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BRIEFING NOTE

ADEQUACY OF THE PROPOSED AMENDMENT TO THE THIRD PARTY LIABILITY FINANCE ARRANGEMENTS COVERING DAMAGES ARISING DURING AND IN THE AFTERMATH OF A RADIOACTIVE RELEASE FROM A SWISS NUCLEAR POWER PLANT

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THIRD PARTY LIABILITY FOR SWISS NUCLEAR POWER PLANTS

SUMMARY

Swiss Nuclear Power Programme: In Switzerland, the first commercial nuclear power plant was brought into service in 1969 at Beznau. Earlier, at the start of that year, the 30MWt heavy water development reactor located underground at Lucens suffered a fuel core melt down and, as a result, the plant was permanently shut down and abandoned in its sealed underground chamber after just one month of being licensed for permanent operation.[1]

There are five nuclear power reactors located on four sites with a total capacity of about 3,250 MWe, these being the two Beznau reactors at Döttingen (Aargau), and single reactor plants at Gösgen (Soleure), Leibstadt (Aargau) and Mühleberg (Bern). Combined, these nuclear power plants (NPPs) generate almost 40% of electricity annually produced in Switzerland, and there are also three small, nuclear research reactor facilities, one located at each of the universities of Bale and Lausanne, and one at the Paul-Scherrer Institute. In February of this year, the Swiss government Federal Council announced a new energy policy that centred about a mix renewable and gas-fired electricity generating plants and included for the five existing NPPs to be replaced with new nuclear-builds when appropriate.

Third Party Liability: At present, all operators must take out private insurance cover, for all accidents and incidents giving rise to a radioactive release and its radiological consequences, with a Swiss insurer of at least CHF 500 million for each NPP with an additional CHF 50 million for procedural and interest costs as these might arise. Separately, the operators also have to pay into a *Nuclear Damage Fund* that is administered by the Federal Office of Energy with the objective that this fund will be sufficient to make up any liability shortfall of the private insurance cover up to a total of CHF 1,000 million (1 milliard = CHF 1.10^9) to meet all third party claims for any single radiation incident. There are similar third party liability cover arrangements for the transportation of nuclear materials, although at a lower limit of CHF 50 (+5) million for private cover of damages and procedural costs, etc.. So far, the Swiss federal government has, apparently, considered these liability cover arrangements to be sufficiently robust that it has not been necessary for Switzerland to ratify the international nuclear liability treaties (notably the *Paris-Brussels Convention* and *Revision Protocols*) to which it is signatory.

However, presently under consideration are changes to the federal legislation that underpins the liability responsibilities for NPP and other nuclear activities in Switzerland. The *Act on Nuclear Third Party Liability 1983* is likely to be completely revised, particularly in that the private insurance cover required for each NPP is to be raised to CHF 1 milliard by private insurance or other financial security, and with the *Nuclear Damage Fund* providing for any shortfall up to a total of CHF 1.8 milliard available for all claims arising from any one incident. Now to be incorporated in the revised Act are features and provisions necessary to comply with the intended Swiss ratification of the Paris and Brussels liability conventions: particularly the introduction of CHF 450 million as the third tranche of compensation to be met jointly and severally by the Paris convention signatory states; a three year statute limitation period running from the time that the individual claimant was aware of the damage; a second limitation period of ten years after which claims may be subject to judicial review, in addition to the existing Swiss requirement of a 30 year statute barred period; and, amongst other things, the levelling of compensation in Switzerland to that shared by the other signatory states.[2]

The immediate advantage to potential third parties if Switzerland ratifies and becomes a full signatory of the Paris-Brussels conventions is, in addition to the increase in the assured primary/secondary funds (from CHF 1 milliard to CHF 1.8 milliard), the availability of the third CHF 450 million payment should claims (from all states affected) exceed the CHF 1.8 milliard together with, some would argue, the commonality of a single

