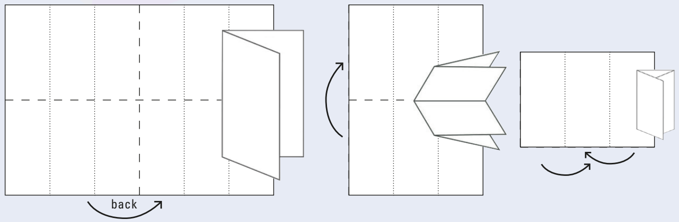
HOW TO USE THIS MAP

The **front side** of this map introduces the **main terms** used in systems theory, and some of the main thought changes it calls for. Read it so you know what **key terms** to expect, or maybe to look things up on Wikipedia or in the references. The **reverse side** contains the most worthwhile **themes and examples** used in the DeepDive on Systems Thinking master elective at IDE, TU Delft. The descriptions may be too compact, especially if you are not familiar with the examples. Follow the pointers to the sources.



WHY A MAP?

There basically are two types: discovery maps and planning maps. This is the first type. The earliest maps are made by travelers who organized their notes into a document to guide others to recognize spots in the terrain: treasure, danger, and unknown areas. That is the type of map this is. It can only give limited explanation to the many things it to brings together. It may overlook things that were beyond the view of this traveler. It will be biased by the experience of its maker. For instance, I focused on simple examples that connect easily to a general, design/engineering audience, and stayed away from large-scale organisations (not because these are less interesting, but because they need much more introduction).

A map is not the terrain. It is incomplete. What it shows and what it highlights is shaped by its maker. You will need more than just a map to make your journey.

Over the past two centuries, systems thinking has introduced a number of concepts, tools, and lenses for science, engineering, and design. Currently it is in a renewed wave of interest, as designers are confronted with new, complex challenges.

But what are systems, or rather:
What does it mean to look at something as a system?

Here's the definition:

A SYSTEM IS A SET OF ELEMENTS AND RELATIONS WHICH OPERATE TOGETHER TOWARDS AN OVERARCHING PURPOSE

Systems thinking provides a language to describe, visualize, and maybe understand, predict and improve 'how things hang together'. Examples vary from how traffic behaves on the roads, to how blood delivers chemicals throughout our bodies. Systems concepts range from toys like Lego construction sets to the solar system and beyond. Systems thinking has developed a way of talking about such things. It seeks to unite the inputs of people from different disciplines, so that they can collaborate in tackling complex problems.

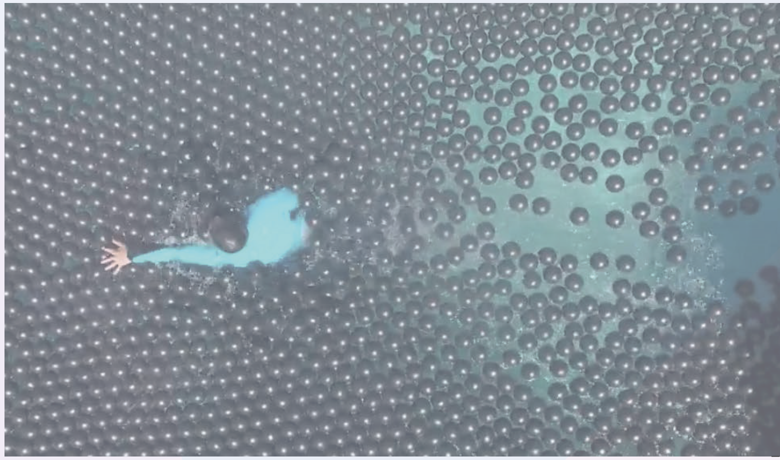
Parts of systems thinking are very technical, and quantitative, often described in mathematical terms; other parts are more conceptual, qualitative, trying to bring things together by developing a relevant framing for a large design challenge. But across these parts there is a common set of ideas, and the opportunity to port insights from one discipline to another, or to develop a shared view that different specialists can all work with.

This map brings together definitions and examples from science, engineering, and design. The aim is to point at key experiences and examples that have played a part, and to convey in a few words (and a pointer to a more in-depth training or hands-on experience) what it means.

The picture on the front (Courtesy of Derek Muller, Veritasium) shows a man struggling to swim through a pool covered with lattices of 'shade balls'. Note how the lattices are partially arranged, yet broken at various places, an illustration of the law of middle numbers.

