Exchange with the Knowledge Management Group of the *Bundesgesellschaft für Endlagerung* (BGE) (July 17, 2025)
Duration: 1:05 hours, including presentation of results

Expert 1:

[To illustrate the IAEA's knowledge gaps in the life cycle of a nuclear facility] The knowledge gaps that arise and are not transferred are not necessarily caused solely by changes in ownership. In our field of final storage, the timeline would initially be much longer, and we would have the problem that these knowledge gaps arise as a result of a generational change. The retirement of colleagues causes these gaps.

[On the illustration of the "knowledge iceberg"] Perhaps you could take up the suggestion that, in addition to explicit and implicit knowledge, there is also tacit knowledge. Implicit and tacit knowledge also differ slightly in their definition. But if you do that with "visible" and "invisible," then you could summarize it as coded and non-coded knowledge. What you do is: you incorporate non-coded knowledge into your database, which would otherwise be lost.

PM:

Thanks for pointing that out.

Expert 1:

That's always the problem when I talk about invisible knowledge: am I talking about tacit or implicit knowledge? Here we are talking about coded and non-coded, visible and invisible knowledge. My personal conclusion from the last few years is that I have decided to break it down into codified—i.e., written—knowledge and non-written knowledge. This makes it much easier when dealing with other colleagues than having to constantly explain the difference between tacit and implicit knowledge.

[On spatial knowledge] When I am in a nuclear power plant and look at the nuclear regulations, I am in the area of plants, systems, and components, i.e., ASK. I would then have to have documents assigned to each component that is coded according to the regulations.

PM:

Yes, that's exactly what I've mapped out at my test site in Mont Terri. [After presenting the results] Where do you see the strengths and weaknesses of my approach?

Expert 2:

It's definitely complex, and I think it stands or falls with the data situation. If we were to start doing that here, incorporating drillings somewhere... Well, I don't know how much effort that would take, because everything has to be transferred from some unreadable paper documents. It's really exciting to see what you can do with it. But I think it's also a long way to go.

Expert 1:

And congratulations on choosing Mont Terri as your test site and being able to access a large digital database there. But you're now at a point where I'm starting to think a little bit. The entire AR is strongly linked to the spatial reference. In the object, I always receive information about specific elements that are located there, so to speak. Imagine that in 100 years, Mont Terri is closed. Will I still be able to access the data, or will I have the opportunity to view it virtually in the same way that you have now experienced it in vivo, so to speak?

PM:

Yes, that's a good question that points to VR. You're right, I've carried out all use cases on site with AR so far. Of course, you can also view all geometries and semantic data in a VR environment regardless of location [shows a corresponding video].

Expert 1:

All right, great. That's exactly the point I'm getting at. Is it possible to freeze such a state in VR via video? So that I not only get the calculation here, but can also store it somewhere as an mp4 file, for example?

PM:

Yes, you can simply make videos through the glasses—that's how the screen recordings I showed you were created—and save them externally. If you want, you could also store them as videos in the information system.

Expert 1:

That's why I'm asking whether it might not make sense to simply freeze the real environment at a certain point in time and store it on a file share due to the amount of data that is then produced.

PM:

That was exactly the topic of my expert interview with BASE. How do you deal with databases that are continuously updated in the course of long-term digital archiving? Behind my Unity application is a database that runs on an Ubuntu server. It knows when it was changed. Therefore, you can say at any time: "Reset me to the status that was current in year X on day Y." On the one hand, this can already be done within the application, as you have seen with time filtering. Such a process could also be initiated from outside. So yes, both are possible.

Expert 1:

Otherwise, I'm very impressed. I think it's not a bad idea and it's worthwhile.

Expert 2:

What was [BASE's] statement on the lifespan of this data when it comes to long-term archiving?

PM:

The discussion focused on three time horizons: short-term, medium-term, and long-term. Short-term is the period until the final repository is closed. When it comes to data storage, a distinction can be made between data that does not need to be accessed regularly and data that I need and update repeatedly. I can store the former on robust media and leave it alone for the time being. The other data must be checked and maintained regularly. Maintenance here means that I have redundant systems and back up not only the data but also its environment. This is, of course, a challenge with a digital system like mine, which is based on a game engine and a connected graph database. There is no guarantee that this game engine will still exist in 100 years, and the glasses will probably no longer exist either. That's why I took into account in the software concept that everything that is created here in terms of digital data or artifacts can also be read elsewhere.

