OKLO INC

RIPB Methods: Benefits and Challenges

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About Oklo

Oklo develops clean energy generation sources with advanced fission to mitigate the social and environmental impacts of pollution as well as energy poverty.

- Raised the first-ever modern, venture led series A for a fission company
- Granted a site use permit from Department of Energy for the INL site
- Selected to demonstrate reuse of fuel at INL
- Became the first advanced fission company in the country to have a license application accepted by the NRC

As seen in

HYPERALLERGIC

AD
ARCHITECTURAL DIGEST

Goldman Sachs

WIRED

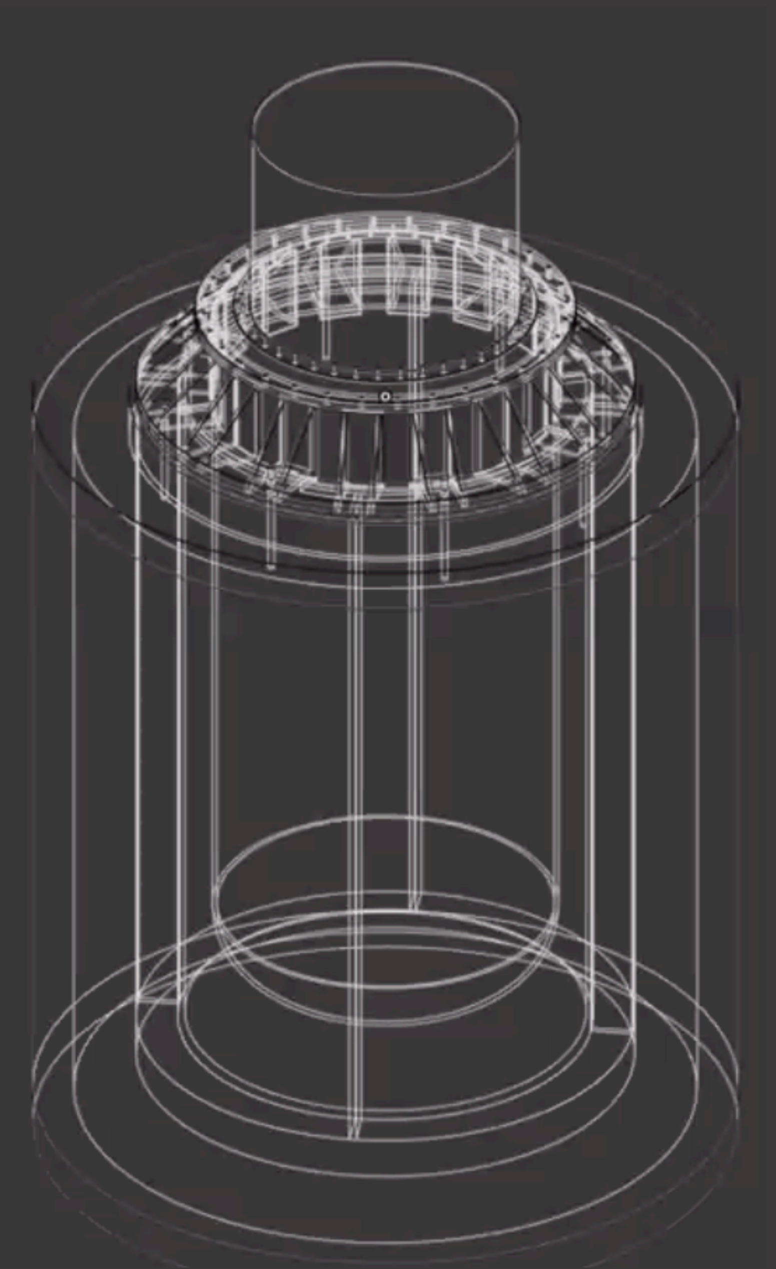
VentureBeat

crunchbase news


The Aurora

The Aurora

- 1-2 MWe output depending on use case
- 20 years between refueling
- Advanced fission battery with solar
- Can utilize used material (“waste”)



	Current large light water reactors	Aurora
Power output (MWth)	1600-4400	< 5
Refueling cycle (years)	1.5-2	None
Radionuclide inventory (metric tons)	100-150	< 5
System pressure (atm)	150	Near atmospheric
Hydrogen explosion risk	Yes	No
Cooling	Loop with low thermal inertia	Passive heat pipes
Electric power dependence	Relies on offsite power or emergency diesel generation	No safety-related electric power dependence
Negative reactivity coefficient	Yes	Yes

LMP and the Aurora

DG-1353 pilot in 2018

DG-1353 pilot

Oklo applied DG-1353 (now RG 1.233) to the Aurora in 2018 to propose a RIPB application

Piloted a COLA with DG-1353 process

- Selection of licensing basis events
- Classification of components
- Determination of defense-in-depth adequacy

Unique characteristics

- The process is risk-informed, not risk-based. Deterministic analysis is a major portion, which is then plotted on a frequency consequence curve.
- The process is not intended to handle passive let alone inherent features. Arbitrary “failing” of physical aspects presents unrealistic results.
- The defense-in-depth portion considers only frequency, not consequence.

