ECE180DA (Winter 2025)

Systems Design I

Lecture 2: Design reviews

January 14, 2025

Design

- Fundamental questions:
  - **What** is a problem worth solving?
  - **Why** would a solution be meaningful?
- Design
  - **Given**: real world (universe of tools, universe of problems)
  - **Do**: identify requirements, capabilities, and dependencies of problems and tools
  - **Goal**: validate optimality of problem + tool combination

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Solving real-world problems

technologies $\rightarrow$ **solution** $\rightarrow$ **application** $:=$ project

The design process ensures that the **best** technologies are engineered in the **best** way to address the **best** problem.

. . . and optimizes resource usage along the way

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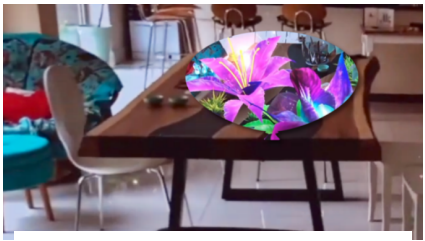
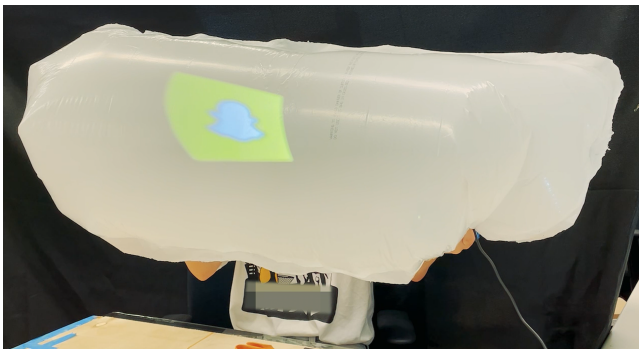
Running example: AR blimp





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Design risk

Top level risk: total value (reward) does not justify total investment (cost)

- Rewards:
  - Productivity / efficiency
  - Physical or mental health
  - Quality of life
  - Social / societal benefit
- Costs:
  - Design + development
  - Fixed / setup
  - Marginal
  - Operational

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Risk decomposition

- Insufficient technical capability
- Incomplete solution
- Integration mismatch
- Real-world / scaling uncertainties
- Unassessed operational cost
- Confounding factors on value
- Value improperly quantified
- Better value proposition from competitors
- Insufficient development resources

Incremental justification

- **To whom?** "stakeholders":
  - Recipients of value
  - Source of investment
  - Implementers
  - Additional experts / peers
- **When?** "early and often":
  - Every new threshold / category in risk
  - Every change in evaluation methodology
  - Every request for more resources

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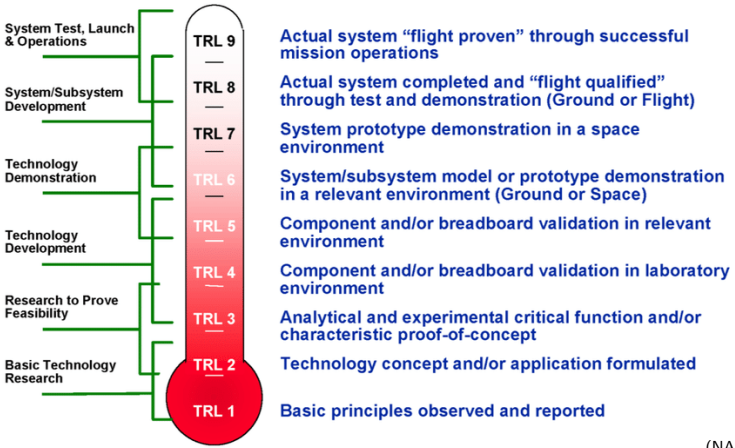
Design process metric: Technology Readiness Level (TRL)



(NASA / source unknown)

Incremental justification

- **To whom?** "stakeholders"
- **When?** "early and often"
- **How?** "design review":
  - Identify risks that have been mitigated
  - Thoroughly characterize risks that will be mitigated with new resources
  - Acknowledge remaining / outstanding risks
  - Break down spent and required resources
  - "Show your work"

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Validation

- **Interactive** validation discussion
  - Define assumptions / preconditions / constraints
  - Describe methods / processes
  - **Live demo** > recorded video > static images > text
  - Explain results in context of high level problem
  - Highlight failures, risks, uncertainty / unknowns, concerns
  - Precisely formulate next and future **questions**
  - Organized for optimal communication