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1 Built and contained in underground vaults at Lucens, the 30MWt heavy-water-moderated, carbon-dioxide-cooled experimental power reactor first came into permanent operation in late December 1968 but had been mainly shut down for modifications to the seals between the water and gas circuits. Within a few hours of the reactor being restarted, on 21 January 1969, water leaked into the carbon dioxide cooling system and corroded the magnesium alloy fuel cladding, with the resulting corrosion products partially blocked two fuel elements. One of these elements melted and burst, causing a steam explosion when the molten core material sprayed into the heavy water moderator. The reactor system had qualified for permanent operation just one month earlier. The last consignments of radioactive waste and contaminated materials, totally about 300 tonnes, were reportedly removed from the Lucens installation in or about September 2005 (Neue Zürcher Zeitung, 18 September 2003), although another source reports that decommissioning was completed in or about 1993 (Decommissioning in Switzerland, OECD, September 2006 - http://www.nea.fr/html/rwm/wpdd/switzerland.pdf)

2 The three tranches of CHF 1 milliard, 0.8 milliard and 450 million are determined from the existing requirements of the Paris Convention articles and are not the unique inspiration of the Swiss government. Also, it is possible for any Contracting Party to the Paris Convention to set a lower amount (minimum CHF 70 million) to be borne by the operator for nuclear facilities considered to be at lower risk.

jurisdiction for settling claims. However, that said, if the radioactive release incident originates from abroad then the CHF 450 million ceiling applies as a total limit to all claimants within Switzerland and, indeed, those claimants would have to abide by the seemingly inflexible statute limitation and barred periods set down in the conventions, although the federal government assumes that the Swiss legal tradition of being able to revise a judgement if new evidence of radiation injury should arise beyond the limitation and barred period time scales.

Adequacy of Third Party Liability Cover: The preliminary Federal Decree on the introduction of these changes to Swiss statute went to stakeholder consultation during 2007. Of the 75 or so respondents, a number[3] expressed reservations on or were entirely opposed to the notion that the amounts to be available for compensation and damages would be sufficient.

This Briefing Note examines this assertion that the monies set aside or assured for third party claims will be insufficient by, first, establishing a hypothetical incident in Switzerland that gives rise to an atmospheric release of radioactivity, modelling its dispersion and deposition, contamination and radioactive dose in the public domain and, from this, calculating the range of third party damages most likely to arise. The modelling and analysis undertaken relies upon European Community modelling software (COSYMA)[4] from which a valuation is made of the third party costs, sometimes referred to as the *external costs*, arising from a radioactive release from the Beznau NPP site in northern Switzerland. The economic analysis is drawn from a *Human Capital* approach[5] which accounts for the treatment cost of the immediate, short and longer term consequences (ill-health, fatality, decontamination, relocation, etc), but which excludes direct costs that would be borne by the operator (NPP post-incident stabilisation, decommissioning, loss of contracted generation sales, etc).

For the incident resulting in radioactive release, first it is assumed that some unspecified high energy event occurs sufficient to degrade (melt) the fuel core and breach and/or bypass the secondary containment thereby releasing a high lofting puff of radioactive fission product contaminated material from the operating reactor. Thereafter, a 1 hour period throughout which there is continuing thermal input (from the irradiated reactor core fuel and/or some external event such as fire) giving rising to a moderately energetic plume release, following which the external heating ceased and the reactor containment remains open or bypassed for a further 4 hours until some form of emergency closure of the containment is effected. This incident is determined to have a frequency of occurrence in the range of 1 in 1 million to 10 million for each year of reactor operation if such is triggered by an accidental (ie system malfunction or failure) or external (seismic) event, although much the same outcome could result from a non-probabilistic (or inevitable) occurrence such as, for example, a determined terrorist act.

Valuations of the third party costs are undertaken for a number of applications of the nominated incident scenario. These include a release from one of the existing 365MWe pressurised water reactors (PWR) at Beznau and, relating to the Federal government's recent energy policy statement concerning a likely nuclear new-build programme, it is assumed that the existing nuclear site at Beznau will be utilised for the development of the much larger 1,600MWe European Pressurised Reactor (EPR). Also, because Switzerland has in place a programme to utilise reactor-grade plutonium fuel (MOX) at Beznau, the impact of a radioactive release from the same EPR NPP partially fuelled with MOX is examined in comparison with a low enriched uranium (LEU) fuelled reactor core. In terms of the real accidental release at Chernobyl in 1986, and postulated releases used in the design acceptance process for NPPs,[6,7] the worse case scenario for this analysis is relatively moderate.

The COSYMA modelling of the incident scenario for different release fraction subsets[8] (ie severity of release) yields the immediate, interim and longer term aftermaths of the incident as a probabilistic based projection of the

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3 These included the Ticino Canton, the political parties PS, PES and the SES and the trade union Travail.Suisse, the French anti nuclear coalition Sortir du Nucleaire and the environmental group Greenpeace.

