Nuclear Waste Management Organization of Japan

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Record of the 5th NUMO Technical Advisory Committee (TAC) meeting

Tokyo, 12-14 June 2019

Background

Since the 4th meeting of TAC, NUMO has used the input provided by TAC to finalise the "pre-siting, SDM-based" safety case (the NUMO Safety Case, noted as SC in the following), which has now been published in Japanese and is under review by the Atomic Energy Society of Japan (AESJ). The translation of the SC into English and first internal independent technical review of the SC documentation is ongoing. A particular focus for this meeting is thus reviewing the finalisation process for key SC chapters from the particular perspective of an international external review, together with appropriate Terms of Reference (ToR) for such a review (Block 2).

The list of participants (TAC members) of the meeting is given in Appendix 1, while the programme of the meeting is included as Appendix 2.

This record provides brief documentation of discussions at the meeting, following the "Chatham House Rule" of not attributing comments to specific participants. In lists of discussion points, each topic raised is noted by a bullet and any response is indicated by ---.

Day 1: Wednesday 12 June

Block 1 Introduction & goals

1. Welcome (Hiroyuki Umeki & Takayuki Sasaki)

The welcome was given by NUMO Executive Director Dr Hiroyuki Umeki on behalf of Dr Shunsuke Kondo, the president of NUMO who was attending EDRAM, thanking TAC members for their time in providing their valuable support. He mentioned key developments since last TAC meeting – in particular publication of the SC in Japanese and the associated press conference, which caused considerable interest. The SC was welcomed by AESJ, who are now reviewing it. The support of TAC in production of this SC was thankfully acknowledged. The next step will be review of the English SC by NEA. After production of the SC, NUMO is initiating a range of R&D – which will be reviewed also by TAC during this meeting.

Chairman Prof Sasaki extended Dr Umeki's welcome and thanks to the foreign TAC members for travelling to Japan. He noted the importance of the AESJ review and potential use of this to modify the SC before the NEA review.

2. Current status of the SC and objectives of TAC meeting (Tetsuo Fujiyama)

An overview of the goals, programme and logistics by Group Manager Tetsuo Fujiyama (NUMO TAC coordinator) provided guidelines for the rest of the meeting. He started by summarising the input of previous TAC meetings and, in particular, the recommendations for SC finalisation. This was followed by an overview of modifications of the last draft during the process of finalisation for AESJ review. An important constraint noted was the delay in finalising the Chapter6 SRs, which is still ongoing.

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The production of the English version of the main SC report is ongoing – with particular focus on Chapter 6 and 7. Work on translation and review of Supporting Reports (SRs) is planned, but has yet to be initiated.

Progress in the AESJ review was summarised – feedback has been generally positive, with no serious technical criticism to date. Examples of comments were presented, which generally focus on requirements to improve clarity of arguments.

The timetable for finalising the SC following AESJ review is still rather uncertain – but should be better defined by spring 2020. This will be considered further when discussing next TAC meeting on Day 3. Finally, the aims and structure of the remaining blocks of the TAC meeting were outlined.

Questions and comments included:

- AESJ comments seem relevant. TAC had previously noted about assessment of evolution of EBS (Engineering Barrier System) – has this been identified?
  ---again not so far.
- Other programmes have issues focused on uncertainties associated with evolution understanding rather than doses as such, has this been picked up?
  ---one case was evolution of plug performance, explained in terms of known stability of bentonite.
- Have there been any technical issues brought up in communication meetings?
  ---suggested use of collective dose is an example.
- No question of waste treatment technology improvement in particular on TRU waste?
  ---focus on HLW so far, so not yet.
- Good that there is high level of interest, especially as generic SC hard to communicate. Would it be worth producing another report on arguments to support feasibility of safe disposal in Japan for non-experts (e.g., 20 page report)? Should be related to reference scenario explanation. This remark was made as the safety case report is now very much described as a procedure, while a lot of people will be looking for facts. The H12 demonstrated that it was feasible and since then a lot of additional information has been gathered which does not seem to invalidate this belief. This could be summarized in a 2020 argument report, but needs to be kept at the very general level in this early stage. It could provide an answer to the question: why does NUMO believe that safe disposal in Japan can be done in the geological context?
- Impressed by numbers of attendees at meetings – where did audience come from and what is their main interest (e.g. much interest is shown in the UK by potential contractors)? Are decision-makers involved? Any government decision-makes? If so, these should be specially targeted.
  ---includes potential contractors, but also regulators and academics not specialising in this field. Also experts from nuclear opponents.
- Have different comments arisen depending of the audiences (one with public audience, the other with more “technical participants”)?
  ---not really.
- Explanation of SC to public: should start from explanation that geological disposal is needed – internationally seen to be critical, maybe even more so at start of volunteering process. The fact that this is specified in law is important but not sufficient.
- How will NUMO respond to AESJ comments?
  ---will result in modifications, but hopefully not major revision unless absolutely essential.
- Will there be an additional report on long-term stability?

