Building Interactive Systems

On Systems

Professor Bilge Mutlu | Spring 2023

What we will discuss today

1. Establish a human-centered, "systems" mindset
2. Define systems contributions
3. Hear from reading groups
4. Set up for Wednesday's **HACK**

Building A Interactive Systems Mindset

Recap: What is An Interactive System?

"a set of computer equipment and programs used together for a particular purpose... characterized by significant amounts of interaction [with] humans [and their environment]"[1,2]

Two requirements:

1. **Systems** Requirement — building a **systems** mindset
2. **Interactivity** Requirement — building a **user-centered** mindset

[1] A Note from the UIST 2021 PC Chairs

[2] https://www.encyclopedia.com/computing/news-wires-white-papers-and-books/interactive-systems

Building A Systems Mindset

How do we build a "systems" mindset?

→ By better understanding systems, modeling, thinking

→ By seeing the world in terms of components, systems, ecosystems

→ Simon (1988) → understanding existing systems → devising new ones

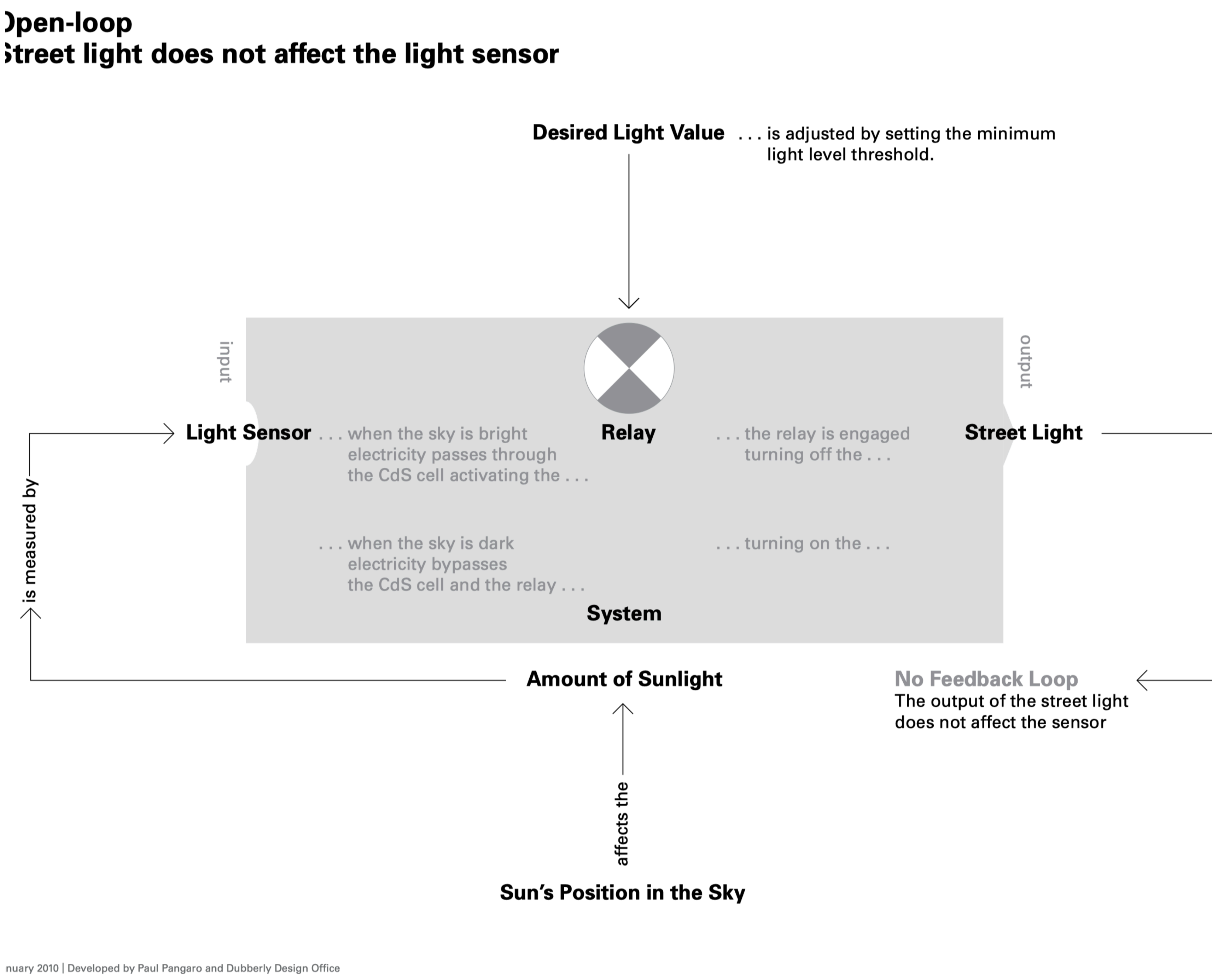
Everyone designs who devises courses of action aimed at changing existing situations into preferred ones[7]

[7] Simon (1988). The science of design: Creating the artificial. *Design Issues*, 67-82.

Open-Loop Systems[3]

Open-loop systems act on the world but receives no feedback.

Example: dusk-to-dawn street light

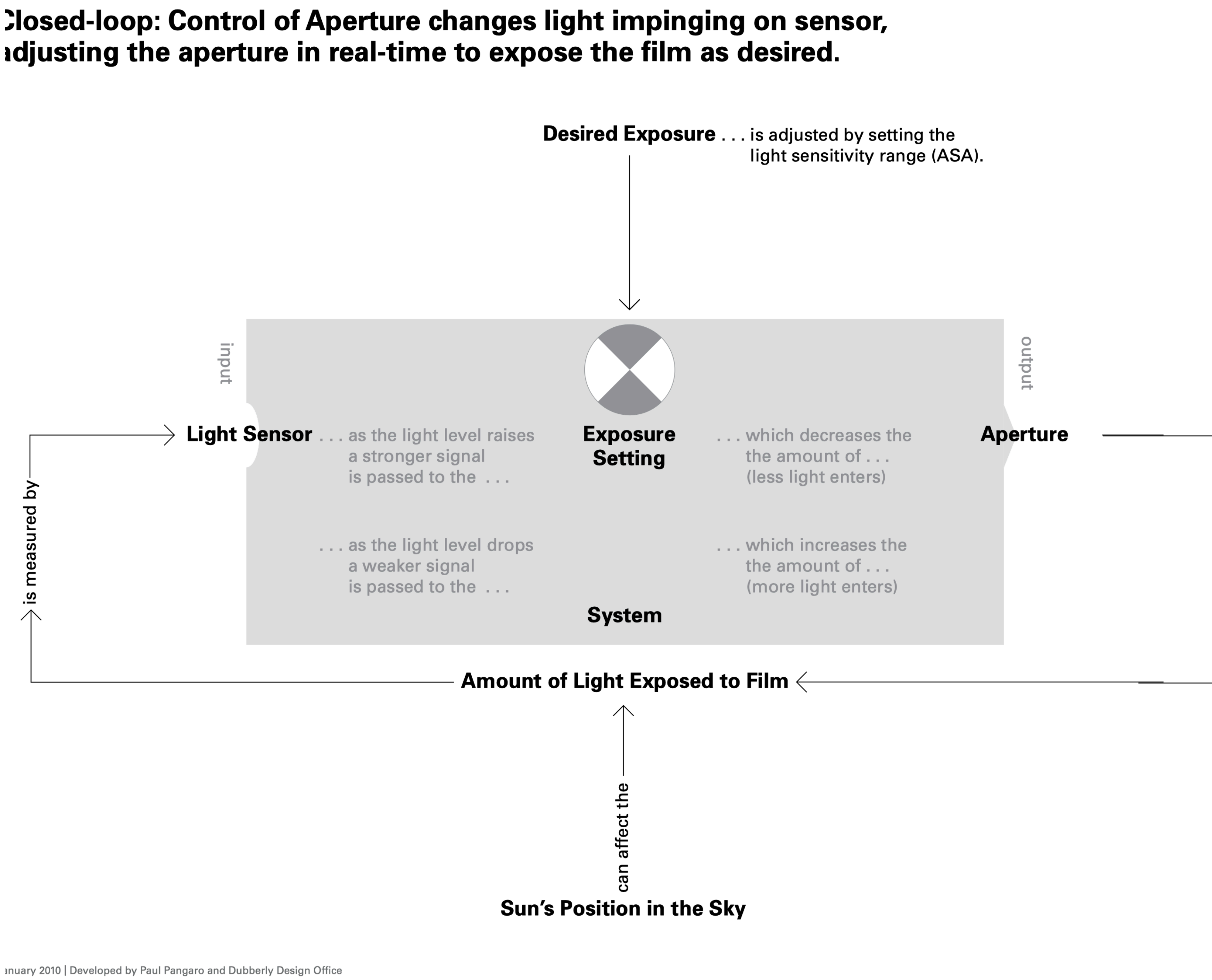


[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

Closed-Loop Systems[3]

Closed-loop systems receive **feedback** from the environment and adjust their future actions based on this information.