Faculty of Industrial Design Engineering, TUDelft

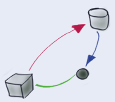
MAP OF SYSTEMS THINKING IN SCIENCE, ENGINEERING & DESIGN



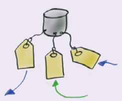
STRUCTURE

How it hangs together

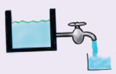
A **system** is a **set** of **connected elements** that **operate coherently** toward a **purpose**.



This network is often visualized as a graph with the **elements** as nodes, their relations as lines to show a connection or arrows to show a direction of influence.
In a systems view, understanding the relations between the elements is essential.

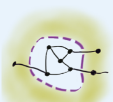


The elements can be different, and can have different **properties** or parts; the relations in the system are often defined between the parts of elements.
Properties are often described by **variables**.

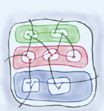


One much-used type of variable is a **stock**, an amount which varies between empty and full, and its change, called **flow**.

The network is **coherent**, meaning that the elements fit together and **influence** eachother.
The **boundary** of the system separates elements that are considered to be part of the system from whatever is outside.



In a **closed** system, all connections are between the elements inside the boundary. In an **open** system, there are influences from (and to) the outside.



Subsystems are parts of a system which have their own boundary. This boundary can be given by nature, chosen for description, or created for control.
Subsystems may occur side to side, or be organized in **levels**, where relations between subsystems within a level work differently than from those between levels.

The **purpose** is readily recognized in human-made systems, but also natural systems can be seen as working toward a goal.

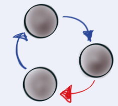
Taking a systems view often means taking more **context** into account, to look outside the initial boundary of your focus, or to include other attributes of the elements you were considering at first.

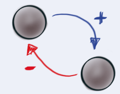
DYNAMICS

How it moves along

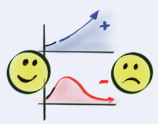
A system **evolves over time** through **feedback loops** which modify the inputs. As a result, patterns of behavior emerge.

Feedback loops take place when a element's output hase influence on its input. Feedback can magnify, distort, or negate inputs that are fed into the system.
Feedback on an element's output can be **direct** (from the receiving element), **indirect** (through a third element), or even **immediate** (feedback from the element itself).

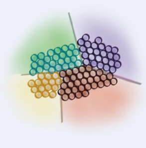




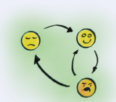
A feedback loop as a whole can be positive or negative. **Positive feedback** loops amplify their signal. **Negative feedback** loops counteract their signal. Feedback can be strong or weak, quick or slow. Timing and delays play an important role.



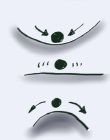
Positive feedback loops are called **virtuous** if it is a desireable strengthening, or **vicious** if it is an undesireable explosion. Negative feedback loops can similarly be called **stabilizing** (good) or **stagnating** (bad).



The dynamic relations, especially feedback loops, can exhibit **patterns**. Such patterns can show as **emerging properties, behavior, and structure** (e.g. new boundaries, levels appear).
When **self-organisation** occurs, a system maintains a structure despite varying external influences.
A system's dynamic can be in different **states**: patterns of how the system behaves and reacts, with particular repertoires of behavior patterns.
Descriptive terms may only be meaningful for certain states, and undefined for others.



A change from one state to another is called a **transition**, and is often accompanied by a reorganization, rearrangement, and adjustments.



When a disturbance occurs, a system may return to its previous state (**stable**), break down to another state (**fragile**), or adjust its structure slightly but remain largely the same (**resilient**).

Some important state dynamics are **hysteresis** (sensitivity to history) and **resonance** (a strong buildup from continuous weak inputs).

CHANGE

How you may (not) be able to direct it

Designers and Engineers want to improve or control how something goes. But the system can have a will of its own.

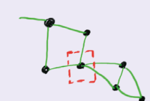
Feedback in systems makes predicting how they react to changes or inputs more difficult (or sometimes easier). The system may resist, absorb, '**kick back**', or explode in reaction to certain inputs.

Chains of cause and effect relations can become complex, because effects become causes and multiple chains of influence occur in parallel, and may interact.

Problems are called **wicked** to indicate that they cannot be simply 'solved' or even completely defined. Instead, improvements are made gradually, iteratively, developed along the way, and requiring action from multiple stakeholders.

