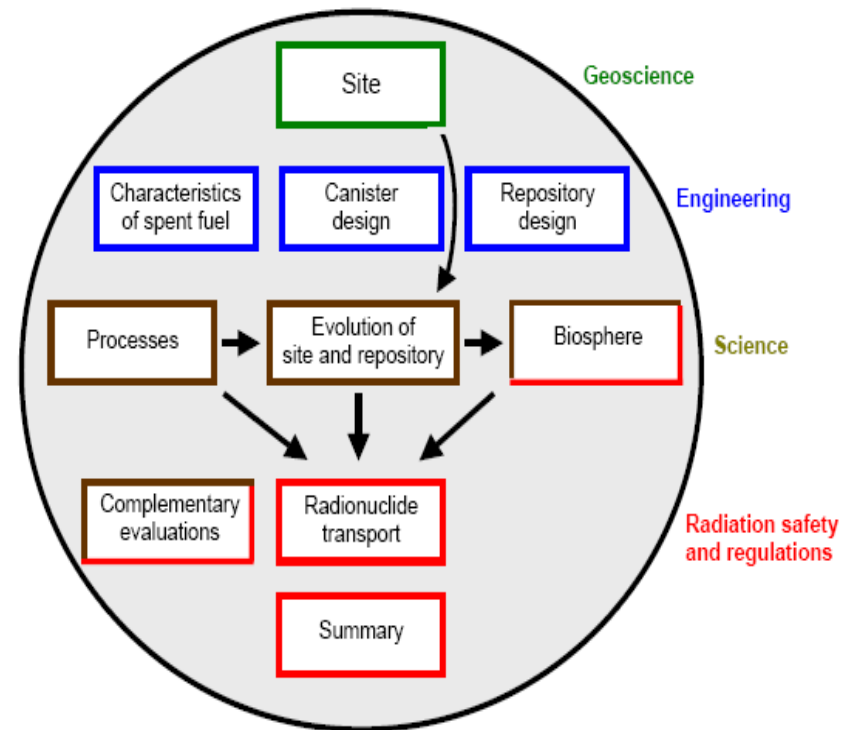


First set of supplementary
information to the oral
presentation

DEMONSTRATION OF LONG TERM SAFETY OF SPENT FUEL DISPOSAL CONCEPT

Safety case portfolio

- Demonstration of long-term safety of disposal is based on safety case and related regulatory review
- Posiva's safety case (so called safety case portfolio) is made up of ten main reports which are progressively updated



Basic principles in safety demonstration - 1

General approach

- quantitative analysis of expected evolution
- quantitative or qualitative analysis of disruptive events
- conservative assumptions throughout the analysis
- analysis of uncertainties
- transparency and traceability of models and data

Scenario analysis

- consideration of thermal, mechanical, hydraulic, and chemical processes inside the repository
- consideration of external events
- base case scenario and disturbance scenarios

Basic principles in safety demonstration - 2

Modelling and input data

- use of best available experimental data and expert judgement
- mutual consistency and site specificity, as far as practicable

Complementary considerations enhance confidence in the safety

- bounding analyses
- natural analogues
- site paleology

Basic principles in safety demonstration - 3

Three different time scales are used, when assessing safety of nuclear waste disposal:

- Period of disposal facility operation, around 100 years
- Reasonably predictable future < 10 000 years
- Era of extreme climate changes > 10 000 years

SAFETY CASE

Collection and interpretation of data

Site investigations:

- Air and ground surface mapping
- Borehole investigations
- At-depth investigations

Safety research:

- Laboratory experiments
- Rock laboratory experiments
- Manufacturing and testing of capsule
- Research models

Description of the disposal system:

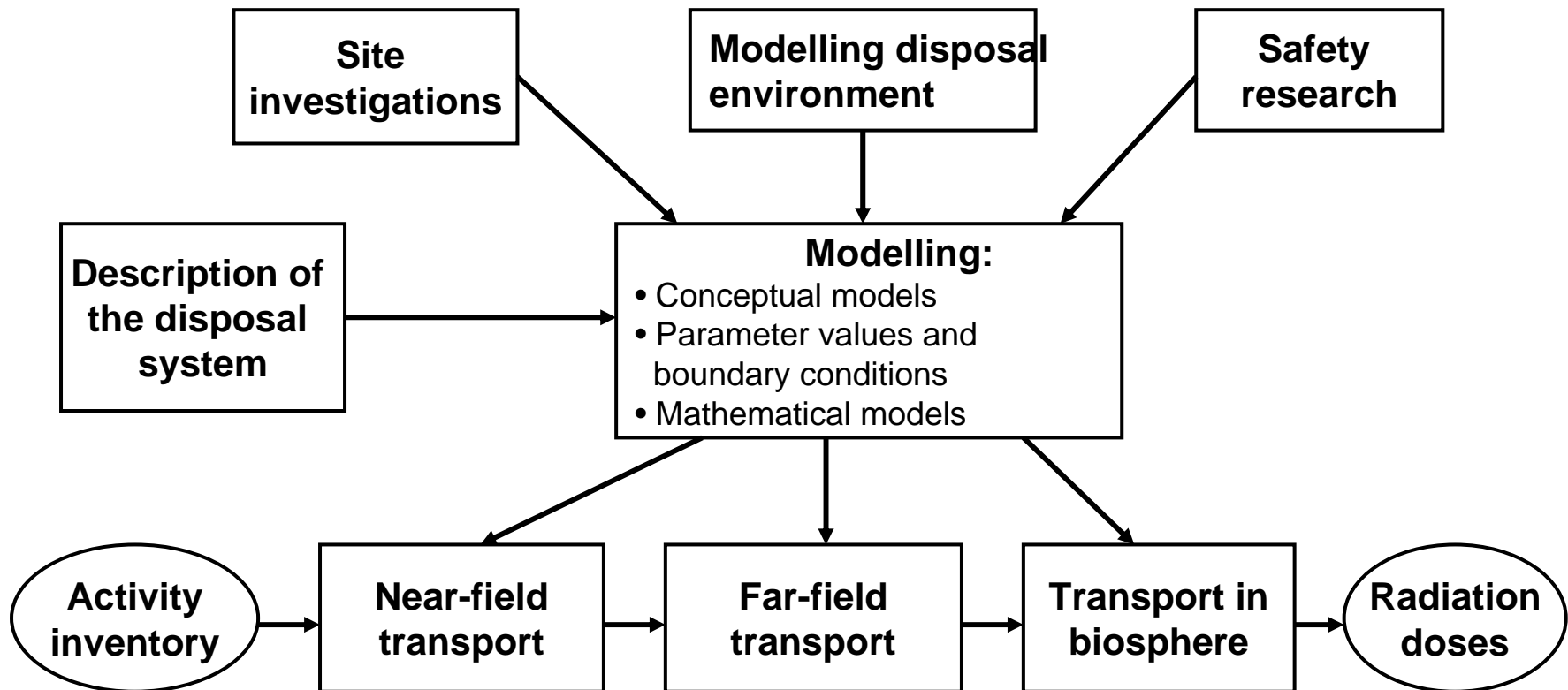
- Disposal site
- Waste packages
- Barriers
- Processes and interactions

Modelling disposal environment:

- Geological structures
- Groundwater flow
- Hydrochemistry

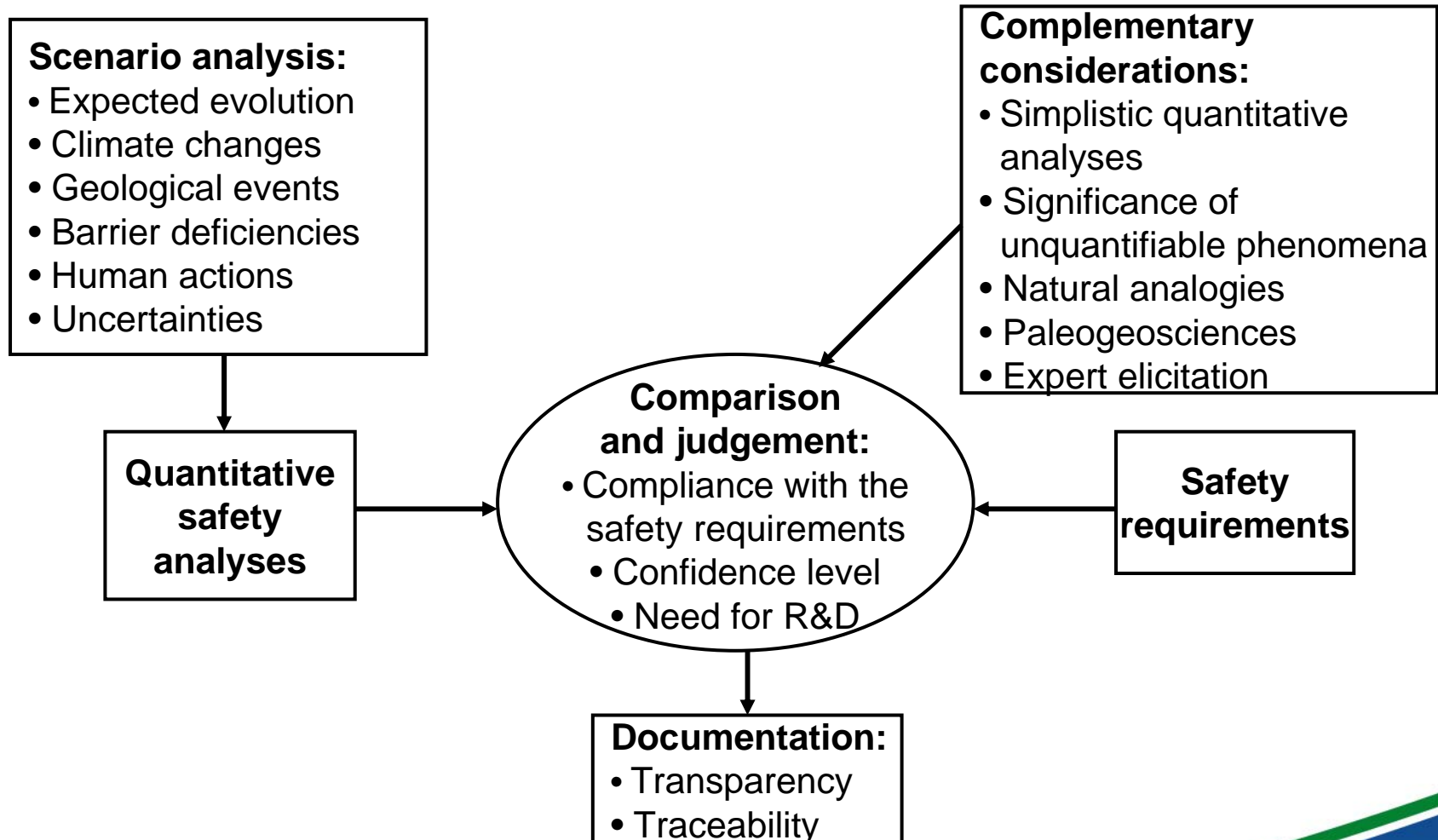
SAFETY CASE

Quantitative safety analysis



SAFETY CASE

Assessment of results



Safety research

- The utilities have full responsibility in planning, research and development for nuclear waste management
- Posiva carries out a R&D programme to fulfil the responsibility of the utilities for spent fuel disposal (volume about 17 M€/year)
- Research institutes and consultants carry out a large part of Posiva's programme as contracted research
- Key areas of Posiva's R&D work are
 - *Site confirmation investigations at Olkiluoto*
 - *Encapsulation and disposal technology development, in collaboration with SKB*
 - *Other safety research, e.g. within the EU integrated projects*
- An extensive report on the utilities' research and technical development programme is submitted every three years for regulatory review
- Public sector's research fund and STUK's regulatory support resources are available for independent research