Example: camera auto-exposure



[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

Feedback

Definition: the return back into a machine or system of part of what it produces, especially to improve what is produced.[4]

Feedback systems:

1. First-order feedback systems
2. Second-order feedback systems

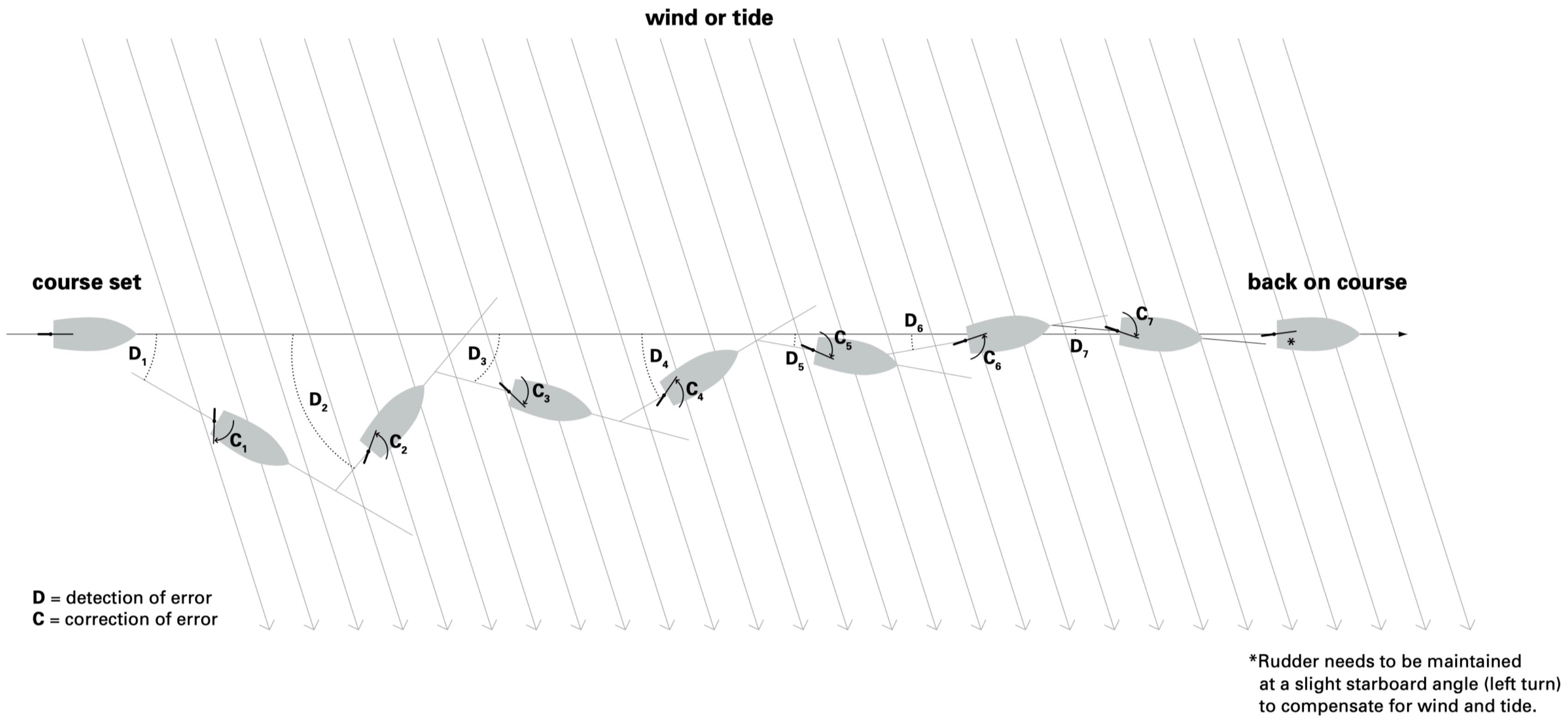
[4] https://dictionary.cambridge.org/us/dictionary/english/feedback

Detour: Cybernetics

Definition: the science of communication and control theory that is concerned especially with the comparative study of automatic control systems (such as the nervous system and brain and mechanical-electrical communication systems)[5]

Comes from `kubernetes` "steersmanship" in Greek. Coined by Weiner (1948).[6]

Example: A captain using negative feedback to steer a ship toward a goal[3]



[5] https://www.merriam-webster.com/dictionary/cybernetics

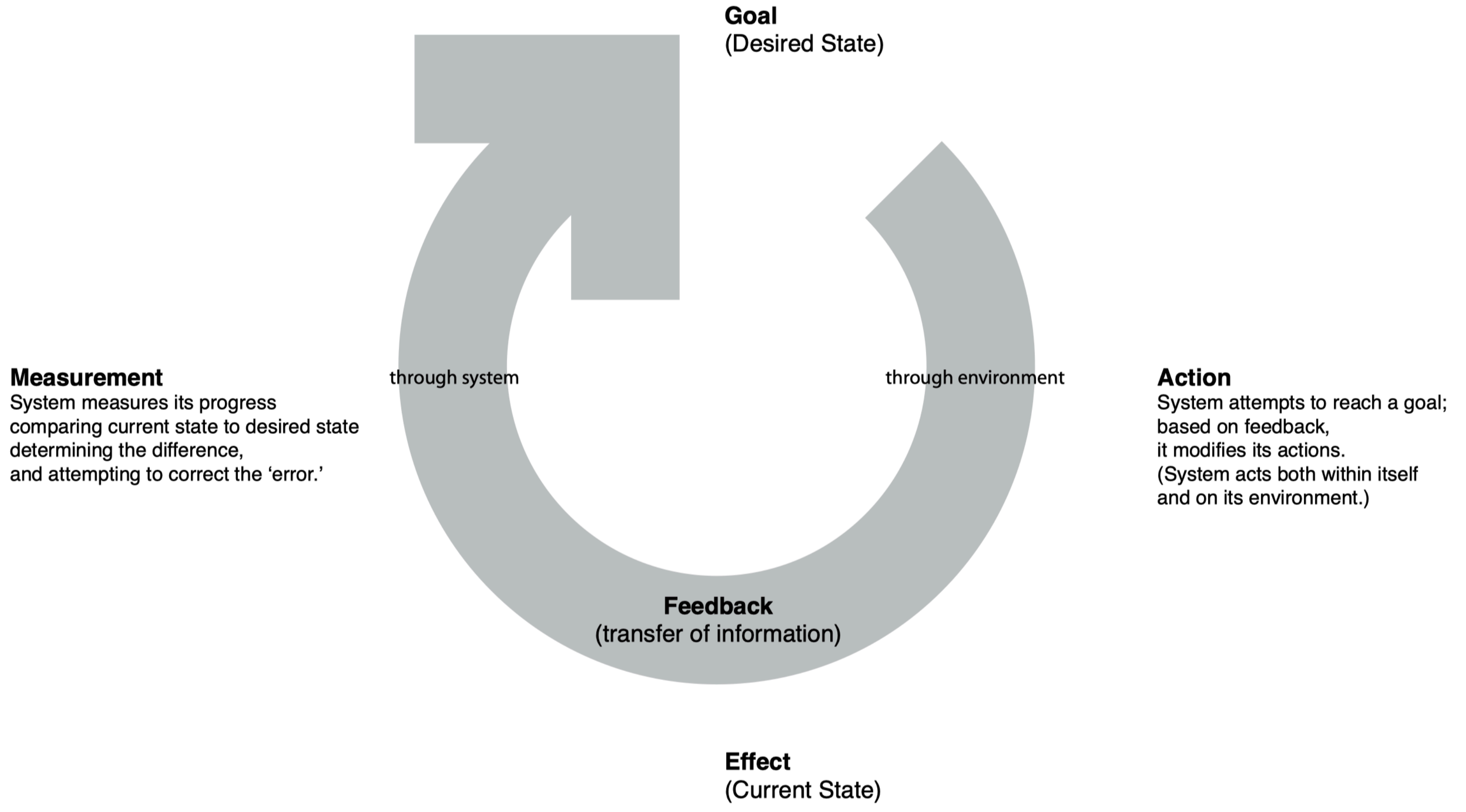
[6] Wiener (1948). Cybernetics or Control and Communication in the Animal and the Machine.

[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

First-Order Feedback Systems[3]

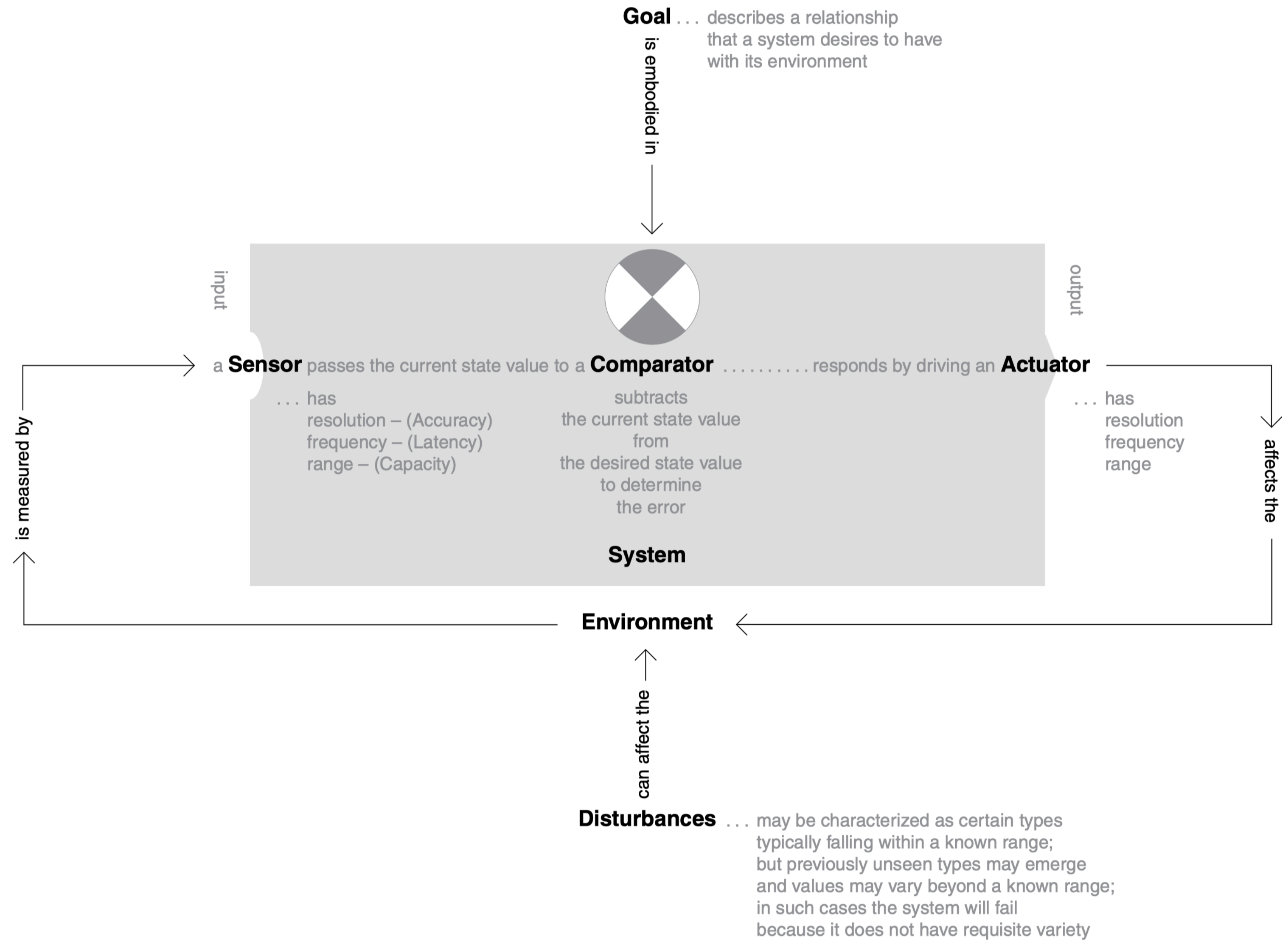
The **cybernetic loop**, which describes a basic, self-regulatory system.