4 COSYMA – **CO**de **SY**stem from **MA**RIA which is an adaptation of the mainframe *Methods for Assessing Radiological Impact of Accidents*, EUR 16240 EN.

5 In the Human Capital approach the value of an individual is determined by his or her production potential and the impact of a radiation induced health effect is determined by its effect on this production potential in terms of loss of contribution to the economy, Other more directly determined costs, such as decontamination, etc., are also accounted for in the analysis.

6 US Nuclear Regulatory Commission, *Reactor Safety Study, an Assessment of Accident Risks in US Commercial Nuclear Power Plants*, WASH-1400, NRC 1975

7 Kelly, G et al, *An Assessment of the Radiological Consequences of Releases from Degraded Core Accidents for the Sizewell PWR*, NRPB-R137, 1982.

8 To describe the total radioactive release 7 different groups of radionuclides have been defined according to their chemistry and volatility, each with a specific release fraction for each of the 3 phases of the incident scenario.

individual risks, extent of land area and population numbers requiring countermeasure actions, and the early and late radiological health consequences for the specific location at Beznau. The COSYMA database is seeded with European wide population, terrain and agricultural information and the dispersion is related to an archive of actual meteorological conditions. The COSYMA valuation routines have been upgraded in terms of the current Swiss GDP (Gross Domestic Product) and appropriate upgrades have been made to certain of the cost-bases linked to COSYMA.[9] The trajectory of the radioactive release plume and the footprint of radioactive fall-out are also projected from Beznau using satellite archived meteorological data (NOAA) to graphically illustrate the tracts of land and communities at risk.[10]

The extent of the radiological consequences, and hence the degree of the damage inflicted upon third parties, is determined by three different fractions of release of the reactor fission product contents. The severest case used in this analysis is directly adapted from the most recent study by the authoritative US Nuclear Regulatory Commission (NRC) for the Sequoyah PWR NPP,[11] the second, moderately severe release is taken from the UK data adapted for the Sizewell B and Hinkley Point PWR NPP proposals,[12] and, for the third case, the release fractions specified for the AREVA EPR design,[13] although considered to be hardly credible, have been adopted for the EPR analysis.

Third Party Liability Valuations: Expressed in terms of probability of occurrence, the third party liability valuations are:

TABLE 1 COSYMA VALUATIONS

		FRACTILE CHF x1.E+9 - MILLIARD				
CASE	NPP	MAXIMUM 99TH	MEAN	50TH	RELEASE FRACTION MODEL	SEVERITY
1)	Beznau 356MWe existing LEU PWR	89.76	**11.90**	7.35	NRC Sequoyah Release	WORSE
2)	Beznau 1,600MWe LEU EPR (assumed)	257.14	**51.05**	37.74	NRC Sequoyah Release	WORSE
3)	Beznau 1,600MWe LEU EPR (assumed)	71.90	**10.47**	7.19	UK Sizewell B	MODERATE
4)	Beznau 1,600MWe 30%MOX EPR (assumed)	110.9	**22.27**	16.9	UK Sizewell B 30% MOX	MODERATE
5)	Beznau 1,600MWe LEU EPR (assumed)	0.44	**0.05**	0.03	EdF 0.03%/day Bypass	LEAST

The above TABLE 1 valuations are for Beznau, although much the same would apply to the other Swiss NPP sites give or take variations in local and regional population variations. The valuations for each of the five cases are expressed in terms of probability fractiles giving, on the basis of probability, the range of least and most expected outcomes (values). For example, the 99th fractile would be expected to occur once every 100 incidents, the 50th fractile is the statistical average, and the centre **MEAN** column is the *expected value* that is most likely to occur once that the radioactive release has occurred from the NPP.

Cases 3) and 4) of TABLE 1 show the expected increase in cost of third party damages if an assumed EPR NPP operating on the Beznau site is fuelled with MOX fuel (4) compared to the same reactor fuelled with low enriched uranium fuel (3). The doubling of the costs arises from the marked radiological penalty accompanying the use of *reactor-grade* MOX in the reactor core. At and downwind of Beznau, the (expected value) projected deaths in the longer term (projected over 50 years) triples over the LEU fuelled reactor for a 30% MOX core load (from 4,690 to 15,960 fatalities or thereabouts) and, adopting the French evacuation thresholds (because

9 COSYMA uses COCO-1 – *Cost Of Consequences Off-site* – for values but these date from c1997, although it is possible to upgrade this by GDP revision to account for present costs but there are some shortfalls associated with this - shortly COCO-2 is to be issued to bring the software completely up to date.