Analyzing deterministic failures

Categorical failure of SSCs is deterministic

No associated failure probability

No longer in risk space

Inappropriate to evaluate deterministic sensitivity analysis against risk measures

Must evaluate against deterministic criteria

Failure of barriers

Passive or inherent characteristics do not disappear

- Challenge in modeling
- Aphysical

Appropriate to analyze barriers in levels of degradation

Zero consequence events

Focus in the defense-in-depth portion is based on frequency changes, regardless of consequence.

Risk is composed of frequency and consequence

- Low and zero consequence events either nullify or substantively reduce total risk
- Categorical classification of components based on frequency is illogical

DG-1353 pilot results

No safety functions or safety-related SSCs

Many NSRST SSCs

- Due to increase of frequency issue
- Still zero consequence
- Unclear regulatory burden

Anticipated challenges for all to implement process, for these and other reasons (bringing beyond design basis space into design basis space, extending frequencies needed to be considered by an order of magnitude)

Risk Triplet – revised!

Instead of "What can go wrong?" then "How likely is it?" then "What are the consequences?"…

…Establishing "What can go wrong" then "what are the consequences" ***before*** the rabbit hole of establishing frequency for FOAK - can be critically important for efficiency in evaluating advanced fission with inherent safety and many events which do not result in consequence.

- In other words "are there any consequences?" is a key question for advanced designs.

This enables evaluating credible events with possible consequences found deterministically against **performance-based** metrics of dose in the regulation. Risk can also be assessed for credible events with consequences, as shown in the Aurora PRA.

COLA Approach

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COLA Approach

- Pursuing custom COL
- There are many things we are doing differently with the NRC to change the paradigm:
  - Quality Assurance (QA) – novel QAPD approved by NRC
  - Continuity of staff involved in pre-application into our application (core team)
  - Project management via Licensing Project Plan (LPP)
  - Simple, safe design means few “safety-related” parts/issues

The Challenge

- Meeting regulations while the design meets regulations “inherently”
- Instead of binary “dumb tags” of SSCs as “safety-related” or not, really assessing what key assumptions or analysis parameters must hold, and how they will be tracked and assured