Examples: thermostats, autopilots, homeostatic systems, animal-food ecosystems.



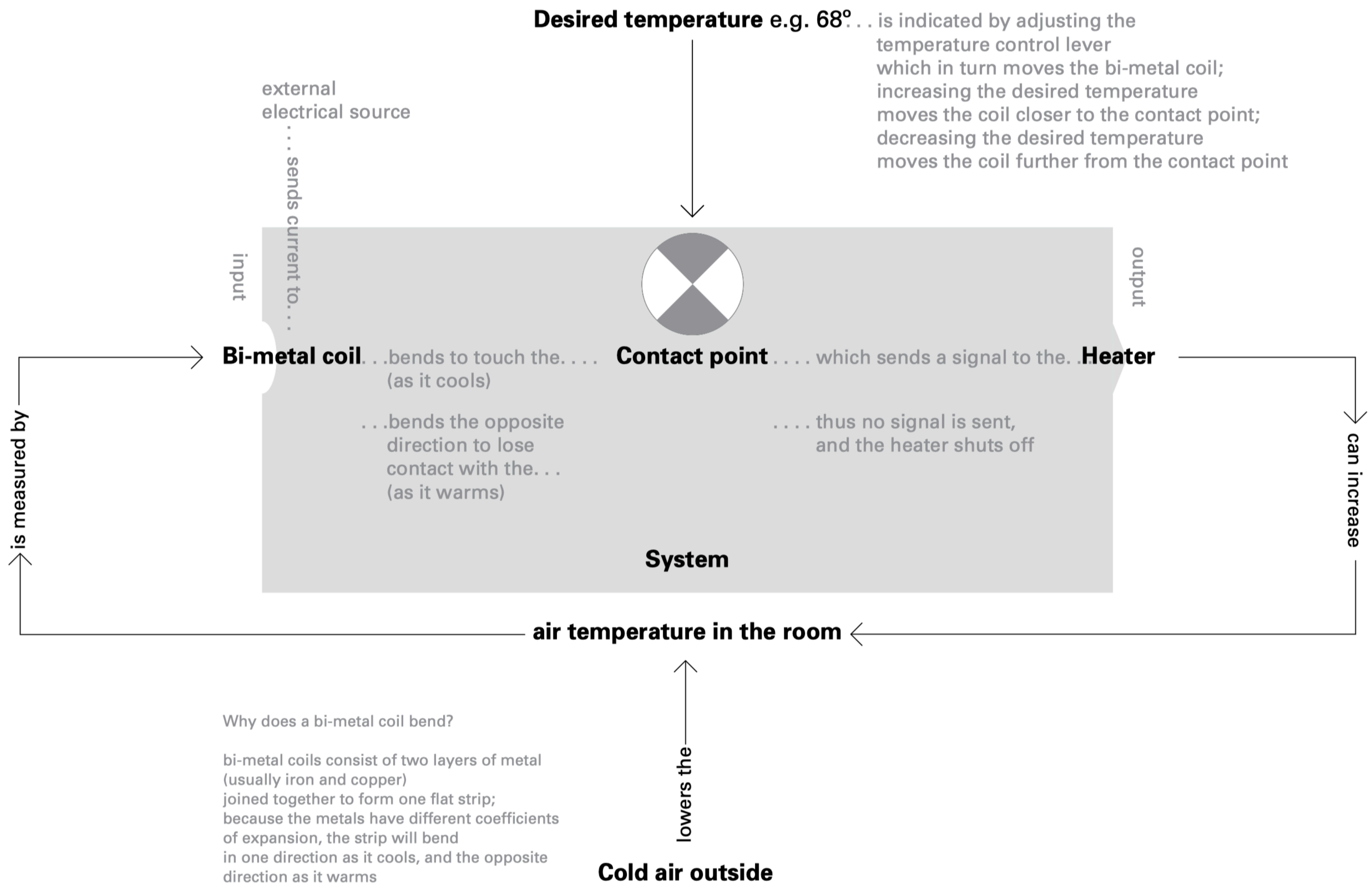
[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

Feedback: Formal Mechanism

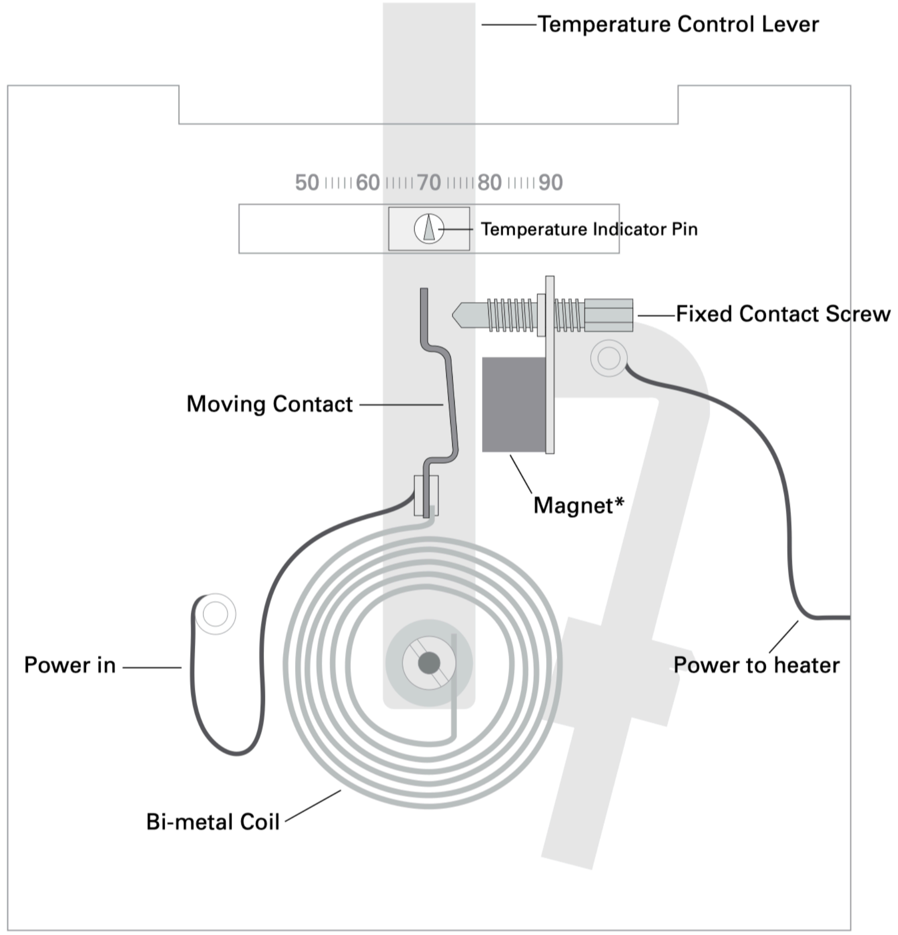


Feedback: Classic Example

Thermostat regulating room temperature (via a heater)



How a Thermostat Works



The bi-metal coil is connected
to the temperature control lever.

*The magnet insures a good contact
and prevents erratic on/off signals
to the heater in the event that the
air temperature within the room fluctuates
to quickly.

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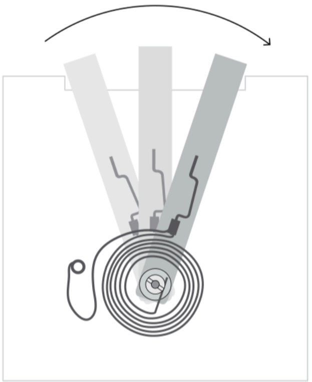
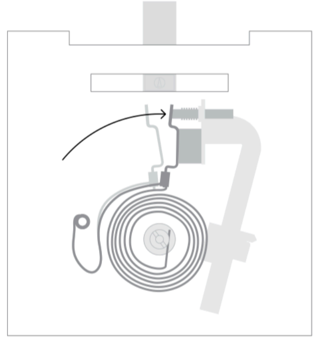
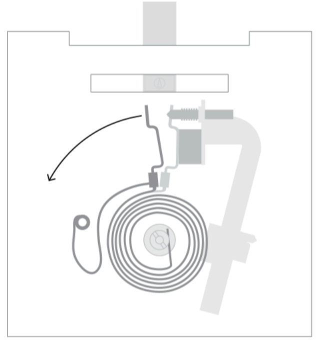


