Introduction to Design Science Methodology

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Slides based on the book *Design Science Methodology for Information Systems and Software Engineering*,

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Design science

- Design science is the **design** and **investigation** of artifacts in context

- Examples
  - *Design and investigation of agent-based route planning algorithms*
  - *Design and investigation of goal-oriented enterprise architecture design method*

Design science versus natural science

- Design science is **solution-oriented**
  - *How to do agent-based route planning*
  - *How to design an enterprise architecture aligned to business goals*
- Natural science, social science **are problem-oriented**
  - *Observational studies of requirements engineering in agile projects*
  - *Observational studies of patterns of evolution of groupware systems*
  - *Experimental studies to understand how software engineers understand UML*

The engineering cycle

- Real-world problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Real-world implementation evaluation

- Stakeholders, goals, phenomena, evaluation, diagnosis.
- If hypothetical real-world problem: Stakeholders do know they are stakeholders …

The engineering cycle

- Real-world problem investigation
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- Design validation
- Treatment implementation
- Real-world implementation evaluation

Treatment = interaction between artifact and context

•You design the artifact in order to create a treatment for the problem context

- *Interaction between pill and patient*
- *Interaction between Software and its Context*
- *Interaction between method and its context of use*

The engineering cycle

- Real-world problem investigation
- Treatment design
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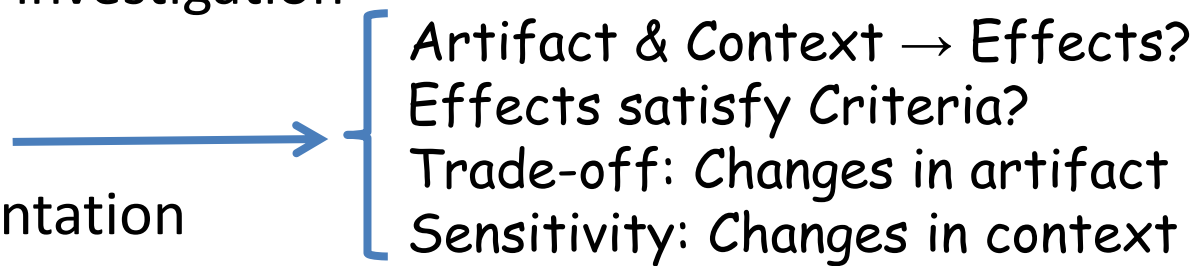
- Treatment implementation
- Real-world implementation evaluation



- Typical research methods for treatment validation:
  - Expert opinion (e.g. focus group)
  - Simulation: artifact prototype applied in simulated context
  - Field experiment: artifact prototype applied in real context to see what happens
  - Technical action research: artifact prototype applied in real context to help a client

The engineering cycle

- Real-world problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Implementation evaluation

Since the problem is real-world, this is transfer to the real world! Possible sequel to research project, but not part of reserch project.

The engineering cycle

- Real-world problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Real-world implementation evaluation

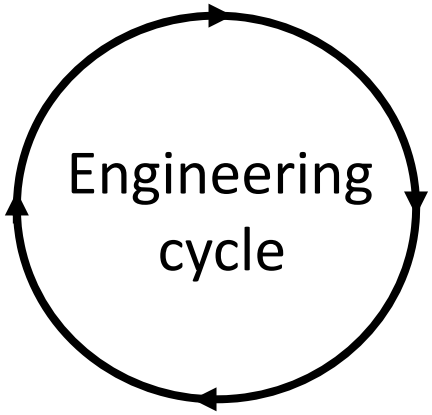
Find out what really happened after a real-world implementation:
Phenomena: Artifact & Context → Effects?
Evaluation: Effects satisfy Criteria?

Engineering cycle

Legend:
? Knowledge questions
! Tasks

Design implementation

Choose a treatment!
Transfer to practice!



Implementation evaluation = Problem investigation

- Stakeholders? Goals?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Treatment validation

- Context & Artifact → Effects?
- Effects satisfy Requirements?
- Trade-offs for different artifacts?
- Sensitivity for different Contexts?

Treatment design

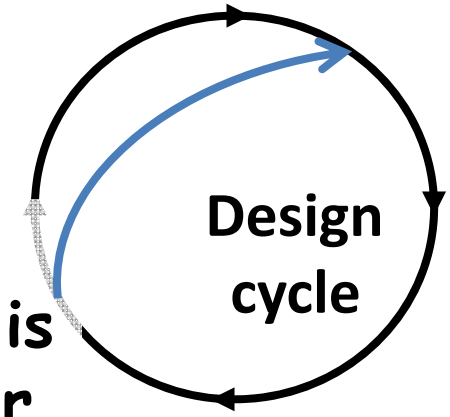
- Specify requirements!
- Contribution to goals?
- Available treatments?
- Design new ones!

