Optimization methodology based on probabilistic approach for the design of radioactive waste disposal facilities

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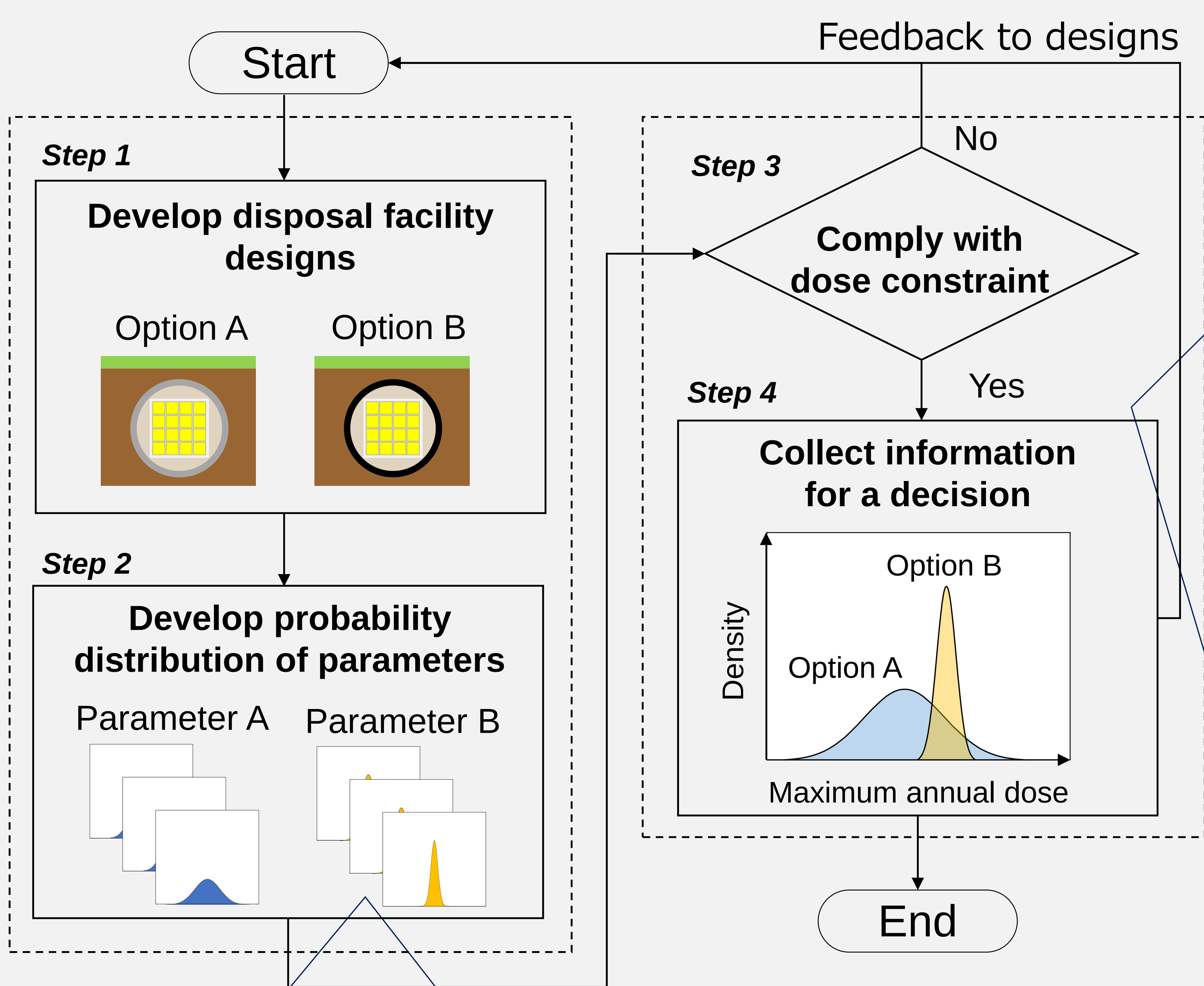
Introduction

- In Japan, the regulation for low-level radioactive waste disposal facilities requires to design the facilities based on the concepts of ALARA (as low as reasonably achievable) and BAT (best available technique).
- Optimization of radiological protection in radioactive waste disposal during the post-closure of disposal facilities can be recognized as the process of determining measures for safety to keep the probability and magnitude of exposure as low as reasonably achievable, taking into account economic and social factors.
- We propose an optimization methodology based on a probabilistic approach for the design of radioactive waste disposal facilities in accordance with the logic of international radiological protection discussed by ICRP and IAEA.