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---there will be synthesis from existing material, capturing progress since H12.

Block 2 Progress since TAC#4 / responses to TAC recommendations

The focus of this block is checking with TAC on how their previous comments have been addressed in the work carried out since then. The presentations include extensive technical material which are not reproduced in the record, which focuses on the TAC discussion.

2.1 Design & engineering (Ch. 4) (Satoru Suzuki)

Discussion points were:

- With regard to the footprint of the disposal site, WIPP experience indicates that dividing ventilation into modular sections would be valuable reduce impacts in case of accidents that could cause release of airborne RNs. This could be worth considering, especially for TRU (such releases not credible for HLW).
  --- WIPP experience is captured and the importance of emergency ventilation system when radionuclides are released is described in the chapter 4, though tailoring layout of the facility for the purpose of reducing the influence of the release of radioactive materials has not been considered yet. More generally, design of the repository would be carried out coupled to operational accident assessment for those resulting in RN release. (*Supplement*; it should be noted that although, in the case of WIPP, drums are buried directly underground, in the case of geological disposal in Japan, waste is assumed to be solidified or enclosed in the waste package. So the WIPP and Japanese cases are different in the extent to which measures against RN leakage from the drum are already taken in Japan).
- Failure in waste package QA was an issue in the WIPP accident. Lessons like this also need to be learned.
- The point that NUMO is working on improving the repository design for the disposal site is evaluated as very important– but recommend going back to a full set of requirements and arguments of their justification (needs a multidisciplinary team to revise & update – possibly as a future project), and carrying out an assessment on how the EBS will be developed in different siting environments.
  --- Agree. In Chapter 4, repository was designed with basic requirements applied to each SDM.
- It looks like an excellent idea to consider PEM as a disposal concept of TRU waste – but you maybe need to avoid void space; e.g. did you consider any measure to fill void space with crushed rock? Does this option feedback to requirements, especially potentially conflicting pre- and post-closure safety requirements? What impact does removal of mortar have on system evolution? In any case, something for the future that does not need to be mentioned in the text for NEA review.
- 4 Groups of TRU – each with different issues / requirements / concerns – with maybe some wastes having specially operational safety concerns (Bituminised waste) and others more post-closure (Hulls & ends). Note also principles in terms of avoiding interactions between HLW and TRU waste as well as, in some cases, interaction between TRU groups. TAC suggests NUMO may, in the future, usefully capture international experience in this area.
- Terminology related to fractures (<1km) needs to be explained carefully to clarify that interest is predominantly water-carrying features.

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- ---Agree. As mentioned, fractures of less than 1 km are present in the emplacement panels and were taken into consideration in the determination of whether or not to dispose wastes in particular locations.
- At this early stage of programme, there is great flexibility and hence requirements allow designs / EBS material choices now examined to be understood as only representatives out of a wider set – which would also allow R&D priorities to be identified. A general strategy on how to deal with current options of disposal concepts is needed. Some are included now in Chapter 4 (although these are not the most safety relevant, e.g., horizontal versus vertical for HLW), while some will be looked at later in the process (e.g., other canister materials were mentioned). At least a diagram explaining the current approach and acknowledging that in the future these will be fully requirements-driven would increase understanding.
- Suggestion to distinguish design principles from design requirements in order to make design requirements to be set more flexibly. Some design principles will drive some solutions. Keep also flexibility in technical solutions for waste processes as much as possible and recognise that the RMS is a key tool for the future.