In **nonlinear** (feedback) systems, costs of a small change may require effort that is **disproportional**. The extra inch may be more costly than the previous mile (or the other way around).

Emergent structure can appear along the lines of existing natural or artificial structure. Or shift or break those lines.



Intervening in systems is most effective at a **leverage point**, where key relations come together. Discovering such points is a strategic element in systemic design.

Interacting with system depends on its **complexity**, whether it's **simple**, **complicated**, **complex** or **chaotic**. Especially if there is **tight coupling** (fast, strong feedback), you may need tactics for chaotic systems.

Three columns of Terms and Jargon
The narrative often goes from left to right: first describe the structure, then see how the relations evolve, finally push it somewhere. But we also need the right-to-left logic: an intervention can bring a system into a new state we had not seen before, and feedback loops can create boundaries in structure which were not there, and were not expected or intended when the elements were assembled.

WHERE IS SYSTEMS THINKING IN DESIGN?

Systems thinking is new, and not new. Parts of it have been in design for a while. **Interaction Design** picked up on Gibson's notion of affordances, which placed emphasis not on the product or the user, but on the relations between them. **Experience Design** took into account the (temporal, contextual) complexity of users, and that design should step beyond the individual single user. **Service Design** has questioned the idea in **Product Design** that design ends with providing a plan for a future product, and that this product or plan can stay the same for a longer period. **Strategic Design** has been aware that the organisations that deliver services and products don't operate as single entities, but in a network of actors. **Social Design** has looked at how the larger scale of societal challenges and of individual behavior are connected and co-dependent. **Sustainable Design** has pursued the flow of stocks (materials, energy) at various scales, and emphasized cyclical use of these resources.

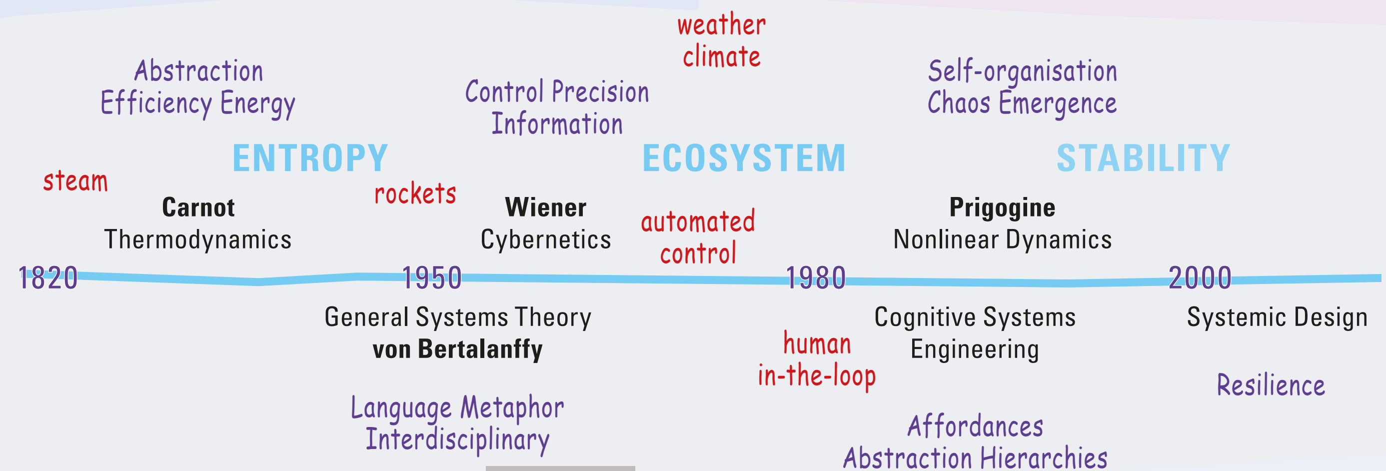
Currently, the term 'system' is hot again, as it was a few times before, and there is renewed interest in bridging disciplines, and collaborating at complex (societal) challenges.

But, as often, there are cool examples and confusing terms, and cool terms such as 'wicked problems' and 'systemic solutions' are readily claimed in a commercial context where companies want to appear ahead of the game. So there's plenty of heavy words and light meaning around.