10 For this the archive date of 16 October 2007 was chosen for no other reason that it was the date of receipt of the instruction to undertake this project.

11 Davis, R. et al *Reassessment of Selected Factors Affecting Siting of Nuclear Power Plants*, NUREG/CR-6295 NRC, 1997

12 For a fuller discussion of these source terms and release fractions see Large J H, *Évaluations Des Consequences Radiologiques De Rejets Accidentels Du Reacteur Epr Proposé En France, (Et De Certains Reacteurs Existants)*, November 2006 - http://www.largeassociates.com/3150%20Flamanville/r3150-final-FR.pdf

13 *Application for the Authorisation to Create a 3rd Nuclear Power Unit on the Flamanville Site, Ch V1, Consequences of Radiological Accidents*, p33, EdF May 2006.

much of the sample fallout is in France) there will occur a doubling of evacuation numbers (from 153,700 to 315,000 or thereabouts), and there will be corresponding increases in the morbidity rates and numbers requiring to shelter. For those individuals caught within the overhead plume and fall-out regions downwind, the greater plutonium content of a MOX fuelled release results in an increase of the contribution of the inhaled dose pathway from about 80% for an LEU core to 96% for the first few hours of exposure. This particular finding emphasises the crucial importance of implementing countermeasures to mitigate public dose but, that said, the reduction afforded by sheltering only has an hour or so of worth because the building space itself fills with contaminated air. Since it is not practical to provide respiratory protection to the numbers of population likely to be at risk, a speedy evacuation is the only practicable dose reduction option available.

The COSYMA modelling arrives at these numerical projections because it slavishly adheres to its instructions which are set in accord with the French emergency planning regime and its prescribed levels of dose that trigger specific countermeasure actions. However, clearly, confronted with such an onerous evacuation requirement in a real situation, the emergency response would have to be modified (ie increasing the tolerated dose before evacuation) to stave off ensuring chaos that would most probably precede a collapse of state organised public order. Of course, injudicious relaxation of the evacuation (and other) dose thresholds could markedly increase the long-term rates of morbidity and mortality, thereby increasing the human capital cost.

In this and other respects, the COSYMA analyses reported here are not intended to provide precise forecasts of third party cost valuations. This is because not only is a much greater detailed input required to define the near field data, population density and meteorological conditions, for each locality and how individuals and the population at large would react, particularly if left uninformed, lacking essential information and direction on what to do and when best to do it. That said, the results do provide reliable indicators of the trends and indices of the probability and magnitude of the third party costs accompanying a radioactive release, accidental or otherwise, for the moderate to severe incident scenarios modelled.

The striking difference between the sets of EPR results comparing Table 1 Cases 2) and 3) to the EdF Case 5) results from EdF's assertion[14] that all seriously damaging incidents, including terrorist acts, can either be *'practically eliminated'* or contained within the absolutely failsafe secondary containment of the EPR. This claim, which is not at all substantiated by information and data available in the public domain, is not accepted for the valuations of Cases 2), 3) and 4) for which the pragmatic approach is adopted, this being that accidents can happen and that NPPs are vulnerable to both unforeseen accidents and external events, including extreme acts of terrorism.[15,16] For Case 5) the assumption is that the main containment (the dome) of the reactor remains substantially intact and that the release of radioactivity is via bypassing the containment at the rates specified in the French EdF nuclear safety case[13] – for this scenario the pressurised containment is assumed to continue to steadily release at a rate of 0.03% per day over a period of 6 days.

Amongst themselves the results are comparable and show, with exception of the EdF very low containment bypass release fraction rate (0.03% per day), that a moderate to serious incident the projected third party will give rise to external third party costs that all by far exceed the sum total of the three tranches of compensation (CHF 2.25 milliard) available under the revised nuclear liability legislation proposed by the Federal government. The TABLE 1 results are not directly comparable with other valuations of the consequences of reactor accidents (eg because of different locations, reactor types, release fractions, etc) that have been reported by the OECD.[18] The OECD collation of various valuations mainly undertaken in the 1990s spans a range of six orders of

14 EdF is referred to here because it will be the operator of the Flamanville EPR so it has to prepare and submit the nuclear safety case from which the release fractions have been extracted for use in these valuations.