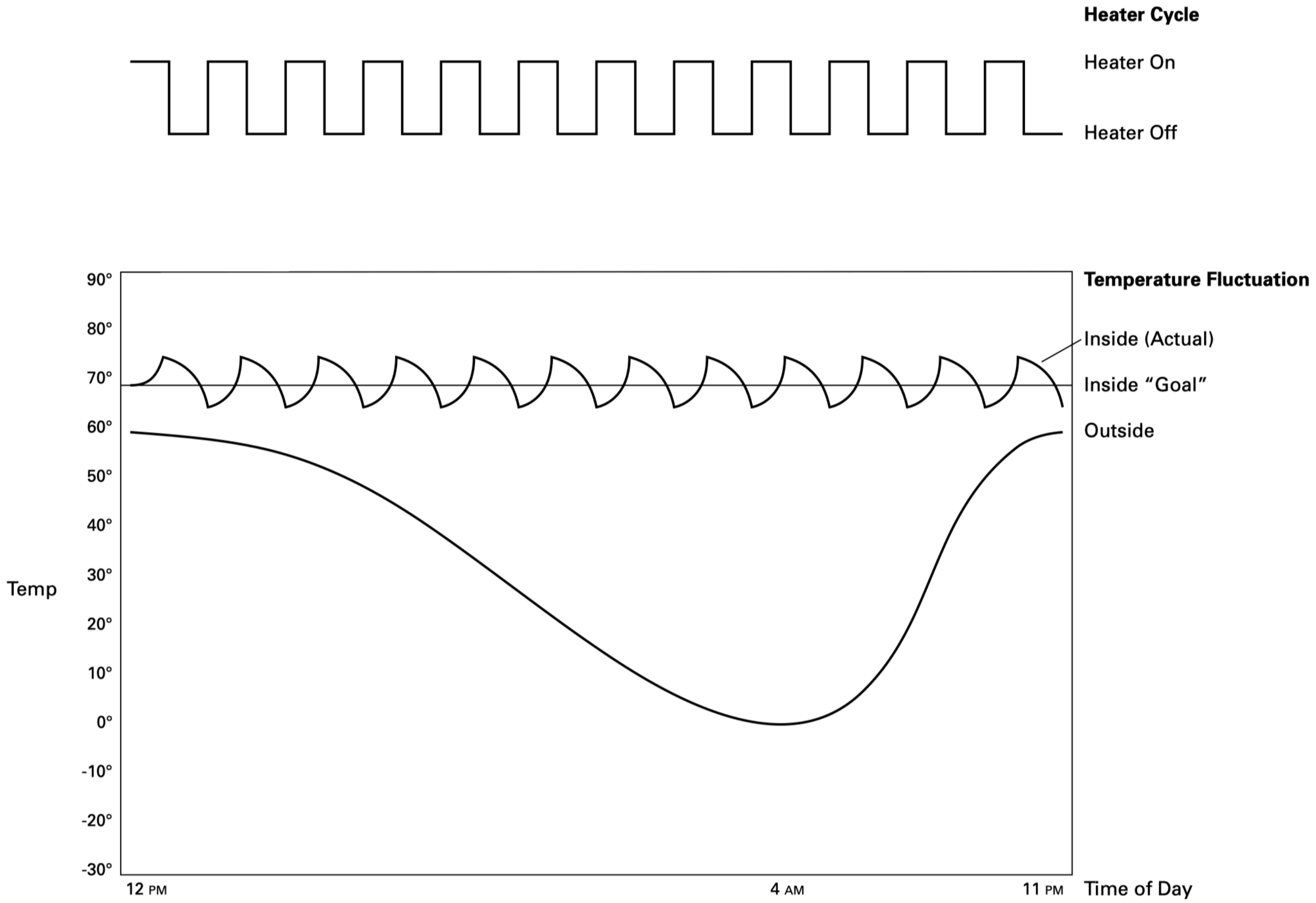
Moving the temperature control lever
moves the bi-metal coil



The bi-metal coil bends towards
the contact screw as it cools



The bi-metal coil bends away from
the contact screw as it warms



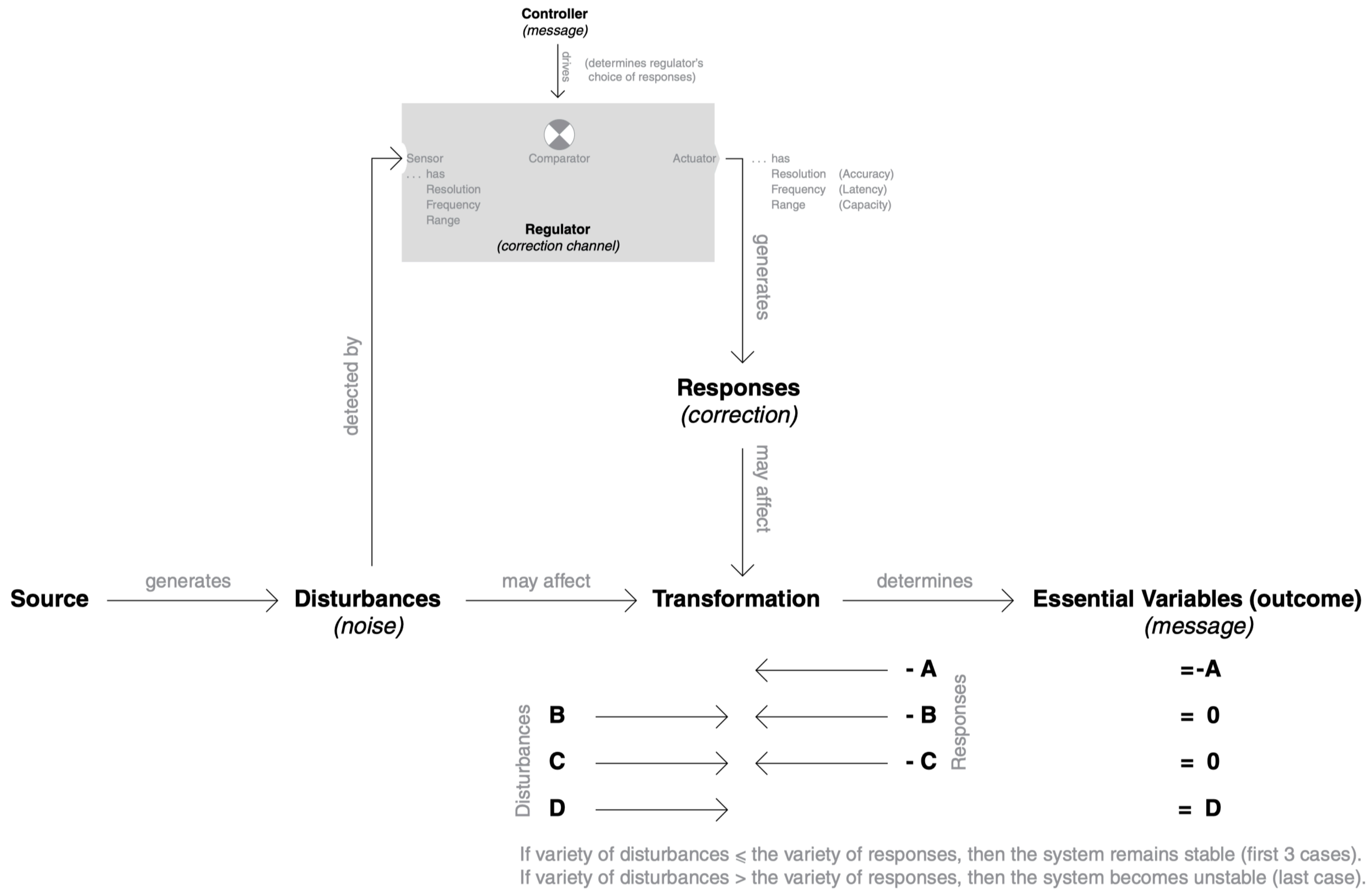
These diagrams are only intended as theoretical examples.

Requisite Variety (RV) Systems[3]

Ashby's Law of Requisite Variety: The system must have at least as much variety as the environment that is the source of the disturbances.

Essential Variables (EVs) are aspects of the system that must be maintained with a specified range for the system to be viable.

Requisite Variety: Formal Mechanism



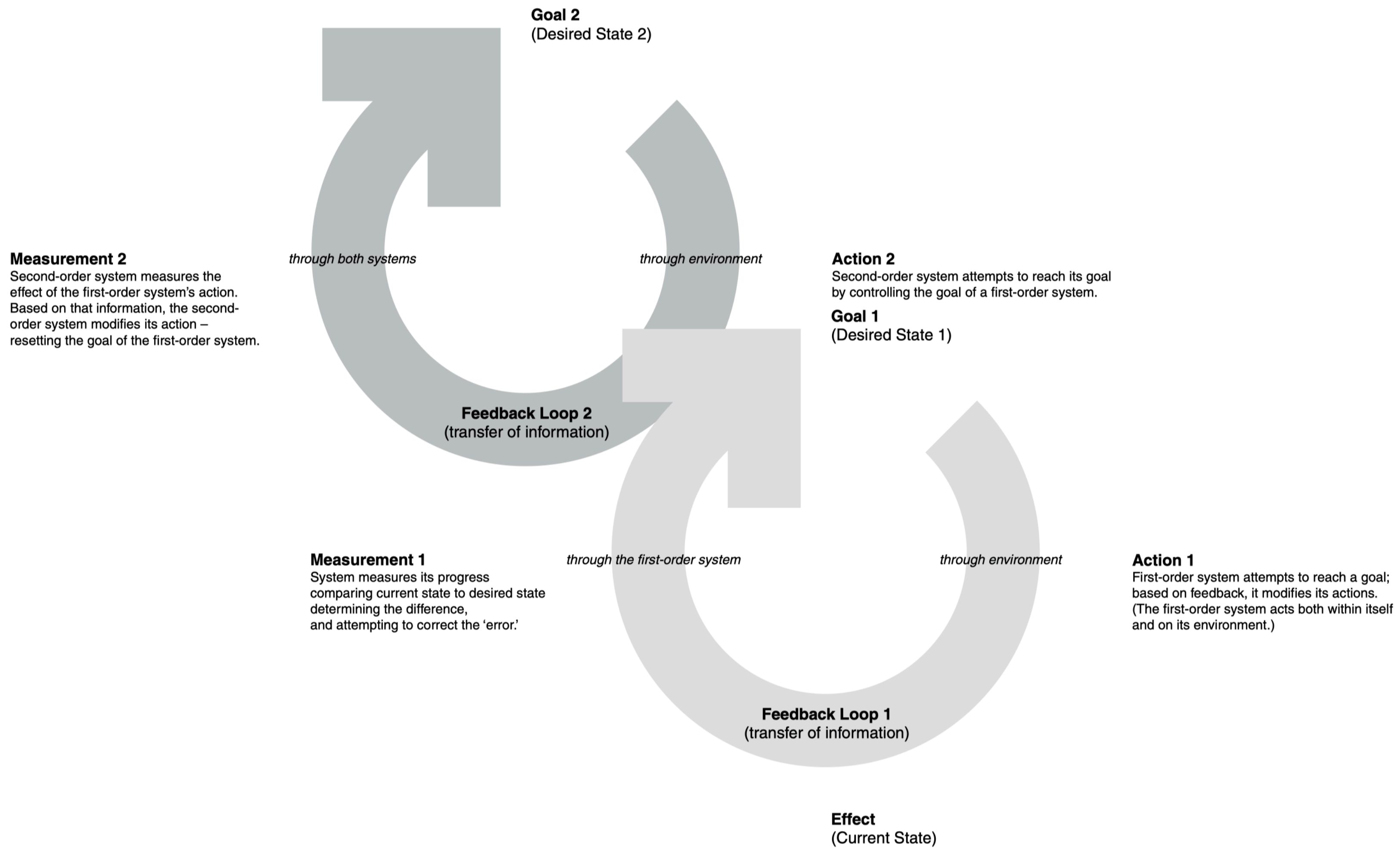
[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

Second-Order Feedback Systems[3]

Second-order feedback systems involve **two** cybernetic loops such that the actions of the outer loop regulates the goal of the inner loop.

This setup enables *learning*.