2.2 Operational safety (Ch. 5) (Satoru Suzuki)

Discussion points were:

- The approach to pre-closure safety assessment is good but external initiators are not mentioned at all.
  --- External initiators are excluded at present because no site-specific information is available. Nevertheless, they will be included in future.
- Emphasise alternatives to trucks to avoid fire risks (e.g., rail).
  ---Agree. In Chapter 5, underground fire risk was assessed based on the results of the design presented in Chapter 4. In the future, based on these results, we will start to study measures to reduce the risks of underground fires.
- The value of 180°C taken by NUMO for bituminised-nitrate thermal runaway seems to be high compared to recent considerations in France. An international review is ongoing on such waste following the French Safety Options national review and this work should be followed as it is likely that the assumed initiation temperature will be significantly decreased. It should be possible to explain the basis of setting the initiation temperature of 180°C before the NEA review.
  --- Initiation temperature of 180°C is based on research results by JAEA on asphalt solidified waste in Japan. We will prepare English-language materials to explain this detailed data before the NEA review.
- Consistency of drop analysis, would HLW worst case not be drop on lid?
  --- The case where HLW drop on lid was also considered – but no stability problem was seen.
- Fire – can consideration of spread only on one side of the truck / only rear tires / no explosion of fuel tank be justified given the data presented on maximum thermal output / initiation heat flux, effects like tyre explosion and chimney effects in ramps?
  --- Data on combustion and detailed analysis conditions are given in a supporting report. Effects such as tire explosion are not considered in this study. Such effects will be considered from now on as needed.
- "What if?" RN release scenario is needed (based on trends in nuclear industry assessment of severe accidents), even if all indications from accidents analysed are that this is very unlikely.

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--- NUMO would like to be able to develop these in the future, referring to past evaluation examples of similar facilities.

2.3 Post-closure safety (Ch. 6) (Keisuke Ishida)

Discussion points were:

- No mention of model / database verification / validation, which would be expected to be part of model development? This is tricky but should be noted as a challenge – especially for TRU. TAC did not have a consensus on how important this was at present, but "sanity checks" and "scoping calculations" can be important. The entire assessment of fractured rocks will be tricky, but international expertise must be compiled and used to better understand far field performance. Maybe AI / machine learning could also contribute here.
- Consideration of evolution is good, but impact of low saline waters on erosion of bentonite is not considered (SKB's and Posiva's research also supported by EU project BELBAR suggest bentonite is generally stable only when charge concentration > 8 mM. This limit appears valid for a large range of different bentonite materials).
  ---NUMO reference bentonite is somewhat different in properties to the bentonites considered in Europe
  ---in some cases (TRU, PEM) the bentonite may be surrounded by concrete, which will alter inflowing water chemistry before there is any chance of bentonite erosion
  ---the low salinity water is simply taken from the national database and would typically be representative of more permeable formations near recharge points, so probably of little relevance to the deep geological settings considered in the SDMs.
- To what extent are effects such as uplift and erosion considered (in the most likely scenario)? It is a fundamental question to what extent some of the long-term evolution impacts ends up in the reference scenario or not. If it has a likelihood of occurrence around 5%, it should be part of the reference. This is where the NUMO reference might be different from the reference evolutions in other programmes. Of course, this also depends on the assessment timescale.
- Are gas effects considered? These can be very important on 100ky timescale (especially for TRU). 2-phase flow calculations may be needed. May also need assessment for steel overpack
  ---consideration of such effects in scenario development: transport pathways through buffer generated, but considered closed after saturation. Should be identified as key issue for the future (e.g., checking requirements for J case).
- Claimed Base Case includes most probable parameters – but this is not the case, many unrealistic (e.g., OP lifetime).
- Alternatives to river release – small lake, marsh, springs…: should these not at least be discussed?