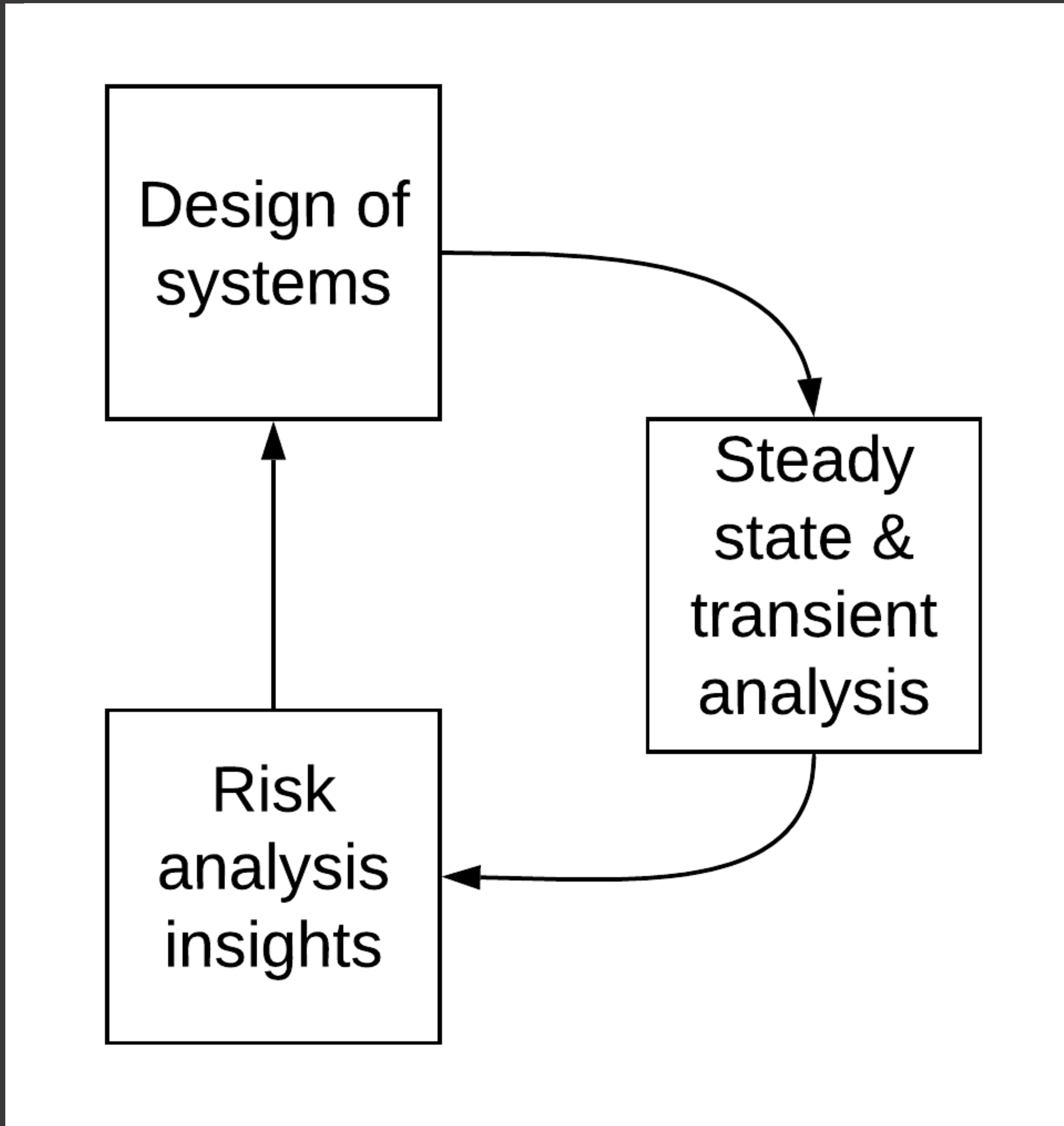
Design and analysis methodology

Iterative and systematic process

- Systems are designed to safety goals
- Performance is analyzed under many different event types to find the Maximum Credible Accident (MCA), including:
  - Historical event types for non-LWRs
  - Event categories in NUREG 0800
  - External hazards
- PRA is used for defense-in-depth to the determination of the MCA

Key parameters are called design bases

Subsequent slides explain the use of design bases, design commitments, and programmatic controls to ensure as-analyzed performance



Design bases, design commitments, and programmatic controls

Design Bases

The characteristics of a system that ensure the safe operation of the reactor

Design Commitments

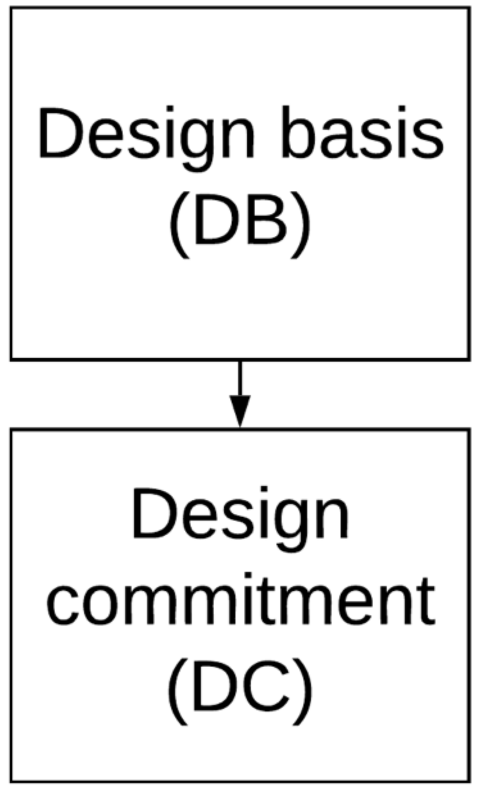
The specific commitments made to ensure that a design basis is met