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Design review format

- Agenda
  - Introduction
    - People, purpose, process (of review)
  - Background
    - Summary of + changes from previous reviews
    - Necessary underlying knowledge
  - **Interactive** validation discussion
  - Past and future resource allocation / project management
  - Wrap-up
    - Suggested conclusions
    - Action items for audience (stakeholders) and design team

Stakeholder responsibility: judgement

- Do the data and results support the conclusions drawn?
- Are the assumptions reasonable and complete?
- Are the design methods / processes appropriate to the questions?
- Are the upcoming risks well-grounded, complete, and acceptable?
- Is this still moving towards the original problem?
- Are resources being well managed?
- "Devil's advocate", but **constructive feedback**

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Keep in mind

- Show, don't tell
- Know your audience
  - Stakeholders are likely domain experts but not necessarily technical experts
- Stakeholders are allies
  - Be open and forthcoming
  - Solicit feedback; don't pitch or persuade
  - Failures identified now prevent bigger failures later
- Communicate
  - Have an agenda
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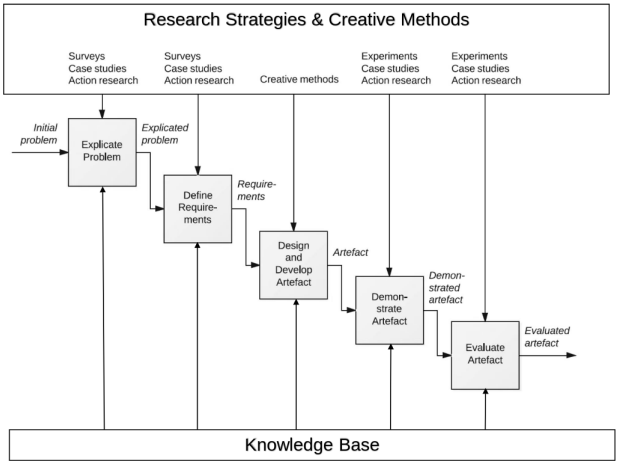
Formal design reviews

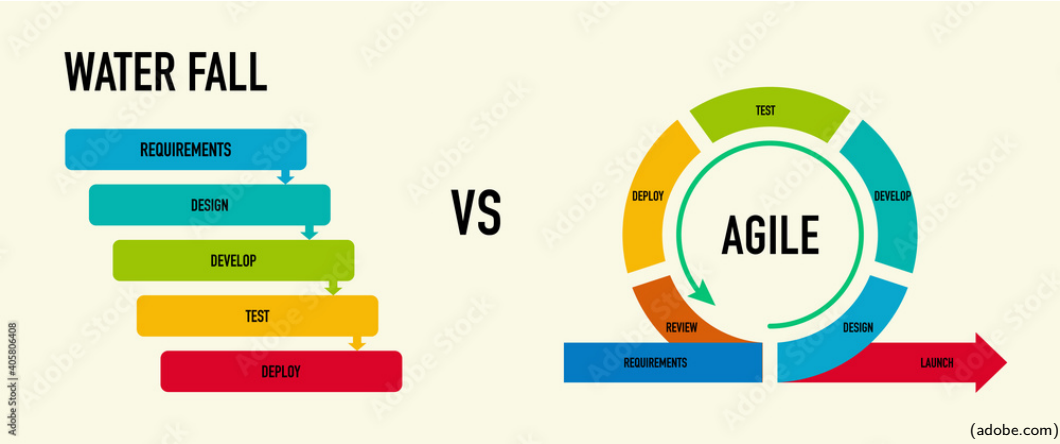
0. Concept Review(s) (*CR)
1. Requirements Review (RR)
2. System Design Review (SDR)
3. Preliminary Design Review (PDR)
4. Critical Design Review (CDR)
5. Test Readiness Review (TRR)
6. Final Design Review (FDR)
7. Production Readiness Review (PRR)

Waterfall model



(Johannesson & Perjons, 2014)

Alternate(?) approaches



ECE180 assignments

- Concept Review(s) (*CR): **P0-P1**
- Requirements Review (RR) +
  System Design Review (SDR): **P2-P4**
- Preliminary Design Review (PDR): **P5-P6**
- Critical Design Review (CDR) +
  Test Readiness Review (TRR): **P8**
- Final Design Review (FDR): **P9**
- ~~Production Readiness Review (PRR)~~

TRL 1: Brainstorming → Concept reviews / P0-P1

- **Risks to mitigate:** No generated value, no source of investment
- **Goal:** Identify stakeholders
- **Sources:** Personal experiences / influences
- **Process:**
  - Top-down or bottom-up approach
  - Identify gaps = pain points
    - Obvious / explicit gap
    - Non-obvious / implicit gap
  - Generalize the problem
  - Don't presume or get attached to a solution!