This map aims to give an overview of definitions of the terms in academic introductions to systems thinking. Another is to point out where it touches on design, and to provide some holds on how to apply its tools in your design work.

A VERY BRIEF HISTORY OF SYSTEMS THINKING

Systems thinking developed over two centuries across science and engineering. It has seen several waves of popularity, each time fed with experiences in different disciplines. One main theme has been abstracting (and mathematizing) structure and dynamics; the other has been uniting academic thinking about structure across disciplinary boundaries.
The historical root of systems concepts is usually placed with Sadi Carnot modelling the steam engine in the Industrial Revolution. He described the steam engine not as a series of metal pipes, burning coals, and steam, but in thermodynamic terms of temperature, flows of matter, energy and entropy. These highly abstract new notions provided a quantitative theory which helped making these machines (and many others) more efficient. The next wave occurred after World War II, and concerned how to steer machines like rockets and planes not by brute force pushing, but by guiding it subtly by electronic signals: cybernetics. This produced the concept of 'information'. The engineering area of control systems tries to steer such devices to a target, with an emphasis on precision, safety, and robustness under noise. The third quantitative wave gained popularity with large computing simulations in the 1980s, and their use in population biology, weather prediction, and the first wave of Artificial Intelligence. Part of the fascination of the day was that seemingly simple equations can produce surprisingly complex and unpredictable behavior: fractals and chaos theory.



The other theme, of cross-disciplinary integration also had its waves. At about the same time as the cybernetics movement, the 'General Systems Theory' movement proposed systems as a shared language to connect and unite thinkers in various disciplines, ranging from law to psychology, sociology, medicine and organization design. The language of elements, boundaries, relations, worked in many fields, and was seen as a bridge between disciplines. In the late 20th Century, movements of 'systems design' and 'systems engineering' studied how large project can be organized, and 'cognitive systems engineering' studied how to support people at complex tasks such as flying an airplane or running an industrial plant or a complex organization.
In the past decade, the term **Systemic Design** has gained popularity to describe how designers can contribute to improving large-scale problems together with other actors from governments, societal organisations, and individual citizens.

OTHER USES OF THE WORD 'SYSTEM'

In systems thinking, the word 'system' refers to a lens, a perspective, a way of looking at something. And comes with a language, and tools. Nothing is a system, anything can be looked at as a system by focusing on elements, relations, feedback, emergent behavior, etc. [L2]

But outside systems thinking, in everyday language, some scientific disciplines, the word is used with a variety of different meanings. It helps to be prepared for that.

Other meanings of **system**:
a large organisation: the legal system, the healthcare system, a system of government, "change the system from within".
a well-organized model: the solar system, the periodic system of chemistry, a system of equations, a coordinate system.
a complex product: computer system, sound system.
a modular product: Lego system, system furniture.

Other meaning of **feedback**:
a single response: user feedback, student feedback.
In system dynamics, feedback is about a loop, and one that works iteratively. There one piece of feedback is not feedback.

The legal system - TUDelft... tudelft.openresearch.net

IBM Personal System/2 - Wikipedia nl.wikipedia.org

So what's new? How is a systems view different from a 'traditional' view? An important part is that the established form of science (i.e., most of what you got in school or even university) has been built on the successes of analytic, linear thinking and modelling. The approach: identify elements, divide and conquer: Isolate elements, understand them, and put them together. Identify single causes, test them, and then put the elements together. If there are one or two interactions between the elements, accommodate those.

These were keys to considerable success. As long as scientists stuck to the studying questions they could answer. In the context of systems, feedback cycles, emergent properties, and nonlinear dynamics, these famous methods are shown to be less universally useful than thought before (and probably taught in school).
These differences were explained in comparing 'linear' systems (the ones we understood well) to 'nonlinear' ones (all the rest).