Design cycle

Legend:
? Knowledge questions
! Tasks

Design implementation

Choose a treatment!
Transfer to practice!



Implementation evaluation = Problem investigation

- Stakeholders? Goals?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Real-world implementation is not part of your research project

Typically in a research project you iterate over design and validation many times

Treatment validation

- Context & Artifact → Effects?
- Effects satisfy Requirements?
- Trade-offs for different artifacts?
- Sensitivity for different Contexts?

Treatment design

- Specify requirements!
- Contribution to goals?
- Available treatments?
- Design new ones!

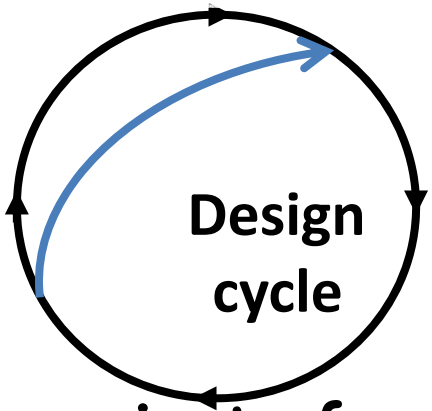
Design cycle

Legend:
? Knowledge questions
! Tasks

Some research projects focus on this (ending with a proposed treatment)

Implementation evaluation = Problem investigation

Choose a treatment!
Transfer to practice!



- Stakeholders? Goals?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Some research projects focus on this (starting with a tiny problem investigation)

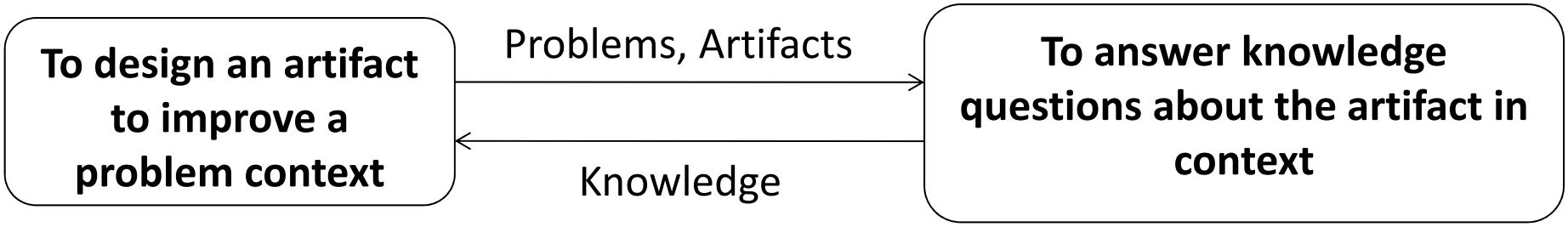
Treatment validation

- Context & Artifact → Effects?
- Effects satisfy Requirements?
- Trade-offs for different artifacts?
- Sensitivity for different Contexts?

Treatment design

- Specify requirements!
- Contribution to goals?
- Available treatments?
- Design new ones!

Research problems in design science



Solve using the engineering cycle.