Second set of
supplementary information
to the oral presentation

**GENERAL SAFETY REGULATIONS
FOR DISPOSAL OF NUCLEAR WASTE
STUK's proposal for revised Government
Decree
Expected to be issued in spring 2008**

GENERAL PRINCIPLES

High level protection of workers, the public and the environment

No future detriments exceeding currently acceptable levels

No reliance on long-term surveillance

Implementation of disposal with due regard to safety and with appropriate timing of the various steps of the disposal process

- *decrease of activity in waste through interim storage*
- *utilization of high technology and scientific knowledge*
- *need for ensuring long-term safety with research and performance monitoring*
- *no unjustified delays in the implementation process*

Ensuring the operational and long-term safety by means of

- *use of proven or otherwise carefully examined, high quality technology*
- *adoption of an appropriate quality management system*
- *maintenance of advanced safety culture*

Continuous safety improvement considering

- *operating experiences*
- *results of safety research*
- *progress in science and technology*

RADIATION PROTECTION CRITERIA

Operational period

Dose-based radiation protection criteria

- *practically no releases from normal operation*
- *0,1 mSv/a for anticipated transients*
- *1 mSv/a for postulated accidents with probability $> 10^{-3}/a$*
- *5 mSv/a for postulated accidents with probability $< 10^{-3}/a$*

Demonstration of operational safety

- *preferably by direct verification*
- *alternatively, by experiments, validated reliable and models, or by their combination*
- *adherence to the principle of conservatism*

REASONABLY PREDICTABLE FUTURE (closure - several 10^3 a)

- **Boreal / temperate climate type will prevail**
- **However, considerable environmental changes will occur due to e.g. land uplift**
- **Geological conditions are stable or change predictably (e.g. groundwater chemistry)**
- **Radiation protection criteria are based on doses (or dose expectancies) to members of hypothetical critical groups due to early failure scenarios**

RADIATION PROTECTION CRITERIA

Reasonably predictable future

- ***Highest individual doses from expected evolution scenarios < 0,1 mSv/a***
- ***Insignificant average doses to larger population groups***
- ***Whenever practicable, the consequences and expectancies of radiation impacts from unlikely disruptive events shall be assessed in relation to the constraints***
- ***Critical group: a self-sustaining community in the environs of the disposal site***
- ***potential impacts on species of fauna and flora shall also be examined.***

ERA OF EXTREME CLIMATE CHANGES (several 10^3 a to a couple of 10^5 a)

- Transition to glacial or permafrost climate type at 5000 - 20 000 years AP**
- The range of potential environmental conditions will be very wide and dose assessments would be meaningless**
- Major geological changes (groundwater flow and chemistry, rock movements) will occur, but their ranges are estimable**
- Radiation protection criteria are based on release rates of radionuclides from the geosphere (geo-bio flux constraints)**

RADIATION PROTECTION CRITERIA

Era of extreme climate changes

- ***maximum impacts comparable to those arising from natural radionuclides***
- ***insignificant large-scale impacts***
- ***release rate constraints to be given in STUK's guide***
 - ***0,03 GBq/a for Ra, Th, Pa, Pu, Am and Cm isotopes***
 - ***0,1 GBq/a for Se-79, I-129 and Np-237***
 - ***0,3 GBq/a for C-14, Cl-36, Cs-135 and for U-isotopes***
 - ***1 GBq/a for Nb-94 and Sn-126***
 - ***3 GBq/a for Tc-99***
 - ***10 GBq/a for Zr-93***
 - ***30 GBq/a for Ni-59***
 - ***100 GBq/a for Pd-107 and Sm-151***