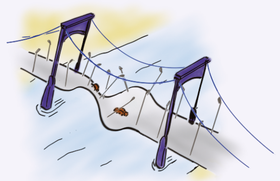
LINEAR ↔ NONLINEAR

LINEAR	NONLINEAR
One chain from cause to effect, in one direction. Stories start at the first cause.	**Multiple paths** of influence, often with competing feedback loops. There is **no privileged starting point** for stories.
Sudden effects are brought about by sudden causes.	Gradual causes can bring about sudden effects.
Elements are more important than relations. What you get out is **proportional** to what you must put in.	**Relations** are more important than elements. At some points, a small improvement requires **ballooning efforts.**
The output is determined by the **input**.	The output is determined by the **structure**. Input variation is absorbed or assimilated.
1 + 1 = 2 (proportional results)	**1 + 1 = 0** (counteracting), **1 + 1 = 1** (saturation), **1 + 1 = 2** (independent), **1 + 1 = 3** (synergy)
The **law of large numbers**: when many things do the same independently, their average is a good predictor.	The **law of middle numbers**: expect regular patterns to last for a while, then change.
With a good model and data, **predictions can go far.** Reasoning goes from **causes to effects.** Understand by **analysing**	Predictions don't go very far. **You'll have to iterate.** Reasoning goes from **ends to means.** Understand by **engaging**
Variables change, **structure remains** Change it by **divide and conquer** Understand it as a **top-down or bottom-up** structure, then drive it one-way from there	**Structure adapts** (resilience) Change it by **modulating stable structure** **Interact with it** as a structure with self-organised patterns, intervening at leverage points
'**Go ballistic**': Understand, plan, act, let go Project: Design stops at product **launch.**	'**Go cybernetic**': Engage, keep steering Forever beta: Design continues **in flight.**

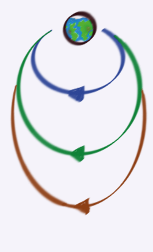
STORIES

Disproportional? - Tacoma Narrows Bridge

Small, repetitive, influences can have huge effects. In 1938 a continuous wind brought the tacoma narrows bridge into an undulation you wouldn't believe from a Sci-Fi movie, until it went beyond breaking point and the bridge collapsed. Although not technically a case of 'resonance', it shows the impact of small, coupled stimulation. After the collapse, a lot was learned about how to improve bridge design. B6 (+loads of youtube videos showing the collapse). B6

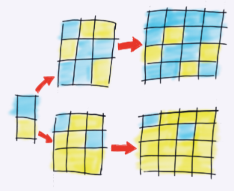


Stocks and Flows - Circular Economy



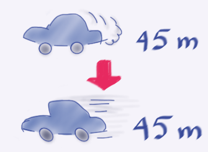
Finite amounts of resources, and how they get depleted, play a large role in sustainable design. How can we connect the flows of such materials in cycles of reuse, refurbishment, recycling, so that we don't run out of them.

Stagnation - Internet Filter Bubbles



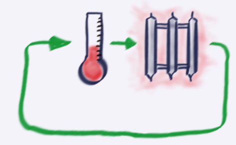
When you search through an online service such as Google, it can track what you asked and which answers you looked at. On your next search, the service is then tuned to what it expects you will be interested in. One effect of this is that what you find on a search will be different from what I find. Also, the service may 'shield' us from discovering something different: trap us in our individual information bubble. V1

The System Kicks Back - Traffic Improvement



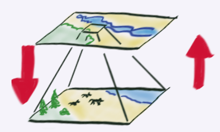
A new highway may reduce the time commuters need to get to work. This is a reason that is often given in its justification. But after the highway is there for a while, the commuting time is again the 45 minutes on average that it was before. People went to live at a greater distance from work (or vice versa). So the effect of the highway then is more traffic, not shorter travel.

Stability - the Thermostat



A thermostat is a simple feedback system which measures the temperature of a vessel, and activates a heater when the temperature falls below a certain level. Human and animal bodies contain many of such homeostatic systems to maintain temperature, hormones, levels of oxygen and nutrients in the blood, balance of standing.

Causal Chains across Levels - Wolves move rivers



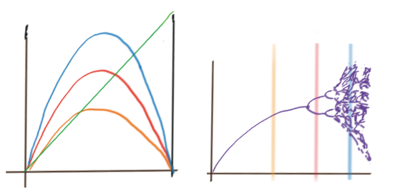
We easily recognize that the large scale influences the small scale. If the land dries up, there is less food for the animals. But it can also work the other way. The reintroduction of predator wolves led, through a chain of effects, to changes in the landscape at a larger scale. V2

Disproportional? - The Butterfly Effect

A prediction depends on your model and your data. With weather predictions it was noted that in order to predict the details of a storm in Europe more , you'd have to invest surprisingly much in your data - to the detail of measuring even whether a butterfly in the Amazon flaps its wings at a certain moment or not.