2.4 Safety case overview (Ch. 7) and conclusions (Ch. 8) (Tetsuo Fujiyama)

Discussion points were

- Uplift / erosion: could be picked up by NEA, so should include at least semi-quantitative analysis.
- How can NUMO modify a SC that is already provided in Japanese? Can modifications be taken over into the English version or other key aspects be covered by an additional letter to NEA?
  ---Should be focus of closed session.

- Development needs must be captured in Ch. 7 for NEA.
- Disagreement within TAC of identifying pros and cons of sites / designs: but all agree need to be able to show how NUMO meet requirements even though sites cannot be compared at present.
- Repetition of previous material can be justified if it is required to be stand-alone (especially if readers focus on chapters 1, 2 and 7 only).
- General arguments on feasibility could be introduced at the beginning and only thereafter limitations leading to R&D priorities. Stress rigorous SC only after site selected.
- No extra detail should be added – emphasis on making the content more easily accessible for the reviewers by providing a clear structure.
- Emphasise flexibility, which responds to the one fixed point – the inventory. The assessment results in terms of doses should be played down and focus instead on demonstrating ability to actually carry out assessments.
- How long does the chapter need to be – could it be much shorter?
  ---Ideally short and sharp, with further details in SRs, but difficult if too different from the J original.
- Are the goals appropriate? They are understandable and achievable – but key aspect is assessing limitations and setting priorities for future work.
- Who is the target audience of Ch. 7?
  --- Same as the rest of the report.
- Title maybe better as "Progress towards initiation of stepwise SC development."
- Consistency checks may be particularly important.
- How is QA assured?
- Mention of management tools should it be in Ch.7 (or Ch. 2)?
- 7.5 SC as a template: should this no consider how it would be used later for comparison of sites & concepts?

It should be noted that these discussion points are of a very initial character. In its closed session, TAC made a more thorough assessment of chapter 7, see below.

2.5 ToR for NEA review (Tetsuo Fujiyama)

Discussion points were:

- NUMO desires from review? Will material be the same as that supplied to AESJ?
  ---E version will capture changes resulting from AESJ review – in revised J SC or annotations to this report.
- When will E version be openly published – before or after NEA review? Usually review after publication.
  ---NEA review and NUMO response as independent reports.
- What does TAC do before NEA review?
  ---Focus on main report. And also check the global consistency.

It was agreed that this topic will be discussed further in the closed session.

Day 2: Thursday 13 June

Block 3 Technical review of NUMO presentations at IHLRWM conference

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These presentations were originally given at International High-Level Radioactive Waste Management (IHLRWM) conference held by ANS and hence TAC were invited to review them as part of NUMO's technical QA programme.

3.1 Site Characterisation and Synthesis into SDMs for NUMO Safety Case (Kunio Ota)

Discussion points were:

- Presentation is excellent, illustrating innovative, state of the art methods. The methodology requires significant data input, which may not be available at early stages of site characterisation. Therefore uncertainty management needs to be taken care of early in the process.
- SDM synthesis of descriptions of sub-models: it will be important to check consistency, especially when working on a real site. Extraction of data may need to consider conservatism.
  ---this is included in the geosynthesis process.
- AESJ comments – the initial focus is on exclusion criteria. It could be important to check how this relates to choosing / rating specific concepts and ensuring iteration with engineers and safety assessors.
  ---This is captured in the geosynthesis process, as also noted below.
- A very good explanation of the characterisation process is given. Is discussion of sequential borehole drilling with feedback included? Maybe explicitly include feedback loops to engineers and modellers. Should be emphasised that this is generic and would be tailored to specific sites.
  ---Geosynthesis is noted in the presentation, which implicitly includes such loops.
- Maybe mention how quality is assessed?
  ---Even if not mentioned in the presentation, lots of work on this ongoing at NUMO and will be reported in the future.
- Is there data in the SDM to allow for decisions on selecting repository depth, or adaptation of repository design (given; geothermal gradient, stress field, rock mechanical / hydro props as function of depth)?
  ---only basis data at present, but this will be expanded in the 4D SDM based on site-specific geosynthesis.
- GW flow modelling at large scale – are there any water chemistry / isotope data to support output?
  ---current data are generic, but site-specific data will have this functionality.
- GW chemistry is reasonable, but can it be related to hydrogeology – e.g. low salinity water associated with short water travel times?
  ---Again can be considered when NUMO moves forward to develop site-specific 4D SDMs.