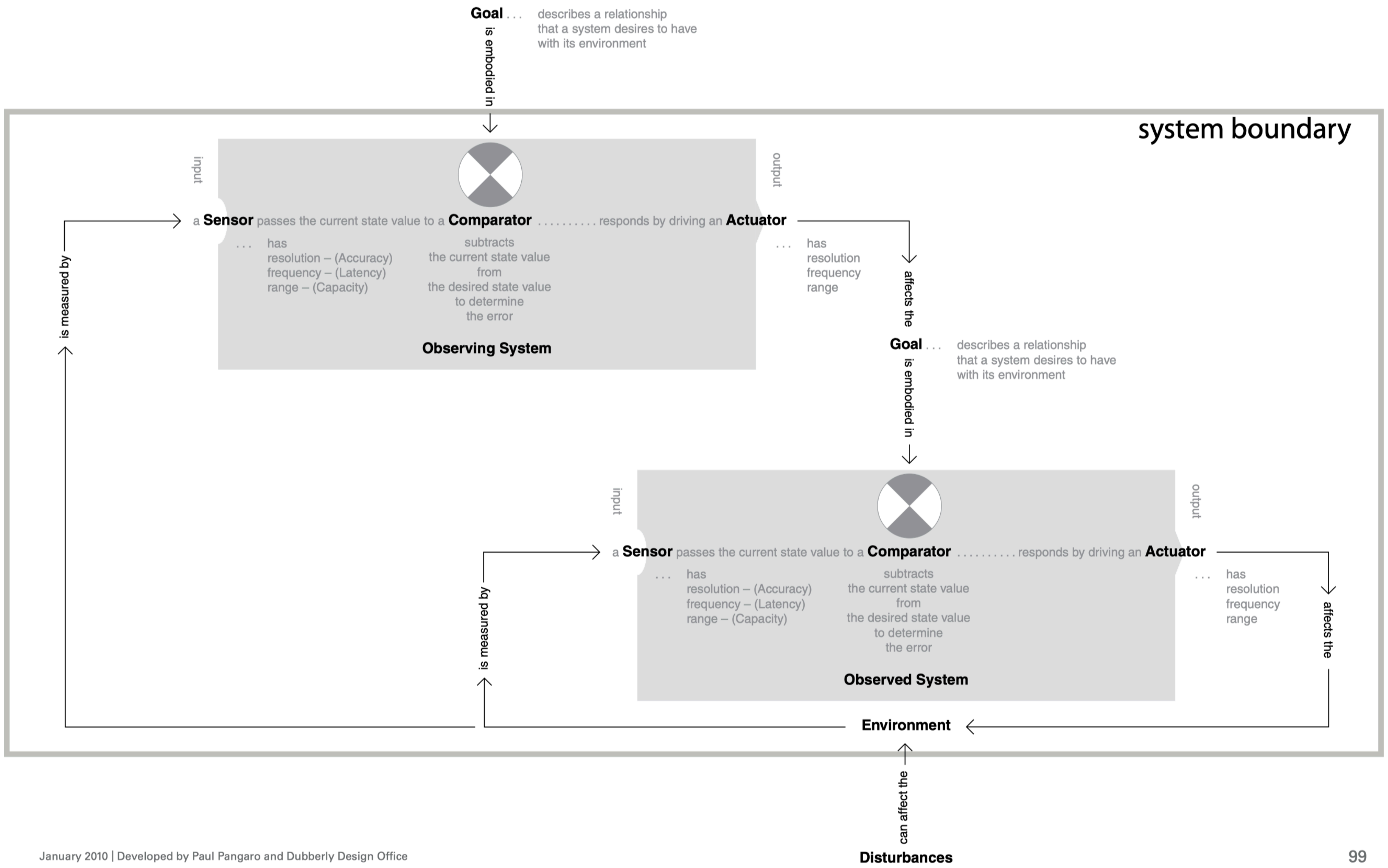
Second-order Feedback: Basics



[3] Dubberly & Pangaro (2010). Introduction to Cybernetics and the Design of Systems.

Second-order Feedback: Formal Mechanism

An automatic feedback system (first-order) is controlled
by another automatic feedback system (second-order).
The first system is 'nested' inside the second.



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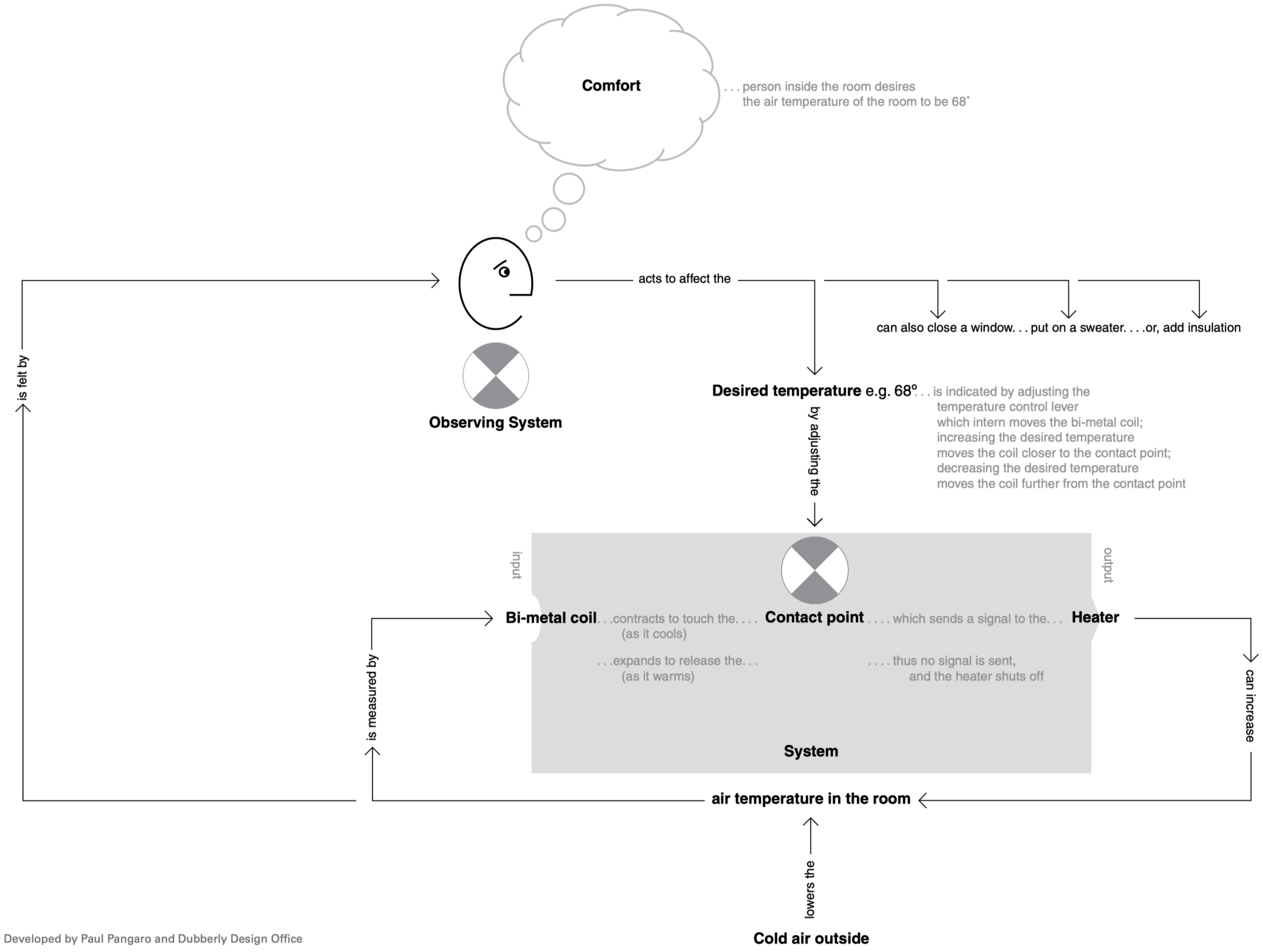
Second-order Feedback: Classic Example
Person controlling a thermostat (regulating a regulator)



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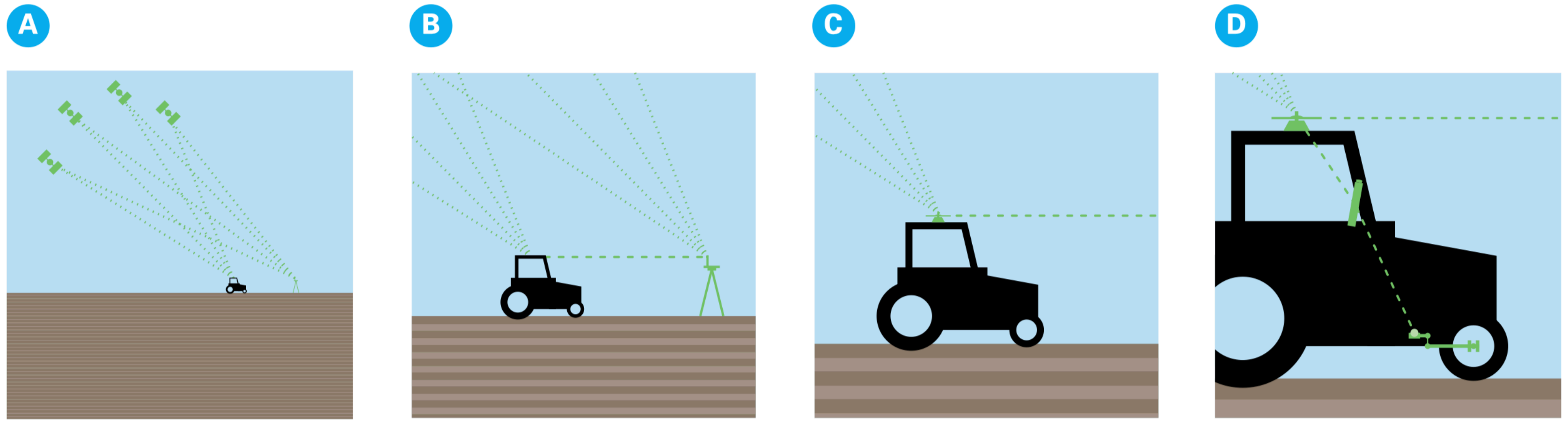
How the AutoSteer system works: Tractor Detail