EXAMPLES TO PLAY WITH AND EXPERIENCE

Surprising Returns - the Logistic Map

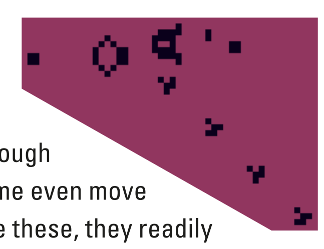


A bank account with fixed interest will grow exponentially; a petering our resource decays exponentially. When you know the amount at time t, this graph gives the amount in the next year. And a timeline looks a bit like this.
In nature, animal populations fluctuate, but not just exponentially. They show stability, fluctuations, and surprising cyclical patterns. The Logistic Map is the simplest mathematical model and it shows surprising complexity. The shape of the returns function is an inverted-U, with 0 (dying out) when the population is too small to succeed, or too large to find enough food. The height of the U is a tuning parameter A, which goes from A=0 to A=4. The value at which it is tuned gives rise to these strange patterns.

For small values of A, the result is simple decay: no matter how many animals we start with, they will die out. As we tune up A between 0 and 2.8, the population will always converge to a certain size. How large depends on A. Then, at A=2.8, the solution becomes an oscillation alternating a higher and lower value. At first, the difference is small, but as A increases, they go further apart. One year up, one year down. Etcetera.
This continues until at 2.8 the cycle takes on 4 values, and repeats after 4 steps. And then it widens. At A = 3.2 it becomes 8 values, later 16 etc, until close to 4 the sequence seems to go haywire: small values and large values alternate in random order (noise).
This structure has been studied in detail, and contains suprising regularities. For instance, around A = 3.6 there is a small stable point again. It's a dynamic process. V4

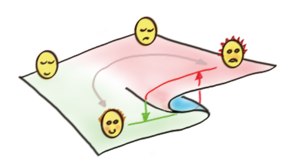
Emerging Levels - Conway's Game of Life

Another famous simple yet surprisingly rich model of population growth simulates spatial patterns of growth and decay. It starts with an n*n grid of cells, each in state alive or dead, and calculates iterations. In each step, if a cell has too few or too many neighbours it will die (of cold or hunger, respectively), otherwise it survives. An empty spot can spawn a living cell if it touches upon exactly three neighbouring cells. This calculation is repeated time and again.



The visual grid shows patterns of moving dots which appear to be cell groups. Most fall apart, some stay at rest. Others go through a repetitive cycle of motion. Some even move about the grid. When people see these, they readily agree on what are 'the animals', usually characterizing them as 'a block' or 'a swimming thing' on the basis of the motion patterns.
But the rules of the simulation didn't specify blocks or swimming things or larger structures: it was just some simple rules defined at the level of a grid cell, which led to these complex emergent patterns complexity. V5 V6 V7

States and Transitions - Zeeman's Catastrophe Machine and Nonlinear Dynamics

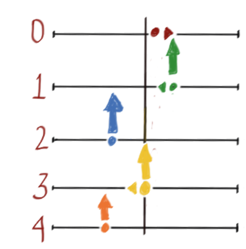


We know the basic states of water (solid, liquid, gas) and their transitions (freezing, boiling, etc). And we know a tuning parameter, temperature, which can predict exactly in what state the water is. But the transitions are not always so simple.
Consider humans with three states of moving: walk, jog, and run, each state allowing a speed range (it's similar for horses that walk, trot, or gallop). We can change from walk to jog, but don't always do that at the same speed. When you speed up from walking you may start to jog at 3 km/hour, and when you slow down, you change at 2 km/hour. If you see a group of people coming by at 2.5 km you can see both joggers and walkers. If it's 1km/h you're pretty sure, and for 3 km/h you also are. The thing is that in that overlap area we can change from one state to the other, but that in itself takes effort. So if we're only going into the overlap speeds briefly we stay in the same walking state, even if that other way of moving would be more efficient or pleasurable. So if you only know of a person he's moving at 2.5 km/hour, you can't be sure if he's walking or jogging, but if you knew the history (he just came down from 3 km/h or up from 1 km/h) you'd know it's jogging or walking. That's hysteresis: you need to know the history to be able to interpret the current state.