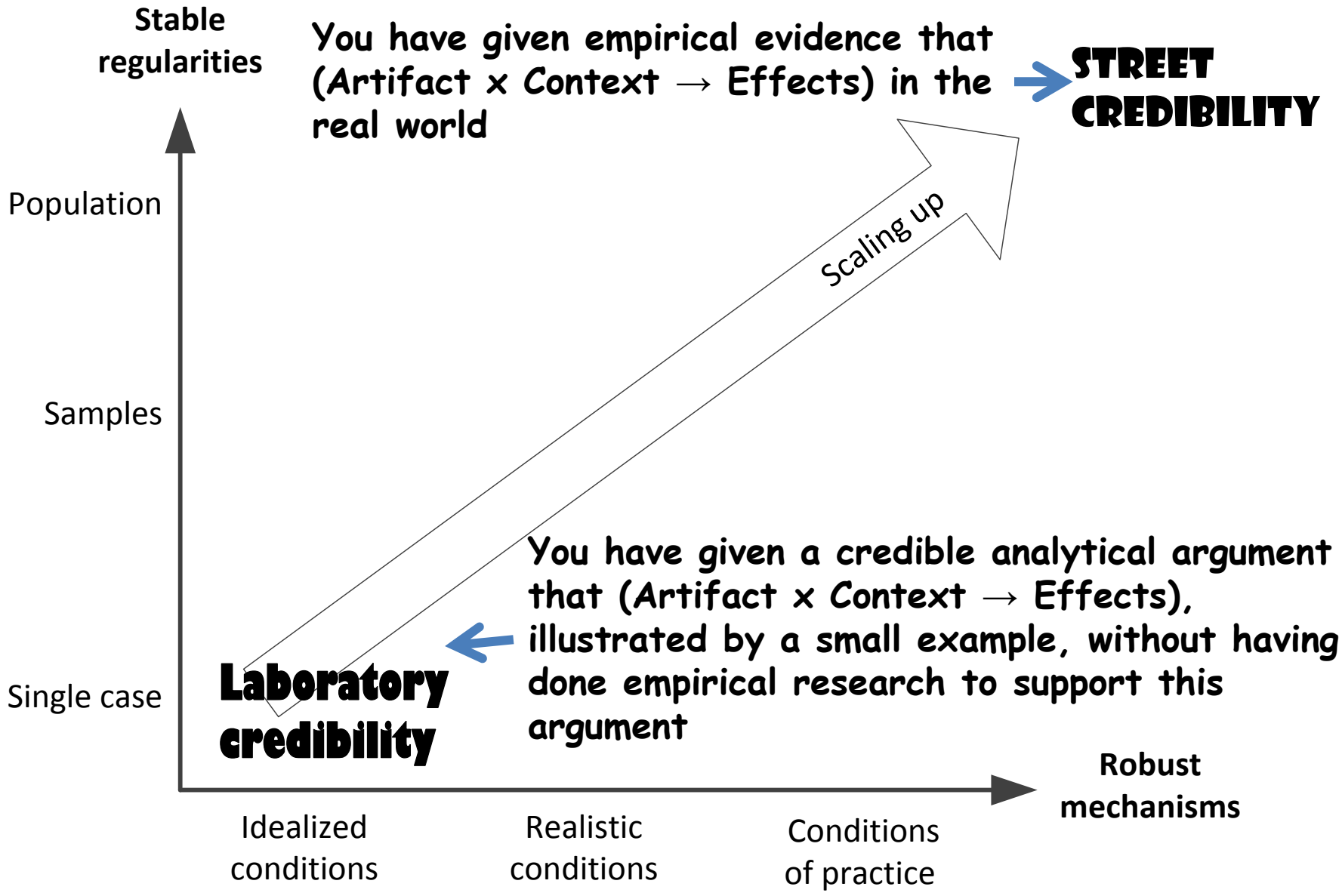
- *"Design a multi-agent system for satellite TV reception in a car."*
- *"Design a multi-agent aircraft taxi-route planning system for use on airports"*
- *"Design an assurance method for data location compliance for CSPs"*