The AutoSteer system relies on feedback
to insure the components work together

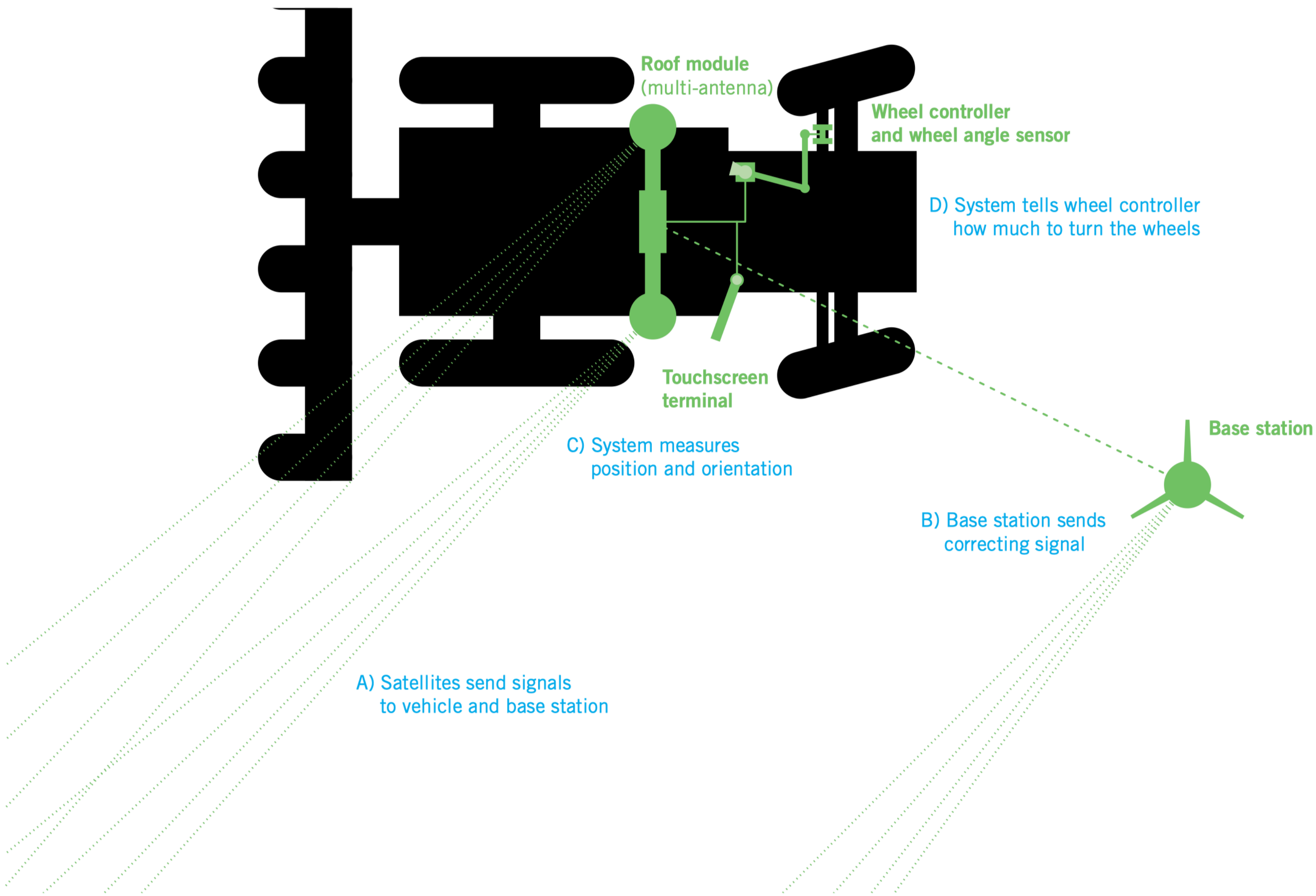


A The AutoSteer system begins with GPS satellite signals

B The base station provides correcting signals

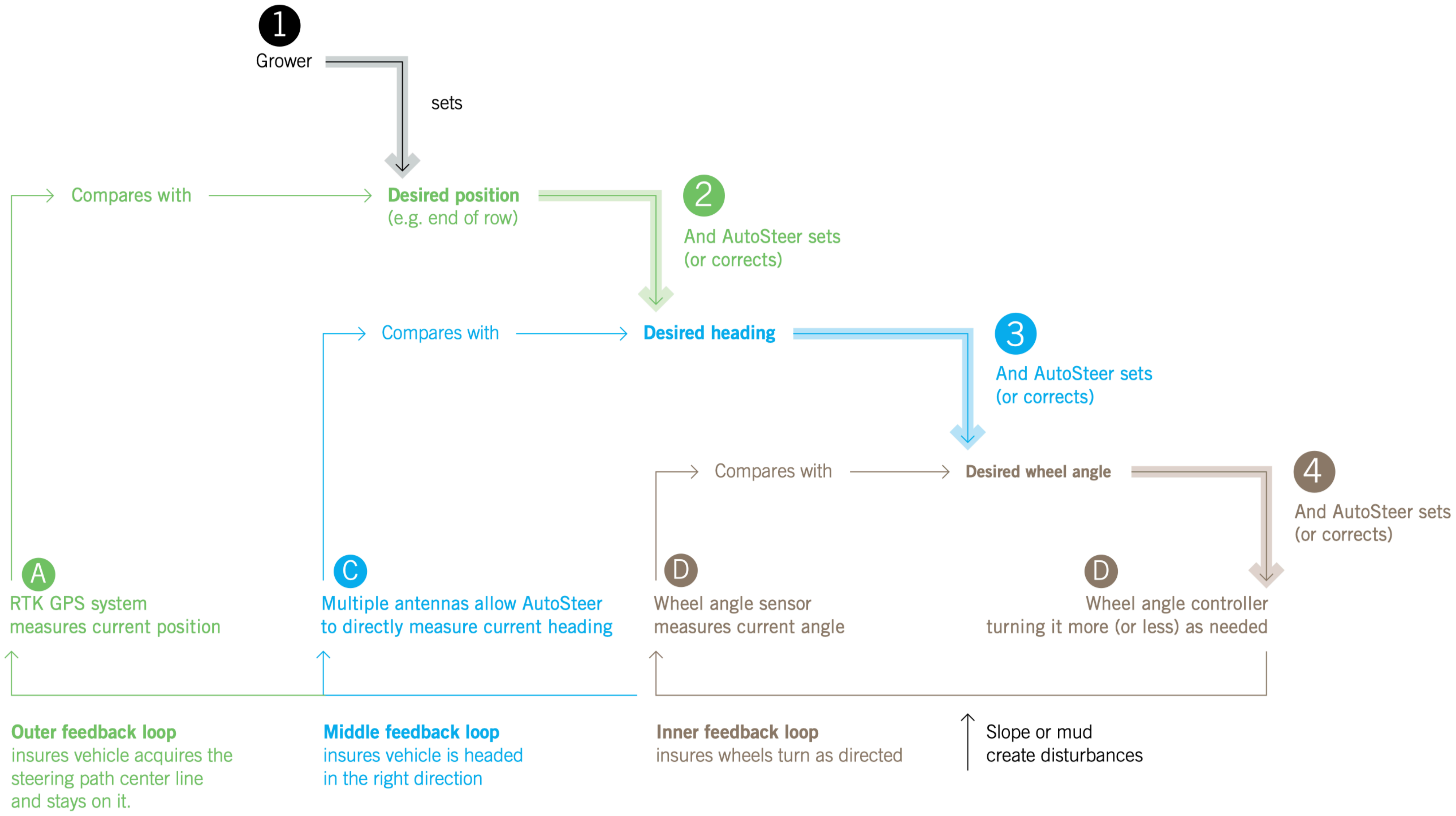
C Multiple antennas measure position and orientation (heading)

D The wheel angle controller and sensor insure precise steering



Second-order Feedback: Electro-mechanical Example: Precision Farming

The AutoSteer system uses three nested feedback loops
to automatically steer farm equipment, positioning it to an accuracy of +/- 2 cm
with repeatability assured year-round.



Building A Human-Centered Mindset

How do we build a "human-centered" mindset?

→ By better understanding interaction between humans and systems

→ By including the human systems we model, analyze, devise

→ By employing human-centered research, design, evaluation methods

What is interaction?[8]