Expert 1:

Very sensible. The solution to the whole problem is that I have everything permanently on a live system. That way, I have the least difficulty with long-term availability.

PM:

One question that arises for me is whether my information system can be an alternative to workflows that have previously been analog in terms of knowledge management. The goal in nuclear technology facilities is to avoid having personnel work in the controlled area for unnecessarily long periods of time. So, the glasses should allow certain tasks to be performed more efficiently—in other words, faster—than without them. On the other hand, I can now suddenly do things that were previously only possible outside the Controlled area. Overall, I find it an exciting consideration whether it is beneficial in terms of Radiation protection to use an application that has a VR mode but plays to its full strengths on site with AR.

Expert 1:

Yes, that's a good question. If I don't have to go into the Controlled area to retrieve certain information that is stored or updated in the system, then that is obviously an advantage. It may also be the case that I have a measuring device somewhere that needs to be read. And if that can only be read on site in the Controlled area—I don't know if that happens at all—but if it did, then virtual access or access via AR would of course also be a solution. But I'm not close enough to that situation to be able to judge.

PM:

How do you rate multi-user mode?

Expert 1:

Multi-user mode definitely makes sense. I thought it was really good, especially when you're on site and want to exchange virtual or digital content that is only accessible via the system. Of course, it's good when that works in multi-user mode. I found that quite impressive. I liked it a lot, especially the ability to access information about the relevant drillings or experiments when I'm on site. Or information about other issues that I can store there. In a backfilled tunnel, that doesn't make much sense , but if I apply it to our mines, you could store a lot of geological information that could then be accessed directly. If there are not just two users, but a whole group of visitors with ten or twelve people, that would be possible, provided the system has the capacity to handle it...

PM:

... Yes, it can.

Expert 1:

... a great thing. And then there's the possibility of virtualizing the whole thing so that when I have a group of visitors, I can take them on a tour of the site to point out the relevant things. We already see these virtual tours as a possible application. But I spend more time underground in the mine than in a nuclear facility. There, I wouldn't have to escort a group of visitors through a controlled area if I had already virtualized what I wanted to show them. That way, I can conduct the tour outside the controlled area, so to speak. So in that respect, it's not bad.

And the link is, of course, also an important point—that brings us to AI and the whole data cloud behind it. That's basically their art. And also the question that didn't quite occur to me spontaneously: How exactly should the whole thing be equipped with AI functionality? Can I also enter into dialogue with my data there? Can I say, "Please show me this or that connection" or "Where can I find information on specific issues?" That wasn't explained in such concrete terms. I mean, I can call up the relevant information on the individual objects via the knowledge panels we've seen. But is there also the possibility of doing this in the form of a dialogue-driven system?

PM:

My system can basically be expanded in this direction. Since AI is already quite mature for such purposes, this was not a research topic for me in the narrower sense. My thoughts are leaning toward a chatbot or even Speech recognition to simplify the process of finding knowledge. This can replace classic manual filtering and sorting. Another consideration is RAG, or Retrieval Augmented Generation. Currently, filtering and searching affects all metadata attributes, but does not yet take into account attached documents such as PDFs, images, and so on. A corresponding RAG system could be integrated into the server environment. This would allow me to ask complex questions within the application, and my questions would be answered automatically based on the knowledge base stored locally on the server. Either I would receive a text response, or internally implemented functions such as navigation or the display/hiding of geometries would be called up.

Expert 1:

For example, I can think of: "Summarize the available results for experiment XYZ for me." The results could also be linked. If I have several experiments or if I have a packer test that is supposed to determine any permeability... You could also ask: "Please tell me the average permeability of layer XYZ that was encountered in the borehole there." Now I'm back in final repository mining, and there are many things I need for long-term safety analyses.

From my point of view, thank you very much. It was an interesting presentation, and I must say that you have achieved something impressive in such a short time. To think the whole thing through, then implement it technically and link the various systems together. Respect, so thank you very much.

PM:

Thank you, I'm very pleased to hear that. Thank you very much for your time and your feedback!