Solve using the empirical cycle

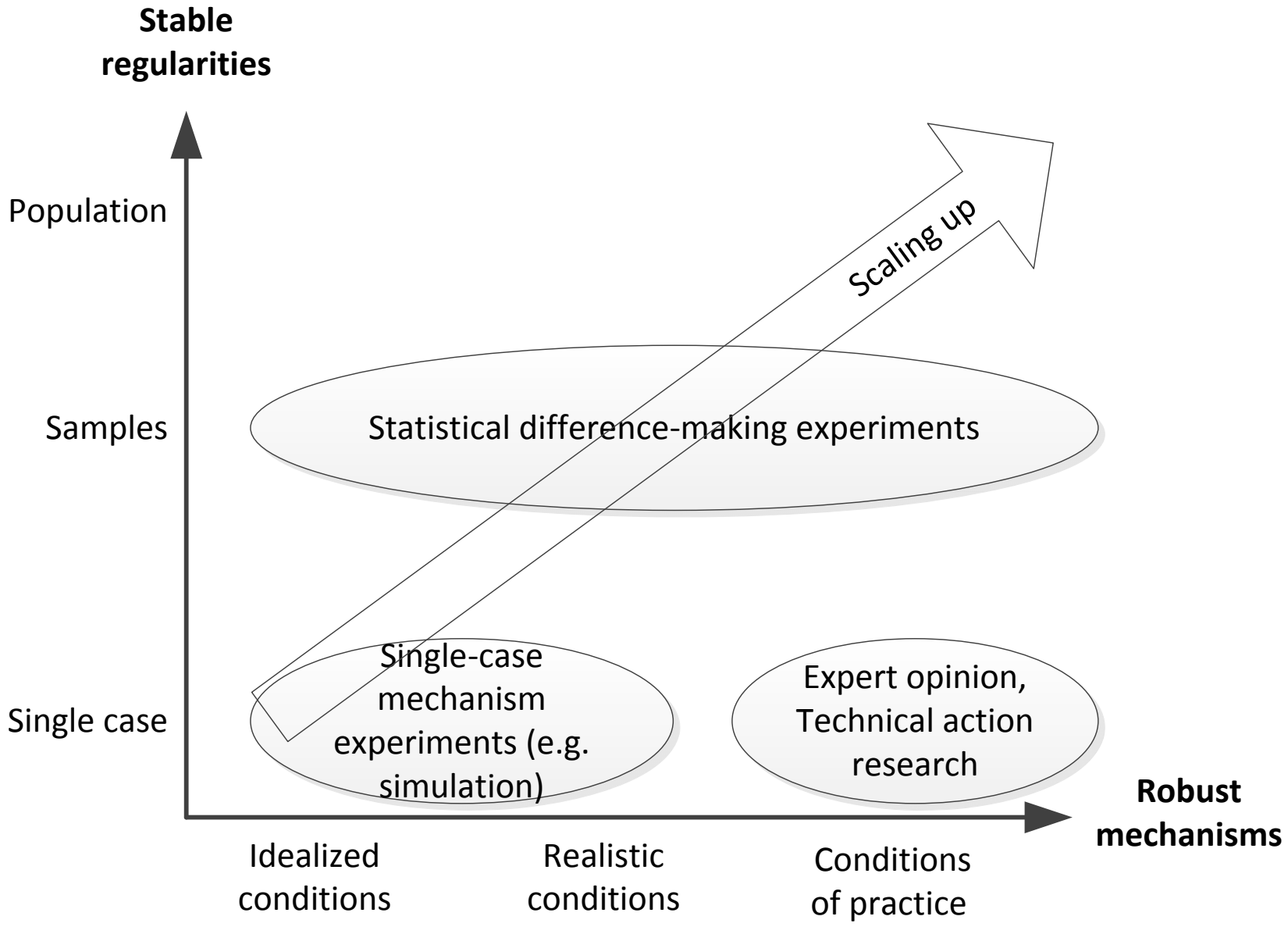
- *"Is this design good enough?"*
- *"Is this agent routing algorithm deadlock-free?"*
- *"Is the method usable and useful for cloud service providers?*

The design researcher iterates over these two activities

Validating new technology



Research methods



The empirical research cycle

- This is the rational decision cycle applied to answer knowledge questions (empirical research questions)
  - Knowledge problem investigation
  - Research design
  - Design validation
  - Research execution
  - Results evaluation

- Knowledge problem investigation → Theoretical framework, Research questions, Target of generalization (a.k.a. population)
- Research design
- Design validation
- Research execution
- Results evaluation

- Knowledge problem investigation
- Research design
- Design validation
- Research execution
- Results evaluation

Decisions about Object of study, measurement and treatment, and inference.
Possible designs:

- Survey,
- Observational case study,
- Experiment,
- Action research,
- Simulation,
- …

- Knowledge problem investigation
- Research design
- Design validation
- Research execution
- Results evaluation

Would this really answer our knowledge questions?
Risk assessment of doing the wrong thing to answer the questions

- Knowledge problem investigation
- Research design
- Design validation
- Research execution
- Results evaluation

Do the reseach as planned.
Unexpected things may happen!

- Knowledge problem investigation
- Research design
- Design validation
- Research execution
- Results evaluation → How can we now answer our knowledge questions? Risk assessment of answering the questions incorrectly

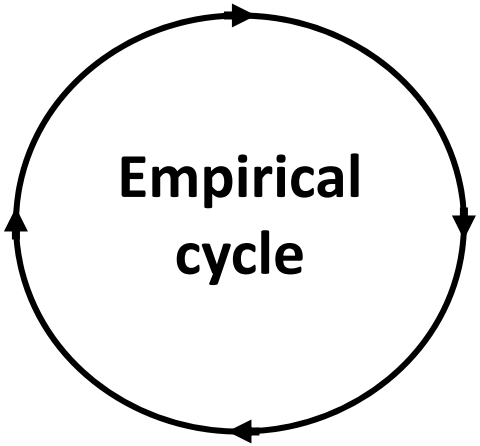
Analysis of results

12. Data?
13. Observations?
14. Explanations?
15. Generalizations?
16. Answers?

New research problem

Research execution

11. What happened?



Research problem analysis

4. Conceptual framework?
5. Research questions?
6. Population?

Research design validation

7. Object of study justification?
8. Treatment specification justification?
9. Measurement specification justification?
10. Inference justification?

Research design

7. Object of study?
8. Treatment specification?
9. Measurement specification?
10. Inference?

- Where are you?
  - Problem investigation / implementation evaluation
  - Design & validation
  - Empirical research
- What are your research goals?
  - Focus

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