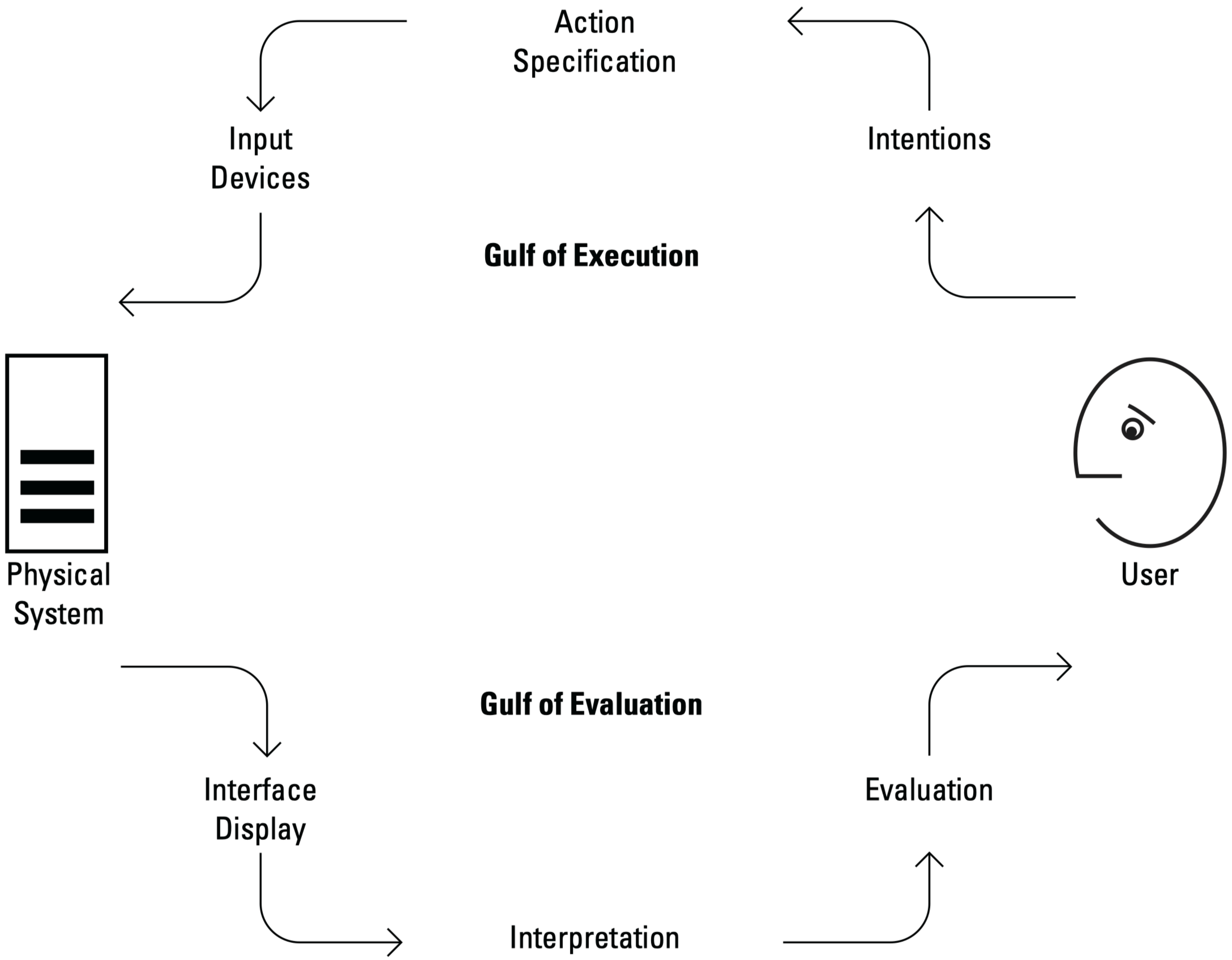
Concept	View of interaction	Key phenomena and constructs	Good interaction	Example support for evaluation and design
Dialogue	a cyclic process of communication acts and their interpretations	mappings between UI and intentions; feedback from the UI; turn taking	understandable; simple, natural; direct	methods/concepts for guessability, feedback, mapping; walkthroughs
Transmission	a sender sending a message over a noisy channel	messages (bits); sender and receiver; noisy channels	maximum throughput of information	metrics and models of user performance
Tool use	a human that uses tools to manipulate and act in the world	mediation by tools; directness of acting in the world; activity as a unit of analysis	useful and transparent tools; amplification of human capabilities	compatibility in instrumental interaction; break down analysis
Optimal behavior	adapting behavior to goals, task, UI, and capabilities	rationality; constraints; preferences; utility; strategies	improves or reaches maximum or satisfactory utility	models of choice, foraging, and adaptation
Embodiment	acting and being in situations of a material and social world	intentionality; context; coupling	provides resources for and supports fluent participation in the world	studies in the wild; thick description
Experience	an ongoing stream of expectations, feelings, memories	non-utilitarian quality; expectations; emotion	satisfies psychological needs; motivating	metrics of user experience; experience design methods
Control	interactive minimization of error against some reference	feedforward; feedback; reference; system; dynamics	rapid and stable convergence to target state	executable simulations of interactive control tasks

Dictionary definition: mutual or reciprocal action or influence.[9]

[8] Hornbæk & Oulasvirta (2017). What is interaction?. *CHI 2017*.

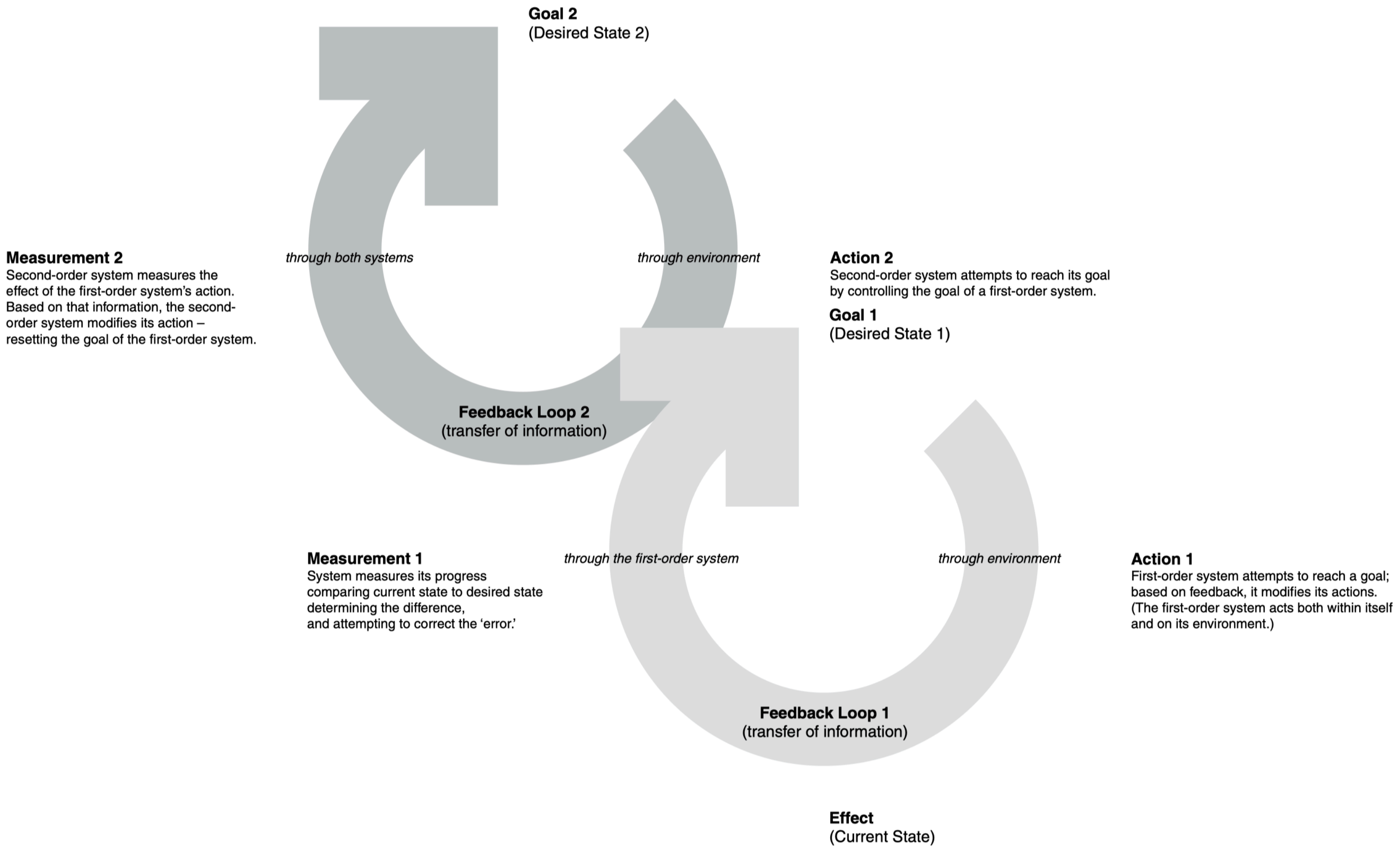
[9] https://www.merriam-webster.com/dictionary/interaction

The "gulf" model is one characterization of human-machine systems.[10]



[10] Dubberly et al. (2009). ON MODELING What is interaction? are there different types?. *interactions*.

Second-order Feedback: Basics



Second-order Feedback: Classic Example
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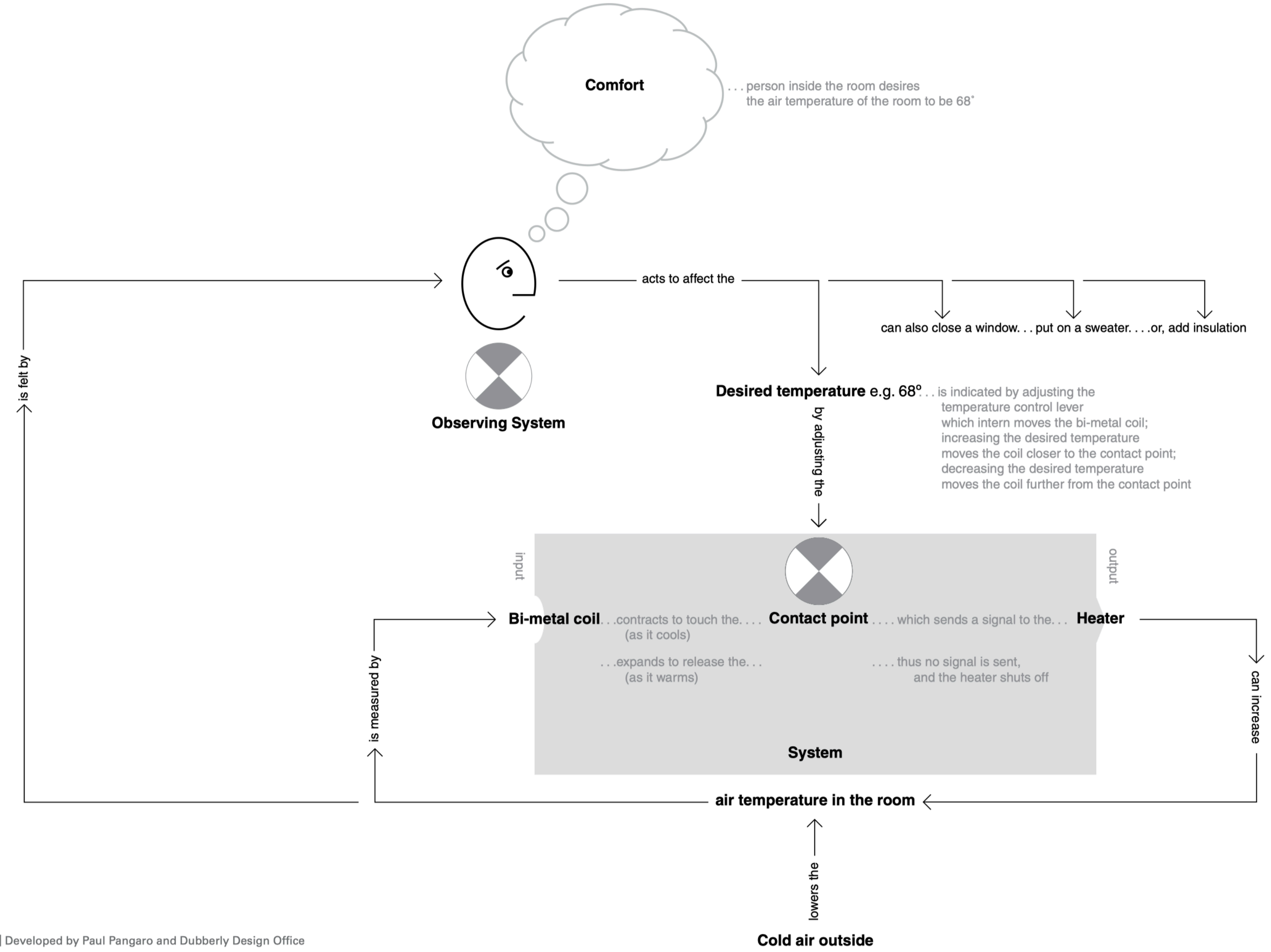

