

# Support for site characterisation and geosynthesis

Next Generation KMS Workshop 3-4 December, 2009 Tokyo

Takeshi Semba

### Site characterisation



### A dynamic and complex process that needs:

- Close links to repository design and PA
- Integration of a huge volume (and flux) of information into site descriptive models that evolve as investigation proceeds
- Iterative review and modification of the characterization plan; based on improved understanding, changes in socio-political conditions or in the longterm disposal program and/or in response to technology development

### The challenge: development of advanced methodology

- Information Synthesis and Interpretation System (ISIS)
  - A component of the comprehensive JAEA Knowledge Management System
  - ➤ Active application during site investigation, rather than simply recording what has been done by a conventional "static" methodology e.g. "geosynthesis"
  - Use advanced technology from Knowledge Engineering; e.g. incorporating past experience and know-how (e.g. from URLs) into Expert Systems

## Geosynthesis - linking data to user needs

Information flow diagrams have been used to couple measurements in the field to the key safety functions of the natural barrier or parameters used for repository design BUT lack the flexibility to respond to surprises and have

limited functionality for autonomic data processing Geological data Geol. site understanding Mapping Independent evidence (underpress., resid. time) Exploratory boreholes Mineral/petrograph. properties Geological site model Local geol. data Rock mechanics parameters WCF in HR Landslide register Geodataset SA Conceptual models Geophysics/geodetic meas Water flowpaths Reflection seismics Min./geom. WCF Refr. seismics/geoelectrics Groundwater flow Reference waters Geodetic meas. Altzellen Structural elements RP gas transp. parameters Long-term scenarios Borcholes Lithology (core/lab) Isotopes, precipitation Block model Geodataset construction Genesis of GW and gases Age of GW and gases Bock mech, core studies Tunnel prognosis profile Hydr. conducti-vity distribution in HR (K-model) Chemistry/isotopes in springs and GW Structural core description Geotech, properties Structural logging Reference waters/colloids Recent stress field Composition of natural gases evidence for regional GW Petrophys. logging Potential distribution in HR Regional model Planning basis Phase III Hura logging Hydrofrac measurements Host rock boundaries Hydr. conductivities/ transmissivities Packer tests Hydr. conductivities and potentials in SR K distribution Water and gas sampling Layout-determ. inhomog. Long-term monitoring processes GW flow Cavern scale model WCF in HR: hydraulics Discrete inflow points Preservation of evidence, ref. measurements Deep boreholes Piezom eter measurements Basic data for RP monitoring 2-phase flow parameters evolution of underpressures Springs and surface waters Basic data for constr./ operation applications Precipitation Hydrogeology of GW captures Meteo data Preservation of evidence

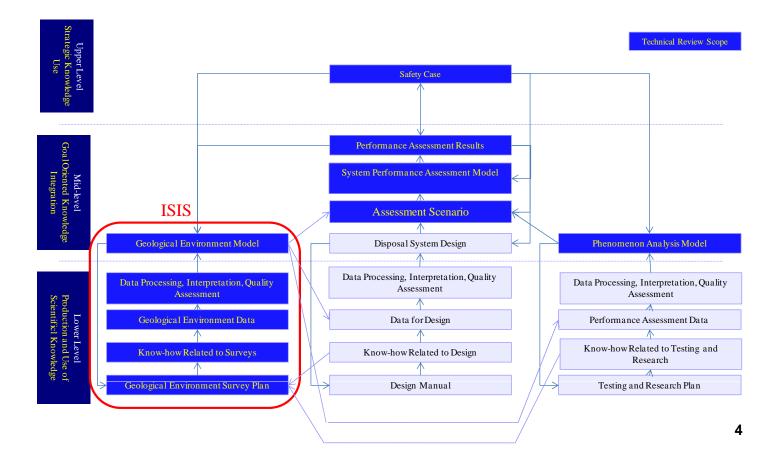
## **Objectives of ISIS development**



- Supporting planning, implementation and integration of a site descriptive model (SDM) with associated site characterization data-set, based on past experience and know-how obtained in Japan (URL R&D) and elsewhere
- Aiding user-friendly communication with experts in different disciplines
- ➤ Providing flexible restructuring of information for performance assessment and design teams (and, potentially, communication with other stakeholders)