3.2 Roles of the NUMO Safety Case in the Stepwise Siting Process (Tetsuo Fujiyama)

Discussion points were:

- This is a good presentation, giving a good overview of current SC in context, with some very informative diagrams.
- Stakeholders expect identification of characteristics that are good or bad – which is coming here.
- Operational safety – could be useful to determine how much is generic or site-specific (maybe mainly for communication).

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- Regulatory constraints? Not defined yet for deep disposal – which should be explained to the public, emphasising role of strong regulator.
- Safety case needs: no mention of requirements?
  ---In principle, requirements included in design factors. Maybe should be explicit mention of SC to develop performance-related requirements system.
- Realism of SC – contrasts with robustness. Needs to be explained more carefully. Realism is, however, clearly required for optimisation and also for a proper assessment on what could happen to the EBS over time. One should separate between, on one hand, the need for realistic SDMs and realistic assessment of EBS evolution and, on the other hand, selection of calculation cases and parameters in the final dose assessment. The latter need always to have conservative bias in order to handle uncertainties. The former (SDM and assessment of EBS evolution) need to be realistic, but with an aim to also describe the uncertainties.
- Last conclusion especially good. How much have KM tools contributed to the current SC?
- If there is a need to have advanced KM tools, why have the existing tools from JAEA and NUMO not been used to develop this generic safety case?
  ---One of the reason could be that transfer of key staff and JAEA support to response to the Fukushima accident had use of the KM tool inactive at JAEA since then.
- As the ever expanding knowledge base is an issue: the remedy might not be advanced KM tools - maybe a good requirement management system might be sufficient. Before jumping into new tool development, it way be worth looking around and analysing experiences from the past.
  ---the JAEA KMS development was needs-driven rather than tool-driven and NUMO plans to continue in this manner.
- RMS – this is recognised and requirements were discussed in design process in Ch.4. Structuring and working with the actual formulation of requirements might, however, be more important than the tool used. This seems like best developed approach to prepare for site characterisation of any national programme at this stage.

3.3 A Systematic Radionuclide Migration Parameter Setting Approach for Potential Siting Environments in Japan (Takafumi Hamamoto)

Discussion points were:

- Very good presentation, showing impacts of design & local conditions and parameters. System evolution studies are critical, but designation as “conservative” must be used with care as it depends on the scenario considered.
- Alteration of montmorillonite by OPC minor – seems very relevant. It is certainly consistent with experimental data, especially from URL projects – see also information within EU CEBAMA project (https://www.cebama.eu/)
- Implemented flow regime and interaction with chemistry in the geochemical models needs to be assessed carefully. In particular, this involves the relationship of groundwater flow to the development of geochemical reaction fronts in the EBS (as would be seen in 3D)
- Is it 1D?
  ---Yes, does not consider radial flow around the tunnel, but compensates by conservative assumption of immediate saturation. Treatment of the EDZ as a mixing tanks does not really compensate for conservative assumption of immediate saturation, both are shortcomings in the model representation.
- Extent of reaction may be more limited in real life, which may be worth mentioning.

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- Are reaction kinetics included?
  ---Yes, included.
- Uncertainties are acknowledged together with the need for validation, which is very important.
- Are temperature effects considered?
  ---Diffusion data were corrected to rock ambient using an Arrhenius approach, as were kinetic parameters and equilibrium constants.
- Do these depend on site pore water chemistry?
  ---Yes – but lowest value chosen for different waters.
- Title of paper could be better – e.g. "An example of…" to emphasise that only one case is considered in detail.