15 As the output size of successive generations of NPPs increase, so does the amount of fuel held in the reactor core, and as the utilisation of this fuel is increased by greater irradiation, or *burn-up*, the potential radiological impact of a radioactive release also increases. To the contrary, the public tolerance to radioactivity, the acceptable radiological health impact, sensibly remains constant or, indeed, may reduce in line with changes of public perception and tolerability of radiation specifically and health harm generally. Essentially, each successive newer generation of NPP has to be more effective in reducing the size of release fraction of any untoward radioactive release (ie the actual release has to be smaller) or, where this is not at all practicable, the type of fault condition or incident has to be eliminated. This requires each successive NPP generation to have a greater resilience to accidents and external events, thus confounding the claim that each generation of NPPs is *'as safe as can be'*. Put another way, since several of the safety features of the EPR cannot be practicably back-fitted to the existing NPPs, a rationale interpretation is that if the EPR is *'safe'* then the existing NPPs are *'unsafe'* in comparison.

16 Another unproven conjecture forwarded by EdF is on the resilience of the EPR design against acts of terrorism, with the claim that whatever the nature of any well planned and implemented terrorist attack, the radiological consequences would be no worse than those arising from the nominated and tolerable *design basis* accident. In other words, well planned and executed intentional and intelligent terrorist acts that seek out the vulnerabilities of the NPP and which might even extend into disrupting the effectiveness of the countermeasure response in the aftermath, would be no more challenging to the NPP and have no greater radiological and/or financial consequence.

magnitude when each are commonly set at 1994 values and exchange rates. The OECD results include Swiss INFRAS & PROGNOS study range of 0.001 to 0.17 €/kWh that adapted the Chernobyl consequences as references values for the Mühleberg NPP[17] and, even if not strictly compatible, comparing the present valuations with the OECD collation is favourable.

Of the OECD collation about two-thirds of the previous valuations significantly exceed the pro-rata sums of money set aside in the proposed revision to third party liability. The OECD use of the projected total kilowatt hours of generation as a basis of comparison of the direct costs (€/kWh) is not particularly convincing because it may transpire that the incident giving rise to these costs may occur at an early point in the NPP's operational history as, for example, at Three Mile Island where the plant had been in commercial operation for one year prior to the fuel core melt down of 1979 and, of course, at Lucens where the reactor was abandoned just one month after commencing fully licensed operation.

In Summary: The public expectation is that liability regimes and other means of financial security provided for this purpose ensure that the operator of the NPP (or other nuclear activity, including transportation) would compensate all consequences arising from a nuclear incident. On the face of it, the Swiss federal government's proposal to revise the third party liability arrangements for nuclear power plant operators seems generous because not only will it increase the cap on the operator's liability and the amount to be covered by the *Nuclear Damage Fund* but, in addition, it will introduce a new tranche of funds that can be drawn from the pool of Paris convention signatories. However, even a doubling of the present funds available to CHF 2.25 milliard would not make any significant inroads into the most likely costs of remedying and compensating for the consequences of a moderate to severe radioactive release from an existing or proposed Swiss NPP.

Moreover, the Swiss approach might be considered to be just a small step in the evolution of how liability of highly hazardous industrial activities, such as nuclear power plants, is to be equitably managed. Prior to the accident at Three Mile Island of 1979 the emergency planning, preparedness and post-incident management regimes simply refused to acknowledge that large-scale radioactive release could occur and, accordingly, liability and compensation systems were geared to 'manageable' incidents and short-term consequences. Now, following Chernobyl of 1986 and the terrorist actions of 9/11 that were seemingly not constrained by any moral boundaries, the focus is somewhat belatedly shifting towards the long-term aspects of radiological incidents and the recognition that there is no single *'cost of an incident'*.[18] The point here is that considered from a third party liability and compensation perspective, the choice of the most appropriate emergency response measures to have in place, size and operating regime of the reactor (to limit to amount of fission products available for release), location of the plant, etc., might well be completely different to the optimum features determined from, say, the perspective of power generation choices, efficiency, capital investment, etc.. Indeed, if the consequences are viewed not just in terms of *human capital* but also as a *subjective valuation* then nuclear power as a means of generating and supplying electricity might be entirely outlawed.