## (JAEA)

### **Role of ISIS in Safety Case development**



### The ISIS toolkit

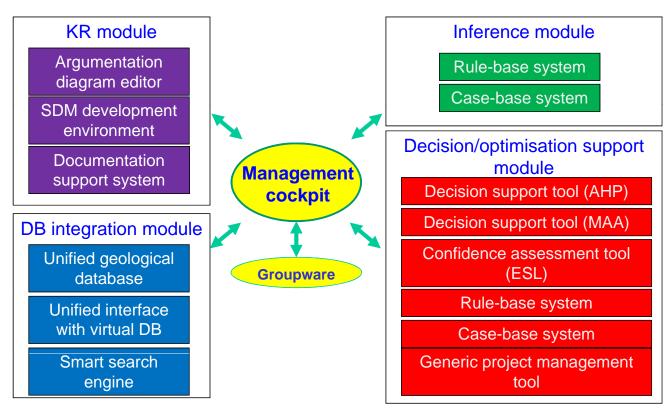


Key tools and methods currently investigated within ISIS

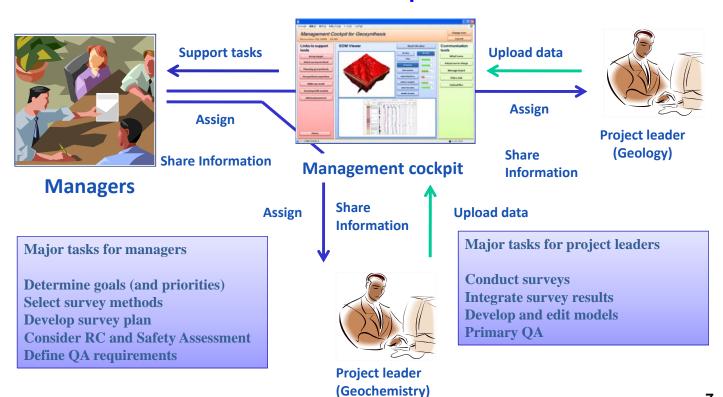
- ➤ Blackboard architecture: a method for efficient sharing and assessment of an evolving knowledge base
- ➤ Hybrid systems: pragmatic integration of IT methods with human experts
- Problem-solving methodology: formal approach for identifying conflicting requirements
- Expert system development tools: particularly focused on capturing tacit knowledge in rule-based or case-based systems

#### **Overall structure of ISIS**





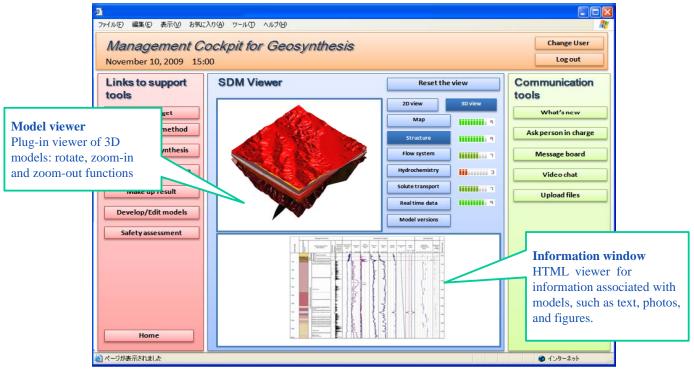
# Overview of the Management Cockpit for Geosynthesis: Relationships



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### Management Cockpit for Geosynthesis: How does it work? –SDM Viewer