3.4 NUMO Safety Case: Results in Perspective (Shogo Nishikawa)

Discussion points were:

- Conclusions – release & transport calculations are consistent. Assessments used are rather old – but no example of more realistic assessment. Even though RWM work recent, probable major differences in systems rather than models & data.
- This can be informative as a very early screening, but the scientific approach can be questioned and the conclusions are currently not supported.
- Benefits in testing & learning are possible – could be further benefits of safety teams discussing differences in a tailored workshop.
  ---may be useful to consider in the future, especially for safety teams in programmes with similar boundary conditions.
- Comparisons – option of running models again to compare contributions of different barriers.
  ---Present study would benefit from this but not possible due to time and budget constraints.
- Understanding would benefit from re-plotting data on same scales.
  ---again not possible due to time and budget constraints.
- Differences for HLW and TRU waste needs to be considered separately in terms of the different barriers.
- What was the impact of dose conversion factors?
  ---not considered as yet.
- Don't emphasise volunteering – the key aspect here is uncertainty in the host rock.
- Conclusions to be reformulated to capture actual aim of identifying key concerns and guidance for how to check how differences arise (assumptions, data and models). In terms of issues, wider range of recent studied can be included.
  ---many of the comments above reflected the focus of the IHLRWM paper, which could cover only a small part of the "Perspectives" work. This actually included comparisons of programme boundary conditions, SDMs, disposal concepts and safety assessment approaches before the assessment of post-closure safety results. The main limitations were thus the inability to compare databases and replot results – which may be considered in the future.

3.5 Advanced Knowledge Management: Sine Qua Non for Holistic Management of Radioactive Waste (Hiroyuki Umeki)

Discussion points were:

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- Very good vision regarding Holistic Management, being developed at the right level in NUMO.
- Area rapidly developing in a number of areas, some of them very closely related to radwaste (e.g. geophysics)
- US DoE has developed a similar design tool for nuclear power applications
- Communication tool may have particular commonality with other applications
- Concerns related to SC, e.g. revision of requirements, more based on system understanding (tacit) rather than tools used.
  ---Note JAEA has never been driven by tools – top-down drive by applications and user needs, combining standard approaches with new ideas.
- EU just launched a big collaboration with NEA and IAEA which will run over next 5 years. The joint programming EURAD which started in June 2019 and will work together with IAEA and NEA to bank on existing experience. Exchange with third parties might be an option.
- Maybe emphasise NUMO drive is to make its job easier, rather than tool development.
- A form of AM is being used in UK for internal communication to assess the quality of the evidence to support various safety arguments and the need for R&D to support the SC and keep it up to date. Software is being shared to regulator.
  ---Hierarchical AM aim in NUMO would be similar, but in Japan sharing codes with regulator is not accepted (unless international standard).
- Posiva has something similar to UK and aims to publish next SC as hypertext.
- Past work on needs of KM in the EU context – focus more on knowledge transfer between generations. With respect to passing on tacit knowledge: people need to be motivated to do it, maybe not sufficient to simply inform them of the need.
- Following a question, “case-based” and “rule-based” expert systems were explained.
- Discussion of why KM not used for present SC is already covered under 3.2 above.
- Learn from the past on trying this out as an implementer, recognising the danger of overloading the safety case and being careful when to introduce/put pressure to utilise this. Currently there seems to be a lack of detailed analysis on what is needed and accurate definition of what is the real problem is: first definition on what is needed, only after that proposing solutions such as advanced KM tools.
- Intelligent assistant concept already applied in other areas: medicine, aerospace, law… / AI support also in other areas managing big data (e.g. high energy physics, drug development): take experience over where appropriate.

Block 4 Key R&D priorities

4.1 Mid-term R&D plan of NUMO (Motoyuki Yamada)

Discussion points were:

- RM / KM – in the R&D plan, the feedback from the SC to refine / extend requirements could be considered also to assess R&D priorities.
- R&D plan as NUMO moves towards PI: emphasis on geology might include uncertainty management as a topic (integrating flow of knowledge to capture propagation of uncertainties).
- As the next milestone for NUMO is site selection the focus of the RD&D should be on geology, assessment methodology development and conceptual design.