Zeeman's Catastrophe Theory paper applies such models to a variety of phenomena, from economies, to human and animal emotions, to behavior change in anorexia/bulimia. And also shows how introduction of a second dimension (for emotion, it's arousal next to attraction, for anorexia it's) can be a way to predict or avoid the 'sudden crashes' of transitions. P4

Delays and Overshoot - Higher Order Control

All of us have witnessed what happens when an amplifier feeds back sound to its microphone, either at music concerts, teleconferences, or phone conversations. It results in a sharp, high-pitched squeak which -if you're lucky- is shut down by a protective mechanic or mechanism. These are overshoots, such as when you have problems setting the shower thermostat in a hotel, that has delays and tends two swing from scolding hot to freezing cold.
Also in other situations, delays may make it difficult to operate an influence. An easy example: the webpage in the browser on your phone: you thought you tapped a button, but saw no response, so you tap it again. But the browser had responded, and loads a new page just as you make your second tap.



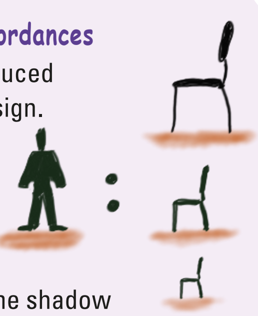
As a result you press a button on the new page that you didn't intend to press at all, and end up in an advertiser's dialogue that you need to find your way out of.
The speed of influences matters, as in delays and orders of influence. For instance, in a car you can control acceleration by pushing the gas pedal; that leads to increased speed which makes you move ahead. But the speed takes time to build up, a delay. When we control rates of change, applying the right amount at the right time is a challenge because of the delays. L4

Complexity - the Cynefin model

Snowden & Boone distinguish four different types of **complexity**, and argue that for each one we must use different (design) tactics to deal with them. **Simple** systems we understand well and know how to solve. **Complicated** ones require more effort, more detail, more expertise, but can still be predicted and handled. **Complex** systems change as we intervene, have feedbacks, and require us to reframe and adjust regularly. Finaly **chaotic** systems do not allow for much prediction, and instead force us to observe and act, keep on steering and engaged continuously. In design, we encounter all four of these, often in different parts of the same project. P3 Pc1

SOME DESIGN EXAMPLES TO START WITH

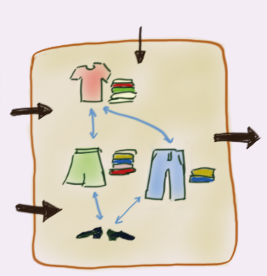
Relations put Central - Gibson's Affordances



The psychologist James Gibson introduced two important systems notion into design.
He coined the term affordances to indicate the action opportunities that a product or situation can have for a person, such as 'I can sit on this box, hide in it, or use it to gain some shadow on a sunny day'. Affordances are relations that depend on the properties of the product and the user. A child may stand on or sit in a box that would not hold or carry a grown adult.
Another innovation was his book 'the senses considered as perceptual systems' where he challenged the existing theories which saw perception as an interpretation by the brain of light patterns on the retina, or sound signals on the eardrum. These theories all had difficulties with explaining spatial behavior, because a lot of information seemed to be missing. Gibson instead described how our eyes are part of an organized structure with muscles and reflexes, and that perceptual behavior in natural circumstances involves active information seeking behavior ('the orienting reflex'). At the level of the active animal or person a different description is needed than that of the stimulus at the level of the cell.

The Wardrobe as a System - Maldini's Services

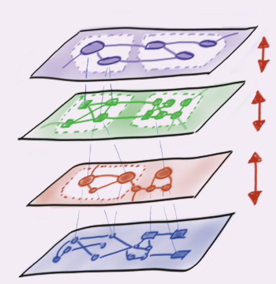
As part of her PhD thesis, Irene Maldini studied how people deal with their clothes. The existing theories, and services, treat people's collection of clothes, their wardrobe, as a numbers of pants, skirts, socks, etc.