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Defining Systems Contributions

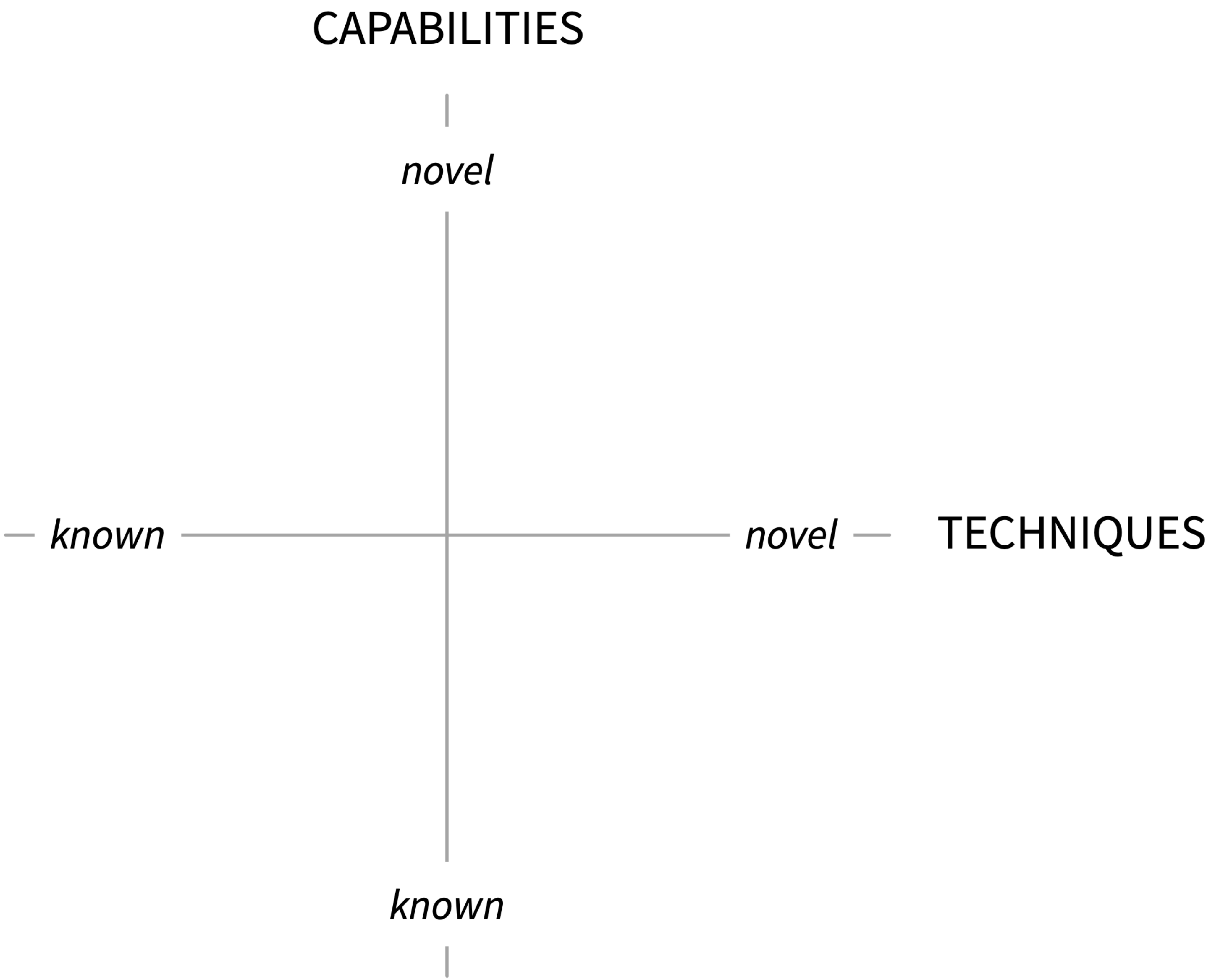
What is a "systems" contribution?

Is systems research merely engineering?

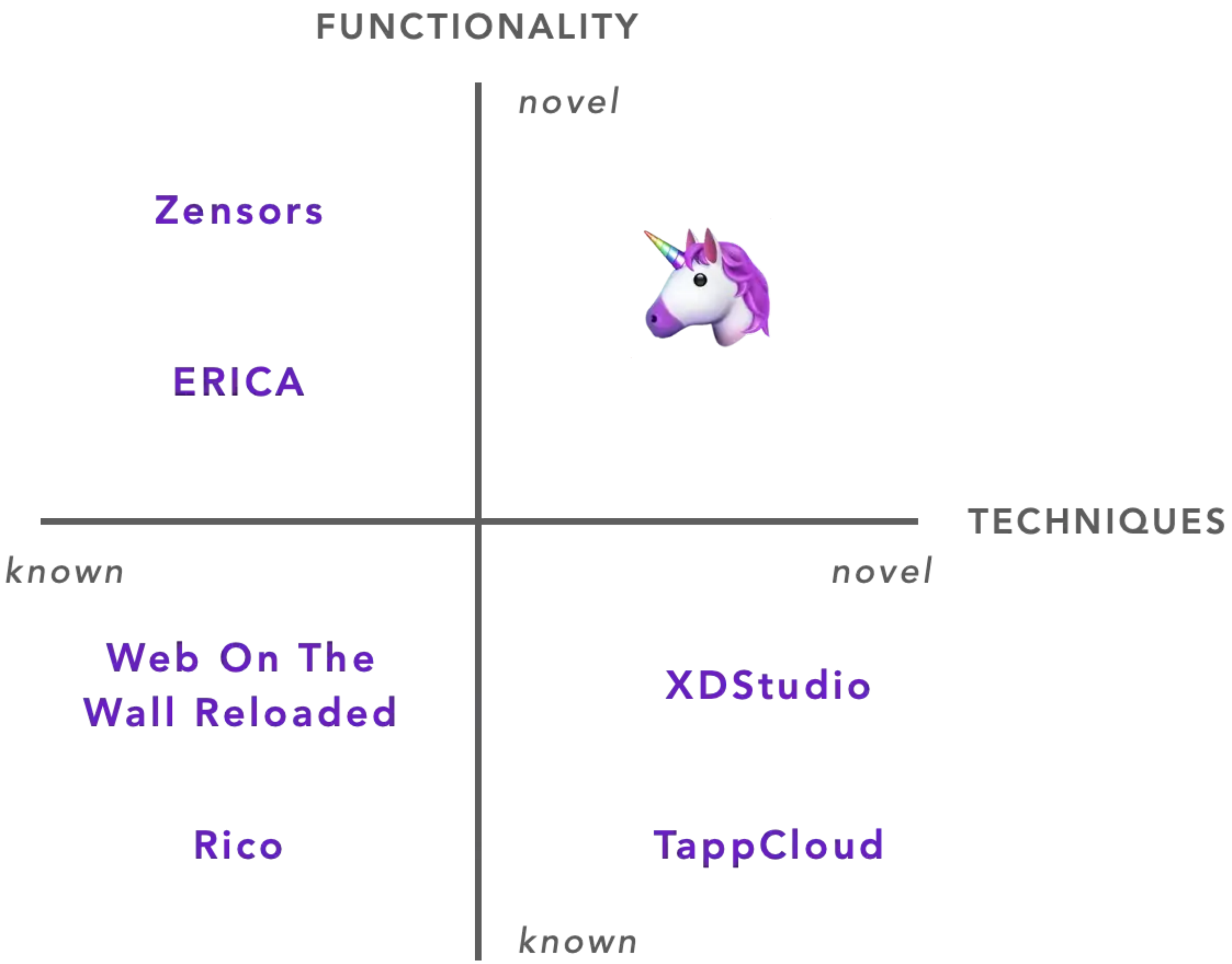
Systems research seeks to discover new techniques for building systems or new capabilities for systems that open up opportunities for new interaction.

No, it is not merely engineering, but engineering is needed.

Contribution can be in **techniques**, which enable new systems, and **capabilities**, which enable new interactions.


CAPABILITIES
novel
known
novel
TECHNIQUES
known

[1]



[1] A Note from the UIST 2021 PC Chairs

The Role of Platforms

- → Systems follow *patterns* and fall under *categories*
- → Patterns, categories lead to shared **platforms**
- → System design can start with platforms
- → Examples from Myers et al. (2000) — Ubiquitous computing, recognition-based user interfaces, three-dimensional technologies, & end-user programming, customization, and scripting

Reading Group Discussion

Discussion Format

- → For each group:
  - → Group leader provides top 3 points of discussion
  - → We'll add to a running list on slides
  - → Random order:
    - → 6 1 2 8 4 5 3 9 7
- → We will remake groups today

Discussion Notes

- → **Dubberly:** different systems follow different process follow. Different levels of complexity. Different uses of user input.
- → **Myers et al:** Good predictions from 2000. Figma is a good example of tools that have become reality. Design tools expanded, but Sigma enables sharing among developers/designers. Interesting perspectives for evaluating past and future tools. Could tools that didn't work in the past work now?
- → **Martelaro et al.:** Flexibility in design is needed, change over time. Designers are shifting from what/how to why/for whom. Software/AI systems detect patterns.
- → Keeping the users' **goals** in mind. Making that easy to do.

Good tools that disappear in your hand.

Discussion Notes

- → Value of abstraction. Applications vs. evolving technology. Abstraction helps find matches.
- → Tradeoff of ease of use vs. power. Easier to use, less you can do with it. Simple principles or interfaces to complex and powerful tools that are complex in implementation. Complex tools can help achieve many goals. Passenger car vs. freight truck.

Wednesday's HACK: Modeling Systems

→ Optional readings:

1. Dubberly (2009). ON MODELING: Models of models. *Interactions*.
2. Dubberly & Evenson (2008). ON MODELING: The analysis-synthesis bridge model. *interactions*.

→ Form groups of 5

→ Model an existing system, explore possibilities

→ Due next week