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- Why automation of techniques now? Technology development for emplacement and remote handling might not need to be described by NUMO at present.
  ---This can be considered part of staff training and recognises the huge challenge of safe construction and operation of a first-of-kind facility in Japan for a huge inventory. Although relatively low priority now, generations of development and testing may well be justified for Japanese boundary conditions.
- It is important that this should go further than 5 years in order to set priorities as function of time (entire life cycle – which in Japan requires input by government). Ideally, start from the main milestones in the programme and then work backwards to assure all required R&D output is available in time for its use.
- Work on materials – may be too detailed (inertia-driven) and misses top-level general studies (e.g. requirements-driven) that could also capture the huge advances in alternative materials in recent years (especially for TRU).
- Advanced tool development is beyond strict requirements at present, but important to build capacity. However, beware of "fatigue" if these are developed but not used for a long time (late site appearing). If needed, use the developed tools in dry runs.
- US experience – delays cause degradation of waste form. This may bring forward new issues (e.g. need to repackage for TRU). Maybe would be best captured in a holistic study.
- Geology focus on 100ky – how does this fit with safety assessment to further in the future?
- Developing KM tools for communication with the public questioned by most TAC members. Public not interested in the safety case per se – but in the honesty of the waste management experts, etc.

4.2 Dry run exercise of general Preliminary Investigation Plan (Kimitaka Yoshimura)

Discussion points were:

- Is it politically OK to have candidates extending over volunteer boundary?
  ---this was not discussed during the exercise. However, following LS, PIA candidate areas will be located entirely in the volunteer community.
- Good idea, which is really important, and confirmed based on experience in other programmes. Active knowledge transfer from experienced to younger staff is a key output.
- In UK, presentation to communities is more of a concern and consistency of the language used is especially important if several communities involved.
- Why exclude if Quaternary sediments to 300m (e.g. for basement >500m)?
  ---unconsolidated Quaternary sediments cannot be considered as a host rock and, in this exercise, we excluded any rocks younger than 0.78MA (Calabrian age).
- Why select candidates with much of the area clearly excluded?
  ---the goal is to represent typical volunteer sites, which could well have characteristics like this.

4.3 4D SDM (Hiromitsu Saegusa)

Discussion points were:

- Transgression maximum – is this still OK with current global warming? May be captured in sensitivity analysis. Some standardisation on assumed future climate change is ongoing and Nagra can provide information.

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- Figures blown up to show details 20 km +/- coastline and depth to 1.5 km would be useful.
  ---could be done.
- Maybe test model by starting in the past and running forward to the present day?
  ---this has been already done at JAEA URL sites and such work is ongoing.
- Similar to the interpretation of water chemistry in Scandinavia, although rock porewater was problem identified there (matrix diffusion impact) for systems with dominant fracture flow.
- 4D SDM is a very ambitious title especially at a generic stage. The work is excellent, but it is in fact a toolbox for assessing long term evolution. While the 3D SDM can reach a relatively high confidence level, the long term evolution can never have the same ambition.
- No possible glaciation from mountains at glacial maximum?
  ---glaciation in Japan is extremely limited, even during an ice age. There are no continental ice sheets as in Scandinavia, but local effects on topography and hydrogeology would be considered, however, if appropriate on a site-specific basis.

4.4 Optimised repository concepts (Yoshito Kitagawa)

Discussion points were:

- Before a site comes forward, huge uncertainties are involved – which should be recognised.
- Maybe rather than optimisation, talk about cost-efficiency: optimisation used differently in other areas. Term used in Finland (and Sweden) is “industrialisation”.
- Maybe clarify how economy is used in a total optimisation study.
- Swiss case – push to make more detailed concept examples to allow costing, but need to identify that it isn’t realistic or reference case.
  In the Swiss case, the conceptual design is requested for the next licencing step. Based on such a conceptual design, costing is not possible. A model based realisation, providing a lot more detail, is therefore developed for costing. Care needs to be taken that this realisation does not get mixed up with the reference concept internally in the programme. Certain requirements in this realisation have not been fixed in the reference and are just there to be able to estimate costs.
- US location example – YMP cost lowest, but based on incorrect assumptions which have cost huge impacts (which would have changed site choice).
- P7: site characterisation – this is coupled to other costs as better characterisation reduced uncertainty. Such coupling should be picked up (although tricky to quantify)

4.5 More realistic RN release models (Keisuke Ishida)

Discussion points were:

- Huge advance in sophistication of model: limitations well understood and development requirements identified. Identifies issues that can provide feedback to design even if results have large uncertainties. In any case, model limitations will certainly decrease with time.
- The complex modelling presented is significantly better than anything we had seen previously and the concept of finding models that help assess multiple joint characterization and design alternatives is encouraged.
- How many CPUs used?