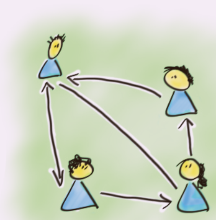
In her study, Irene explored if designers and consumers can think of their wardrobe as elements with many relations, which can form the basis of services, e.g., a repair or replacement service, or suggestions which things you like to wear together. S2

Multilevel interaction - Ecological Interfaces

Systems can (or have) to be modeled at multiple levels of abstraction. In the field of Cognitive Systems Engineering, interfaces have been developed that provide an operator (e.g., an aircraft pilot, or the operator of a chemical plant) with interfaces that allow the operator to switch between the different levels of an abstraction hierarchy, depending on how to guide it in different states.
When the plane (or plant) is running smoothly, the pilot (or operator) can navigate on a high level (efficiently running the business), when the circumstances require, he can switch to an overview of energy and coolant flows, or below that the flows of specific materials (water, fuel), and even below that the valve that controls pipe number 17b. P1



Interacting Groups - Postma's Socionas

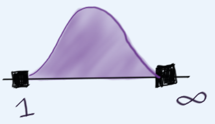


Carolien Postma's IPD graduation assignment was to design a museum experience for 12-14 year olds. At this age, youngsters appeared to have two interests: their own image and interacting with a small group of friends.
Carolien focused not on the individual youngsters, or on '12-14 year olds as a generic group', but on the interactions in these small groups ('cliques'), such as teasing, joking, fighting, getting together, and made these interactions the basis of the museum experience: e.g., visitors were shown items, and prodded to engage with exhibits through questions as 'for which one of your group would this be a fitting product'. S3

SOME THEMES

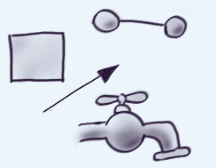
Challenges and Good News for Designers

Complexity is Largest in the Middle



Traditional science and design are at ease with the small and the huge, the microscale and the macroscale, single individuals or humankind as a whole. Theories have been made understanding a single person in detail, or designing for the individual experience. And for the universal needs of people. But with complex systems, important things happen in the middle. Small groups become a level on their own, or cities between citizens and countries.

One famous rule of thumb in general systems theory, or complex systems engineering, is the law of middle numbers, a variant of the law of large numbers from statistics ('any large enough group of people will behave as the average person'). The law of middle numbers states that for inbetween sizes, the dynamics will be regular, but only for a while, and there will also be interruptions with some regularity. Examples are patterns of weather, or areas in lattice structures in crystals (see picture on the front). One challenge for designers and others is that we like to define theories as bipolar opposites: either-or, opposite end, where two nos make a yes. And become blind to what happens in the middle of the spectrum. Rossling argues how the debate about wellbeing focuses on the extreme poor and extreme rich people, and overlooks the vast improvements made in the majority in the middle of the spectrum. In mathematics, Brouwer attempted to eliminate the 'tertium non datur' principle from mathematical reasoning. As did de Bono with Po. Black-and-white thinking is useful, because it gets to conclusions quickly, but those conclusions may not be warranted. B10



Visualisations should be Better

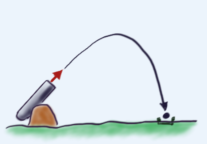
Creating tangible and visual representations to support idea generation, concept development, understanding, and collaboration between stakeholders has become one of the main competencies/offerings of designers. Next to the technical drawings and renderings of product design have come moodboards, collages from the arts, storyboards and character renderings from cinema and theatre, and flowcharts, journey maps, mindmaps, infographics. The study of systems has created many specialized and general visualisations, but there is a lot that can be improved, regarding readability, richness, actionability, and diversity. Some of the visuals require a high degree of mathematical sophistication, others are general. Some seem obvious, but invite ineffective ways of thinking. S4

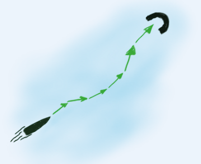
Systems do not Exist - It's Framing

You can't say something **is** a system, you can only decide to **look at it as** a system; and if you do, you have to be clear about what you count as the elements, relations, purpose, boundary,... The choices you make determine how you (re) frame the system.

Predictability Paradox - complex can be easier

With a complex system, sometimes prediction is difficult (see the Butterfly effect), on the other hand, a feedback system can 'absorb' what you do it and therefore be more predictable (see the Logistic Mapping).





From Ballistics to Cybernetics - Forever beta

With wicked problems, complex systems, and nonlinear dynamics, our ability to predict how something we make will behave in the future becomes limited. Feedback effects kick in, the system kicks back. In these circumstances, design cannot be a finished phase which ends with a concept description to be handed over to development for implementation. Essential insights will only emerge during implementation or during use.
In these cases, design must go on after launch. When a new app comes out for your phone, it first version has very limited functionality. Then, in several weeks or months new features are added, often on the basis of ongoing use. Design stays on board and steers along.

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