sensitive networks in accordance with the Office of Nuclear Regulation (Civil Nuclear Security) (ONR (CNS)). As part of these accreditations it is a requirement to regularly test systems both on penetration and disaster recovery, and these are tested both internally and by an accredited external body.

Testing is carried out by external, accredited companies who will be permitted controlled access to DRS networks. Vulnerabilities are identified using a number of techniques including penetration testing, Cyber Essentials Plus certification, annual IT Health Check and periodic internal vulnerability scanning.

In terms of personnel DRS have a Head of Risk who oversees risk management within the organisation, and supporting any risks at all levels within the organisation. DRS does not outsource IT services, it has an in-house ICT department providing support to our users, and therefore no unauthorised third parties (service providers) are able to access our SNI network.

The above considerations have contributed to the DRS ICT Strategy. The ICT strategy is deemed adequate to identify and manage risks and is designed to ensure that key business processes and systems are in place to fully support the company on delivering its business strategy. The objectives of the ICT strategy embrace all of the DRS values and cultures using knowledge, information, software and technology.

All of the above provides a level of cyber resilience which is much more aligned to the nuclear industry requirements than those which would be typically expected of a rail freight organisation. This also means that all other market sectors that DRS operate in benefit from this investment.

## CASE STUDY 2 - CONTINGENCY AND SCENARIO PLANNING

In order to support our transport of nuclear material DRS has been required to develop robust and detailed plans to deal with any reasonable operational event on the network in order to ensure completion of NDA

activities in support of the overarching mission. These plans are normally more extensive that would normally be expected within the rail sector and deal with all aspects of recovery, diversion, security, performance and operational resilience.

The Emergency Plan is intended to give a formulated and structured response to ensure people are safe, assets secure, minimise impact on the business and aid a speedy recovery to 'business as normal'.

Throughout periods of significant bad weather, DRS react very quickly to circumstances that are constantly changing by the minute on the railway. From planning for contingency routes avoiding particularly badly affected areas of the railway to staff commitment across all levels and departments, DRS maintain successful delivery for our nuclear and non-nuclear customers [15].

| Level | Triggers include (but not limited to): | Response Level |
|---|---|---|
| Major | • Major incident declared<br>• Terrorist/conventional attack on the rail network<br>• Major derailment/collision<br>• Loss of life/serious injury<br>• Major fire resulting in evacuation of site | Strategic (Gold):<br>• Emergency plan initiated<br>• Bronze and Silver levels initiated<br>• EMT formed<br>• Support Team initiated |
| Critical | • Interruptions to service/functionality such as severe weather<br>• Protestor activity | Tactical (Silver):<br>• Emergency plan initiated<br>• Bronze level initiated<br>• FHT formed<br>• Support Team initiated |
| Operating or engineering incident | • 'Cat A' Signal Passed at Danger (SPAD)<br>• Minor derailment/collision<br>• Allegations of speeding<br>• Near misses<br>• Non-suspicious fatality<br>• Severe weather (prior to service interruption)<br>• Accident/criminal act | Operational (Bronze):<br>• All incidents will be dealt with by the appropriate on-call Manager(s) |

**Figure 4. DRS Emergency Response Procedure & Contingency Plan for Each Sector Service**

The emergency and business continuity plans go hand in hand with our security procedures to underpin the level of resilience required to operate nuclear material transports to meet the standards required by the nuclear industry. These standards go well beyond those normally expected by a rail freight operator, however they do provide significant added value to critical transports e.g. high value Fast Moving Consumer Goods (FMCG) secondary distribution.

## CONCLUSIONS

Although borne out of the same principles of ALARP, the approach to risk management within the Rail and Nuclear industries have evolved over time. To adapt to the specific environment in which they operate in. Both have their own strengths and constraints and both operate effectively. As a rail company operating in the nuclear market, DRS is in a unique position which demands compliance with aspects of both industries. By

successfully doing this DRS now occupies a position of strength both within the nuclear transport market together with other markets where safe, secure and reliable rail services are critical to business success.

## ACKNOWLEGDEMENTS

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