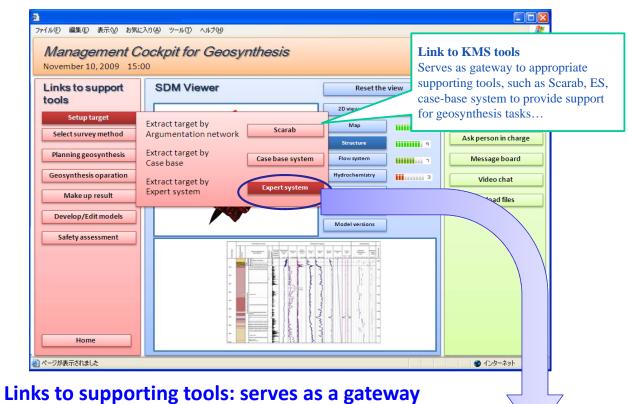


SDM viewer: serves as visual gateway to data and information

## Management Cockpit for Geosynthesis: How does it work? – Link to KMS tools



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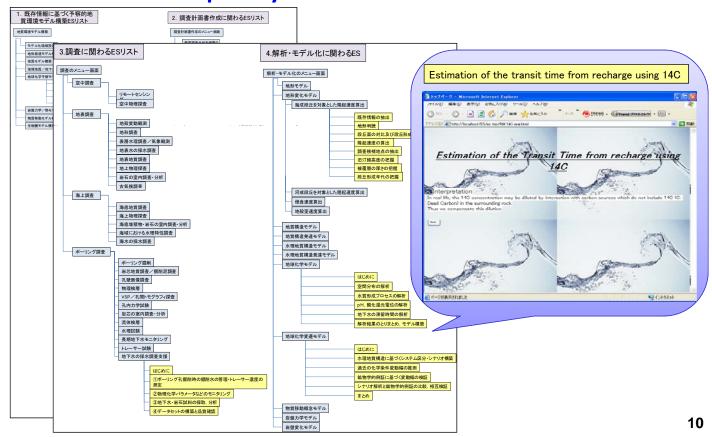
Links to supporting tools: serves as a gateway to KMS tools supporting geosynthesis tasks

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## **Example of KMS tools**



**Lists of Expert Systems for site characterization** 



## Procedure for knowledge acquisition leading to ISIS development



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Knowledge Acquisition

Knowledge Modeling

Expert Systemization

II. Extraction of related knowledge items

III. Construction of ontology model in Protégé

VI. Syntax analysis of rules and cases

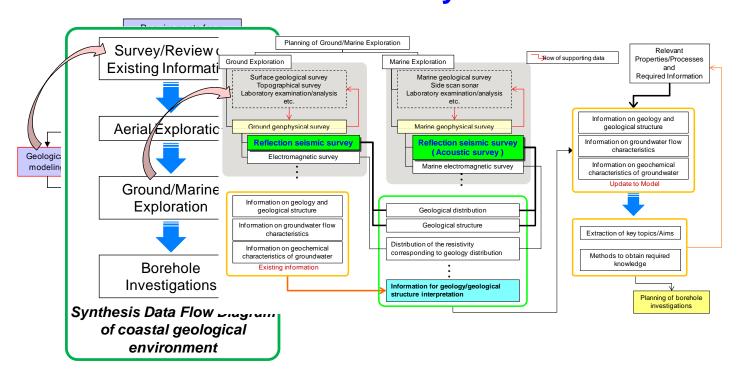
V. Creation of an interface template and formulating knowledge elements as a menu, based on the results of syntax analysis.

VI. An expert uses the interface in step "V" to create the rule base and case base by selecting knowledge elements and syntax.

VII. The expert system group is produced automatically.



## **Task flow analysis**



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## Identification of relevant knowledge elements