The third party compensation system proposed by the federal government simply fails to fulfil the public expectation that *all* consequences of a nuclear incident will be compensated by the operator who has ultimate responsibility for the operation and safety of the NPP, this is particularly so because the amounts set aside would be woefully inadequate to cater for a moderate to severe scale of incident. Also, little or no provision is made for the risk that the operator of the NPP, being burdened by the direct and internal costs of stabilising the nuclear plant, those of managing and securing the NPP site over the longer term, and the loss of capital assets and contracted income for electricity supply, might well be forced into liquidation thereby passing these direct costs onto the Swiss state and ultimately to the Swiss taxpayer. The direct costs of decontaminating, cleaning up and maintaining reactor containment closed can be, depending on the type and severity of incident, very costly and time demanding, as shown by the post accident works at Three Mile Island which incurred costs of about US $975 million and occupied twelve years to completion.

The proposal to ratify the Paris convention serves little more than to endorse an approach mired in the pre-Chernobyl perspective that severely damaging incidents cannot happen, that somehow NPPs are exempt from serious accidents[19] and terrorist attack,[20] and through which the Paris signatory states continue to focus on short-

17 *Externe Kosten und Kalkulatorische Energiepreiszuschläge für den Strom- und Wärmebereich*, Bericht 724.270, Bundesamt für Konjunkturfragen, Schweitz, 1994.

18 *Methodologies for Assessing the Economic Consequences of Nuclear Reactor Accidents*, NEA, OECD, 2000.

19 For the incident scenario considered here, generally for accidents and external events (ie non-human intervention acts) the core damage frequency is usually assumed to be in the range 1 to 10E-6 per reactor year of operation with the Swiss PWR plants assumed to gave a core

termism and that the costs of any credible radiological incident can be prescribed. In effect the Paris commission places a cap on the liability of the NPP operator by introducing the somewhat ambiguously defined periods beyond which third party claims may be invalidated at Law, being an arrangement that could well be punitive to many individuals who would be at risk of developing a radiation-induced trouble years if not decades after their first exposure to radiation.

Most of all, it might be argued, by putting in place these clearly inadequate provisions for third party compensation the Swiss federal government is adopting a blinkered and astigmatic approach as to how the continued operation of existing NPPs and the choice of their future replacement might be properly and comprehensively justified from the public's perspective.

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melt frequency of at 2E-6/Ry, although in a 1993 study for Mühleberg the risk of a large release was assumed to be <1E-9 – this probabilistic frequency approach cannot, of course, be applied to malicious acts, such as terrorism, etc.

20 In presenting its nuclear safety case to the public for the Flamanville EPR, EdF declare that any untoward event that could credibly occur to the EPR would not result in unacceptable radiological consequences to members of the public. EdF claims that all reasonably foreseeable accidents and external hazards will not jeopardise the fundamental nuclear safety of the plant, so much so that there are no foreseeable circumstances under which the radiological containment structures of the nuclear island will be breached. Indeed, with the severely damaging incidents '*practically eliminated'*, so EdF argues, the resilience of the plant to accidents and external hazards is sufficient to safeguard against terrorist and malicious acts, including the crashing of a fully fuelled commercial airliner on the nuclear island. However, the history of technological development is littered with examples of unforeseen failures of hi-tech systems with, for example, with the *Challenger* and *Columbia* shuttle failures reverting NASA's one-in-a-million design criterion to a chance of just 1:57; the *World Trade Center* towers designed to withstand a Boeing 707 crash were to be defeated by the advance in aircraft design over the years; and, of course, the unsinkable ship *Titanic* sank on its maiden voyage. The axiomatic fact is that all engineered systems are at risk of catastrophic failure and that, moreover, it may not be possible at the time of design to foresee all possible causes and mechanism that could initiate and cascade through to failure: an iceberg so far South, a detached piece of polystyrene insulation damaging a ceramic tile, and suicidal terrorism successfully pitting one technology against another. Moreover even those events that might be reasonably foreseen, not all are entirely predictable in terms of frequency or chance of occurrence and, of course, acts of terrorism are totally beyond prediction by *a priori* and probabilistic analysis upon which the NPP nuclear safety case so heavily relies.