THE FARTHEST FUTURE (Beyond a few 10^5 a)

- The potential radiotoxicity of spent fuel becomes less than that in the natural uranium, from which the fuel was fabricated
- The hazard posed by the repository is comparable to that from a uranium ore deposit
- No rigorous quantitative safety assessments are required
demonstration of safety can be based on
 - *simplified bounding analyses*
 - *comparisons with natural analogues*
 - *observations of the geological history of the site*

ACTIVITY IN LWR SPENT FUEL VS ACTIVITY¹⁸ OF NATURAL URANIUM FROM WHICH THE FUEL WAS FABRICATED

At defuelling	4 000 000
After one year	60 000
After 40 years	7 000
After 500 years	100
After 10 000 years	15
After 250 000 years	1

TECHNICAL REQUIREMENTS

Appropriate documentation

- *safety classification*
- *operational limit and conditions*
- *operational procedures*
- *waste classification and package specifications*
- *database of the disposed waste packages*

Prevention and mitigation of accidents

- *radiation protection (remote handling, radiation shielding, filtration)*
- *redundancy of key safety functions*
- *prevention of nuclear criticality*
- *prevention of fires and explosions*
- *consideration of external events*
- *separation of construction and emplacement activities*
- *security control*
- *emergency preparedness*

Monitoring

- *radiological in-facility, release route and environmental monitoring*
- *performance monitoring for ensuring long-term safety*

PERFORMANCE OF BARRIERS

A system of multiple barriers so that long-term safety is not jeopardised by

- *deficiency in one of the barriers*
- *predictable geological change*

Engineered barriers shall provide almost complete containment for a time period of

- *several hundreds of years for short-lived waste*
- *several thousands of years for long-lived waste*

The host rock shall

- *be favourable for the isolation of radionuclides from the biosphere*
- *have blocks of bedrock with adequate size and intactness for the construction of the waste emplacement rooms*
- *include no unsuitable features (like proximity to natural resources, abnormally high rock stresses, anomalous tectonic or seismic activity, lack of reducing capacity or other adverse groundwater feature)*

WASTE CATEGORIZATION

Short-lived nuclear waste

Waste with activity concentration after a time period of 500 years less than

- *100 MBq per kg in each disposal package*
 - *10 MBq per kg waste in each disposal room*
- (e.g. operational LILW from NPPs, most NPP dismantling waste)*

Long-lived nuclear waste

Waste with activity concentration after a time period of 500 years more than

- *100 MBq per kg in each disposal package*
 - *10 MBq per kg waste in each disposal room*
- (e.g. spent nuclear fuel, activated metal waste from dismantling of NPP)*

IMPLEMENTATION OF DISPOSAL

The host rock shall be characterised by means of surface based and at-depth investigations

- for the design of the emplacement rooms
- for obtaining data needed for the safety assessment

The depth of the disposal facility shall be selected with due regard to local geological conditions; the aim is

- *to mitigate the impacts of above-ground events, actions and environmental changes on the long-term safety*
- *to render inadvertent human intrusion to the repository difficult*

The excavation, other construction and closure of the underground facility shall be implemented in the best manner with regard to

- *retaining the characteristics of the host rock that are important to long-term safety*
- *preventing adverse effects on the operational safety or the integrity of the disposed waste packages*

DEMONSTRATION OF LONG-TERM SAFETY

The long-term safety case shall

- *address both expected evolutions and unlikely disruptive events*
- *include a quantitative assessment as well as complementary considerations whenever such quantitative analyses are not feasible or are too uncertain*
- *be based on high quality experimental knowledge and expert judgement*
- *be based on models and data which are site specific and validated as far as practicable*
- *adhere to the principle of conservatism and discuss the implications of uncertainties*
- *be included in the PSAR, FSAR, closure plan, and be updated every 15 years*