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---24 – so great expansion possible. It should be recognized that parallel computing on a 20 computer node system is significantly better than single processor analysis but there are within Japan and across the globe significantly more powerful systems (up to 10,000's of thousands of nodes and soon operating at Exascale computation speeds). Thus the current complexity that NUMO wishes to represent is, or soon will be, possible.

- Nevertheless, regardless of computer power, the complexity of all the processes at all the scales that eventually will need to be assessed cannot be computationally handled along with uncertainty analysis and the data value problem in the foreseeable future and therefore mathematical representations of the input-output relationships using Reduced Order Models (ROM - https://en.wikipedia.org/wiki/Model_order_reduction) and data input or model output interrogation using artificial intelligence are methods that eventually need to be understood and used to handle the uncertainty issues.
- Maybe note such models may also be needed to respond to regulator requirements.
- Excellent to show the problems of upscaling. Problems were noted and will need to be carefully considered, but a key issue may well be representation of the GBI at the larger scale. Should also include the smaller scale models that are critical for solute transport scales.
- If models become bigger, can the required data be obtained? Technology is developing, but there is uncertainty here – especially for complex sites.
- Is the drain in the connecting tunnel at HLW panel scale not sealed?
- Numerical tools are useful integrators and as a check on data/knowledge that developed across all the qualitative planning and data collection. However, they do not represent independent knowledge from the qualitative scientific and engineering expertise.
  ---this is interpreted as the fact that system understanding is based mainly on conceptual models that interpret observations. Numerical analyses can be used to test these, but should not be over-interpreted as providing rigorous quantitative descriptions of actual system evolution – and certainly not at early stages of the programme. The confidence that quantitative analysis is credible comes only after models have been validated (to the extent possible) in other settings and, for a specific site, are supported by a wide range of hydrogeological, geochemical and isotopic data.
- During the current site acquisition and subsequent site characterization phases of the NUMO work, NUMO is unlikely to have deep expertise in numerical simulation but it is essential that they have a small team who understand the numerical tools, can use them independently to check the accuracy and assumptions embedded and link the qualitative expert based work with the numerical tools. NUMO's responsible team is clearly building that expertise and it is strongly encourage that this be continued.

4.6 Suggestions for other priority topics (TAC)

This brainstorming session resulted in the following suggestions:

- Concepts – large KB (knowledge base) on traditional concepts, but very limited for more exotic options, which need a bit more background. Assess the applicability of these more exotic options in relation to requirements – do they solve anything the traditional ones would not, how much development work would be needed before application to specific site etc.
- This again is high priority for a volunteer siting approach. There needs to be an understanding of a range of possible options. This then needs to be linked to the implementation schedule. As an example, consider if there was a need for a change in container material. There needs to be an understanding of the merits of various options

and an understanding of the R&D needed in Japan to support such a change. This might require some additional work to be done in the near term.

These will be expanded on during the closed session.

Day 3: Friday 14 June

Block 5 TAC closed session & wrap up

TAC discussion concentrated on the ToR for the NEA review, suggested modifications of Chapter 7 to make it clearer for NEA and input to the list of R&D priorities.. Comments and questions from NUMO mainly involved clarification.

The closing address by Executive Director Dr Umeki emphasised how valuable TAC input has been for both the production of the SC and the developing future R&D programme and thanked members for their efforts. He noted that the future membership and remit of TAC following the next meeting needs to be discussed, as the programme is now moving to the next stage and a younger generation is taking over. Chairman Prof Sasaki added his thanks to both TAC members and NUMO and closed the meeting as scheduled.

Appendices
1. TAC Participants list
2. TAC meeting programme