Programmatic Controls

Administrative controls used to ensure that the design commitments are met

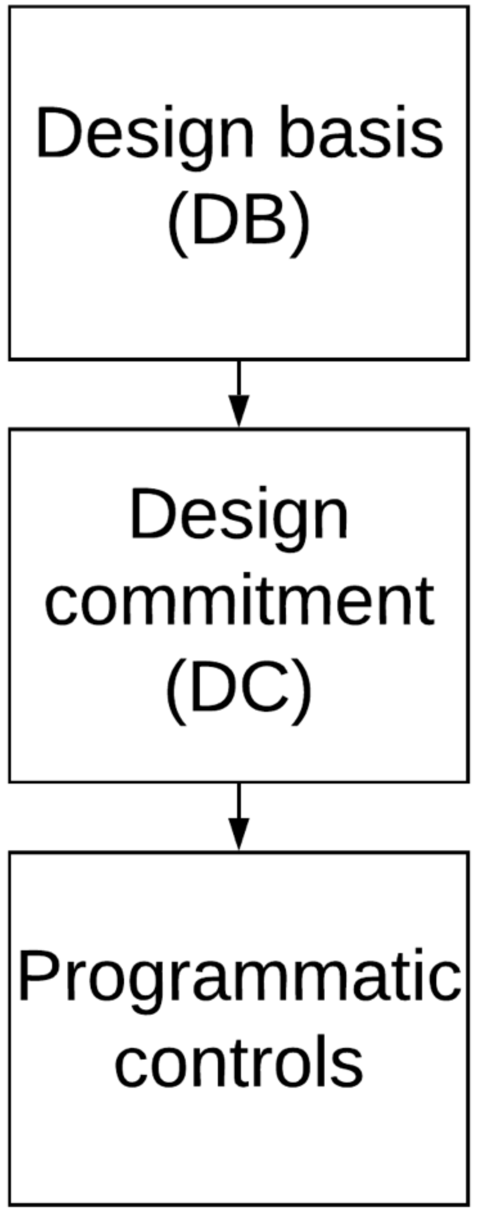
Design basis (DB)

Design bases:
The characteristics of a system that ensure the safe operation of the reactor.



Design commitments:

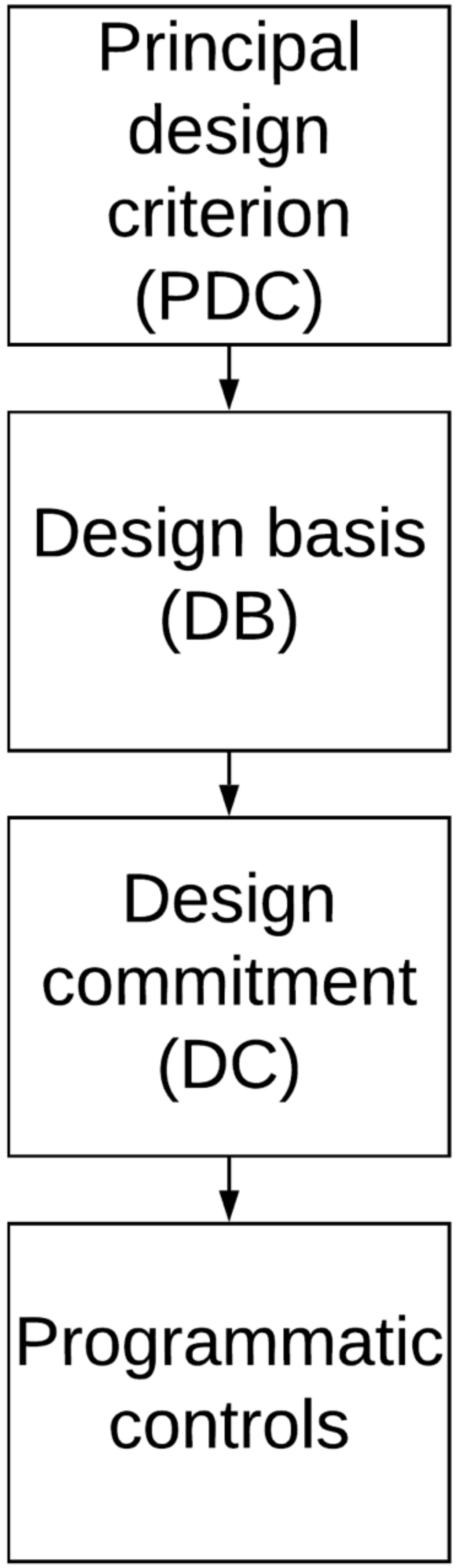
The specific commitments made to ensure that a design basis is met.



Programmatic controls:

Administrative controls used to ensure that the design commitments are met. These are the tools that the regulator uses to ensure as-built, as-operated performance and include:

- Quality Assurance Program (QAP)
- Preoperational tests (POTs)
- Startup tests (SUTs)
- Inspections, test, and analysis acceptance criteria (ITAAC)
- Technical Specifications (TS)



Summary

FSAR describes

- Each system and provides the DBs and DCs
- Assumptions and key parameters in analysis and confirms the sufficiency of the DBs and DCs in ensuring safety
- Includes PRA as required by regulation, which was used for defense-in-depth

The design process is iterative with insight from risk and PDC allow for a functional derivation of DBs as opposed to systematic

Ultimately, the Aurora-INL COLA is primarily performance based to meet the regulations, and utilizes a primarily deterministic event analysis method, which incorporates risk insight.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