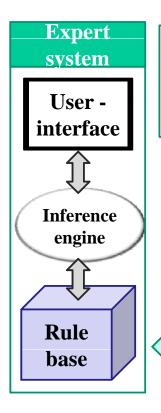


#### - Rule-base and Case-base -

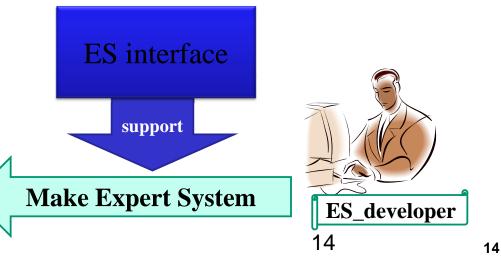
| Rule-base | Decision-making rules within tasks of site investigation, represented using IFTHEN format                                  | e.g. Selection of drilling methods  If full core recovery needed  YES  Then a wireline drilling method should be selected  NO  Then a non-core drilling method should be selected (tricon bit, etc.) |
|-----------|--|--|
| Case-base | Cases how a problem in site investigation was solved in the past, to suggest ways to handle similar problems in the future | e.g. Troubleshooting of drilling fluid loss  |



## Concept of the ES development interface



ES development interface allows experts from various fields to produce Expert Systems which fit their requirements without programming skills



The structure of the ES development interface



## ES development interface

## Interface for the ES-top page

Produces the "top page" of ESs.

On the top page, the concept of the
ES and key background
knowledge are presented.

### Interface for the rulebase

Decision tree Truth table format format

User makes the rules in the format of a decision tree OR truth table.

User makes the linkage of rules & the inference engine through the ES-top page interface

Inference engine

Previously prepared for use in Expert Systems

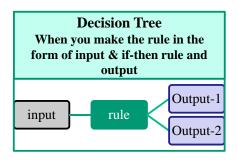
#### The Rule format



The Decision tree format & Truth table are appropriate for describing the characteristics of knowledge in relevant fields with the minimum of effort



The ES development interface allows both formats.

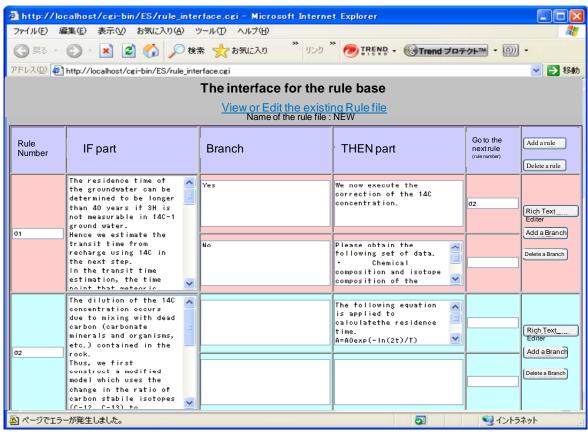


| Truth table When you want to describe all the requirement combinations and then choose the best option |               |               |  |
|--|---------------|---------------|--|
|  | Requirement 1 | Requirement 2 |  |
| Method 1   | 0             | 0             |  |
| Method 2   | 0             | ×             |  |
| Method 3   | ×             | 0             |  |
| Method 4   | 0             | ×             |  |

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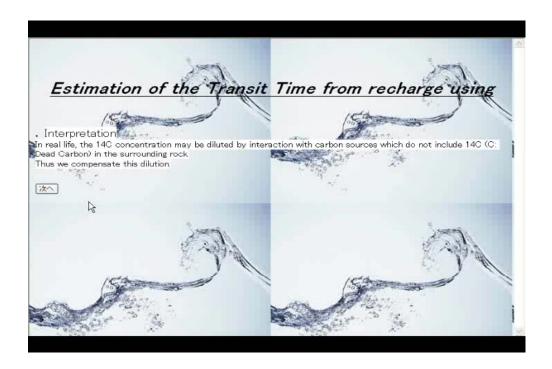
## ES development interface Rule-base editor







## Example generated by using ES development interface



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## Conclusions and a look to the future



#### **Conclusions**

- The methodology and tools for acquiring required expert knowledge have been developed
- ISIS can provide a solution to the problems examined to date, especially when set within the context of an overarching KMS program

#### **Future Plans (five-year program)**

- Expansion of the range of test applications, leading to implementation of a system applicable to a volunteer site
- Extension of methodology from "simpler" rule-based reasoning to utilize more complex case-based knowledge
- Review of expert system contents in a formal manner, to support integrated QA of the KMS supporting Safety Case development