Optimization methodology based on probabilistic approach

Flowchart of the methodology

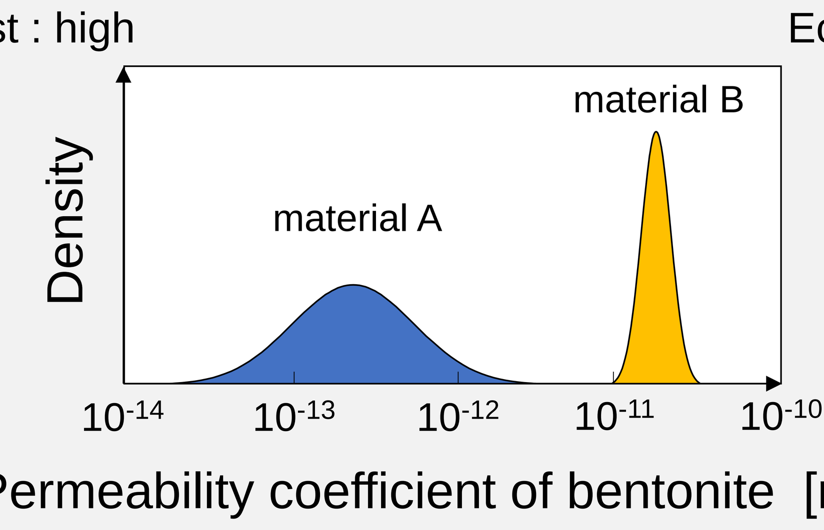


Step 2：Develop probability distribution of parameter

- ✓ Determine probability distribution on the basis of past construction experiences and/or expert judgments.
- ✓ Organize information on the **engineering and economic costs** associated with the engineering measures.

Example

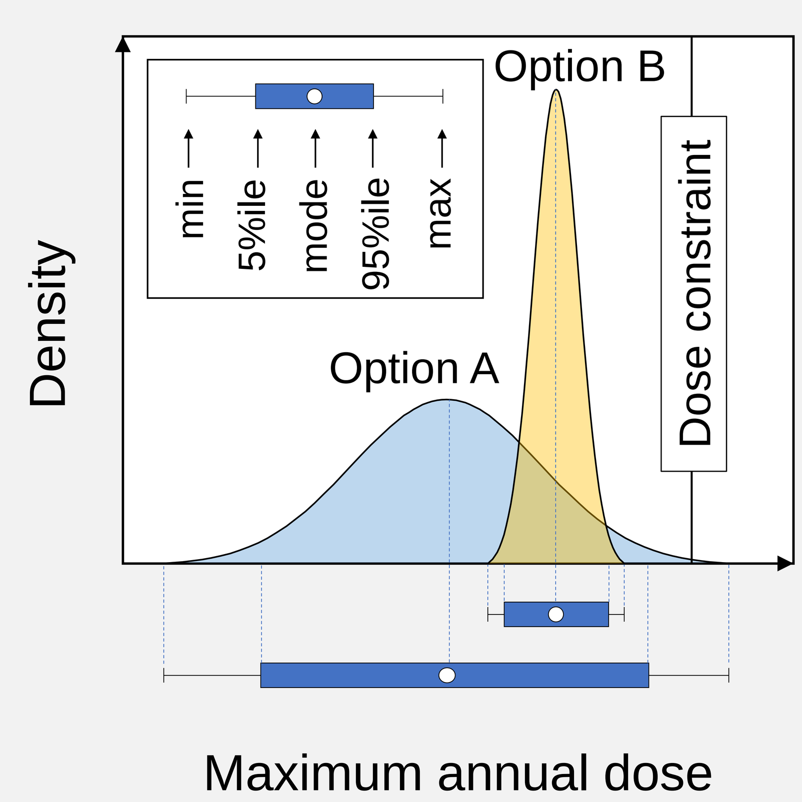
Performance : high	Performance : low
Quality control : difficult	Quality control : easy
Engineering cost : high	Engineering cost : low
Economic cost : high	Economic cost : low



Step 3：Comply with dose constraint

- ✓ When the 95th percentile of the maximum annual dose distribution is less than a dose constraint, it is demonstrated that the disposal facility is designed to comply with the requirement.