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- **Risks to mitigate:** Value improperly quantified, confounding factors on value
- **Goal:** Explicate the problem
- **Sources:** User studies, interviews, market research
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  - Find root causes

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- **Risks to mitigate:** Unassessed costs, integration mismatch
- **Goal:** Artifact definition
- **Sources:** Technical research, product analysis
- **Process:**
  - Clarify objectives
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  - Set requirements
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TRL 3: Proof-of-concept → Preliminary Design Review (PDR) / P5-6

- **Risks to mitigate:** Incomplete solution, insufficient resources
- **Goal:** Design and development plan
- **Sources:** Low fidelity experiments, past experience
- **Process:**
  - Develop design candidates
  - Identify evaluation methods
  - Promise deliverables
  - Allocate resources

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TRL 4-5: Component validation → Critical Design Review (CDR) / P8

- **Risks to mitigate:** Insufficient technical capabilities
- **Goal:** Reassurance / course correction
- **Sources:** High-fidelity component experiments, initial integrative experiments
- **Process:**
  - Compile and analyze experimental results
  - Generate deliverables
  - (Execute on PDR plan)

TRL 4-5: Component validation → Critical Design Review (CDR) / P8

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TRL 6: (Sub)system validation → Final Design Review (FDR) / P9

- **Risks to mitigate:** Real-world uncertainties, better value proposition from competitors
- **Goal:** Validated integrated system design
- **Sources:** Integrative experiments, user studies
- **Process:**
  - Compile and analyze experimental results
  - Run demos / user studies
  - Generate deliverables
  - (Execute on PDR / CDR plan)

TRL 6: (Sub)system validation → Final Design Review (FDR) / P9

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TRL 7-8: Full system qualification → Production Readiness Review (PRR) / Out of scope

- **Risks to mitigate:** Manufacturing / scaling uncertainties
- **Goal:** Manufacturing plan
- **Sources:** test deployments
- **Process:**
  - System integration
  - Design for manufacturing
  - Embedded validation

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Forward risk management

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  → Concept reviews = P0-P1
- **Risks to mitigate:** Value improperly quantified, confounding factors on value,
  Risks to mitigate: Unassessed costs, integration mismatch
  → Requirements Review / System Design Review (RR/SDR) = P2-P4
- **Risks to mitigate:** Incomplete solution, insufficient resources
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Design review reminders

- Don't assume the answer going in
  - Evaluate to **eliminate**, not justify—finding supporting evidence is not enough; only stop once you've contradicted all refuting evidence.
- **Process** is more important than product
  - Justification is the key deliverable
  - Don't build what you don't have to
- Leave any preconceived expectations at the door
- **Analyze and validate** your choice of technologies, solution, and application

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Comparative analysis

Isolated evaluations are not enough

- Identify candidates and alternatives
- Determine the metric / figure of merit (FOM)
- Select evaluation methods
  - Literature search
  - Analysis
  - Prototyping
- Execute the method to **validate** a choice based on FOM

Comparative analysis

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Tasks: ask and answer questions

- Risk comes from unknowns, formulate / generalize questions to minimize the unknown
- Ask quantitative (**not** yes/no) questions
- Look for answers in the form of relationships
- Deliver design value by identifying optimal methods to answer these questions
- Plan what to do with the outcomes before executing the methods

Tasks: ask and answer questions

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- Ask quantitative (**not** yes/no) questions
- Look for answers in the form of relationships
- Deliver design value by identifying optimal methods to answer these questions
- Plan what to do with the outcomes before executing the methods

Next up

- Done by now:
  - Video lecture A1 (engineering and society)
- Thursday class:
  - Meet-and-greet, project team formation
  - Work on P1 (due next Thursday week 3) and P2
- To be done before next Monday:
  - Video lecture A2 (how to present)