By analogically adopting



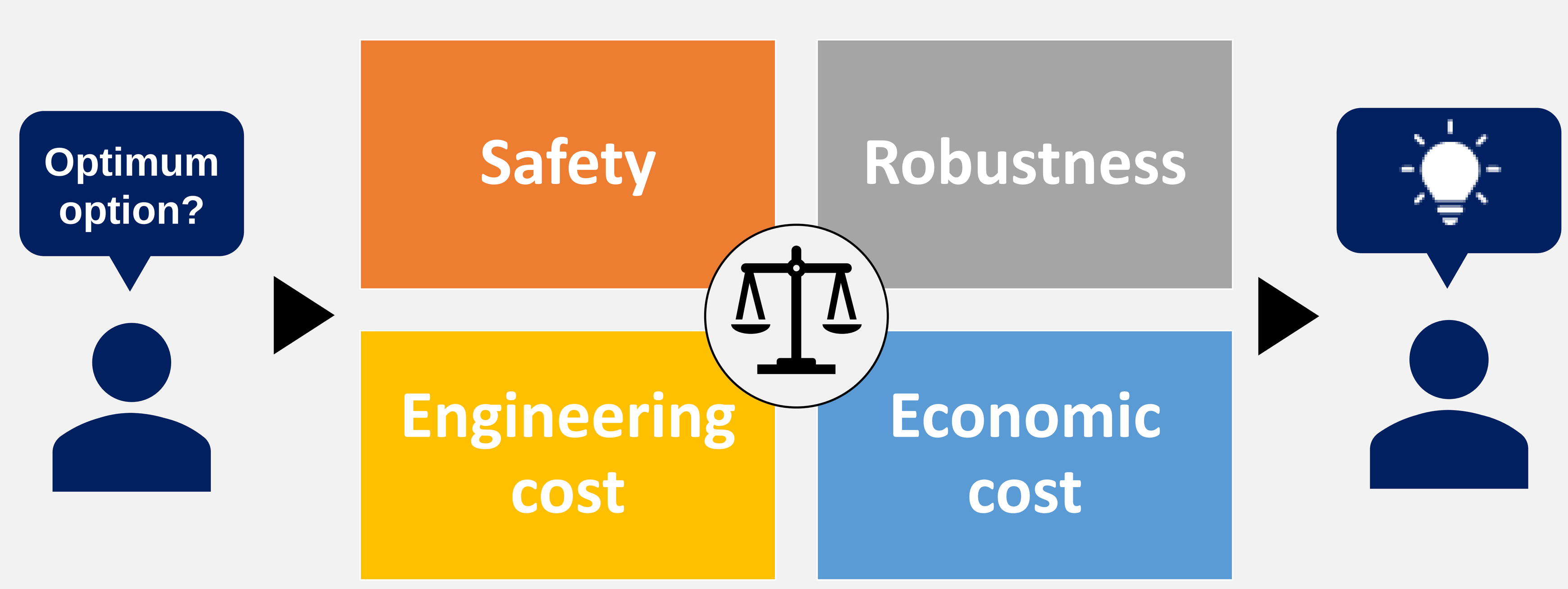
Concept of "Representative person"

When the 95th percentile of the dose distribution to the representative person is less than the dose constraint, the vast majority of the population is protected from the radiation.

ICRP Publ. 101a

Step 4：Collect information for a decision

- ✓ The **mode** of the dose distribution can be converted into a degree of **safety** of a disposal facility.
- ✓ The **width** of the dose distribution can be converted into a degree of **robustness** of the assessment.



This methodology can support reasonable decision-making.

Summary

- This methodology enables
  - quantitative comparisons between design options using not only the safety of the facility (expressed by the mode of the probability distribution of doses) but also the robustness of the assessment (expressed by the width of the probability distribution of doses) as indices.
  - a reasonable discussion of which engineering measures to spend resources on to increase safety and robustness within the limited resources of the disposal project.

Note: the flow chart was changed with reference to figures in Ref.[1, 2].

[1] R. Nakabayashi, D. Sugiyama, "Methodology to optimize radiation protection in radioactive waste disposal after closure of a disposal facility based on probabilistic approach", JNST, Vol.55, No.33, 335–347, (2018).
[2] R. Nakabayashi, D. Sugiyama, "Development of methodology of probabilistic safety assessment for radioactive waste disposal in consideration of epistemic uncertainty and aleatory uncertainty", JNST, Vol.53, No.12, 2006–2017, (2017).