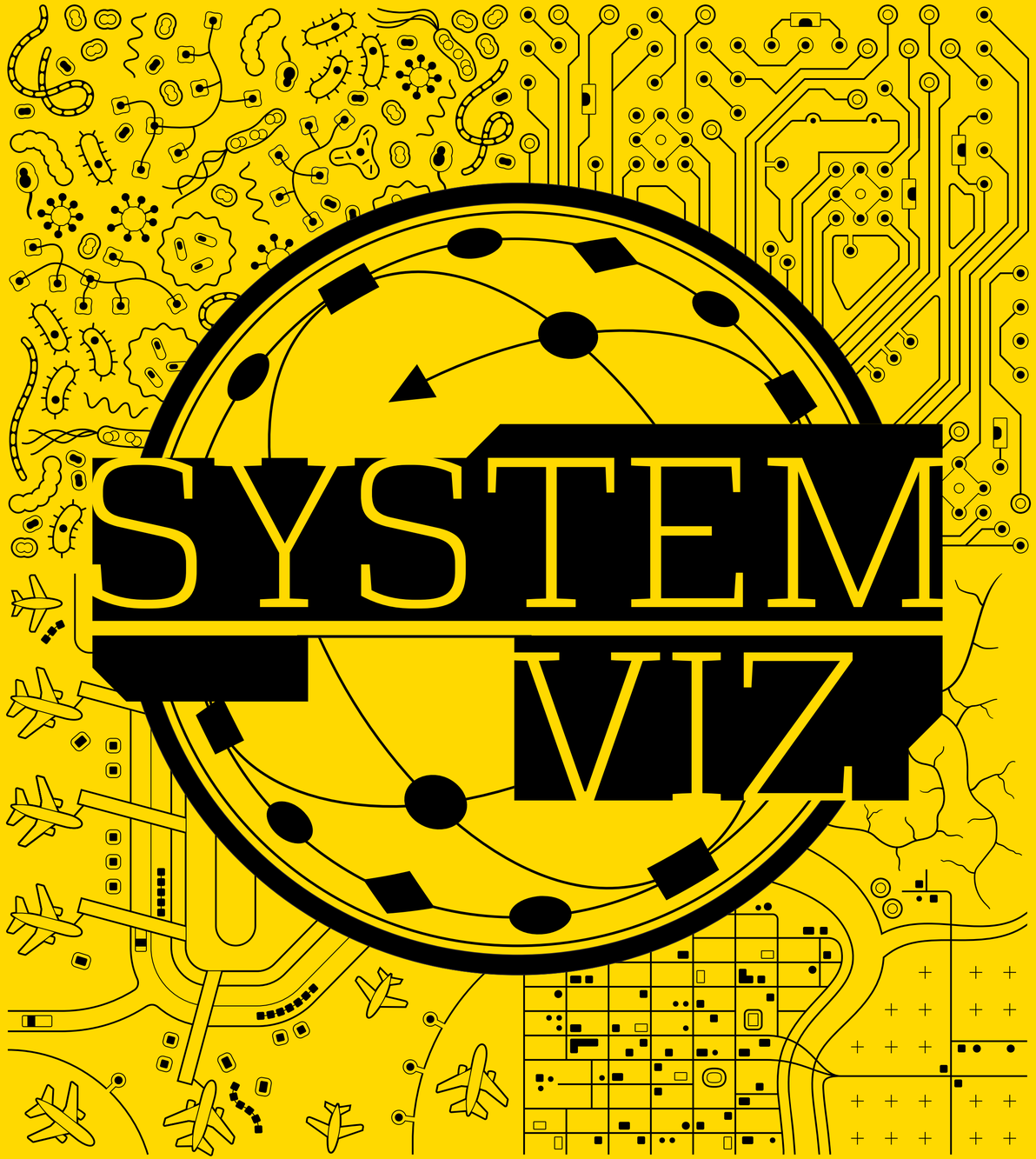
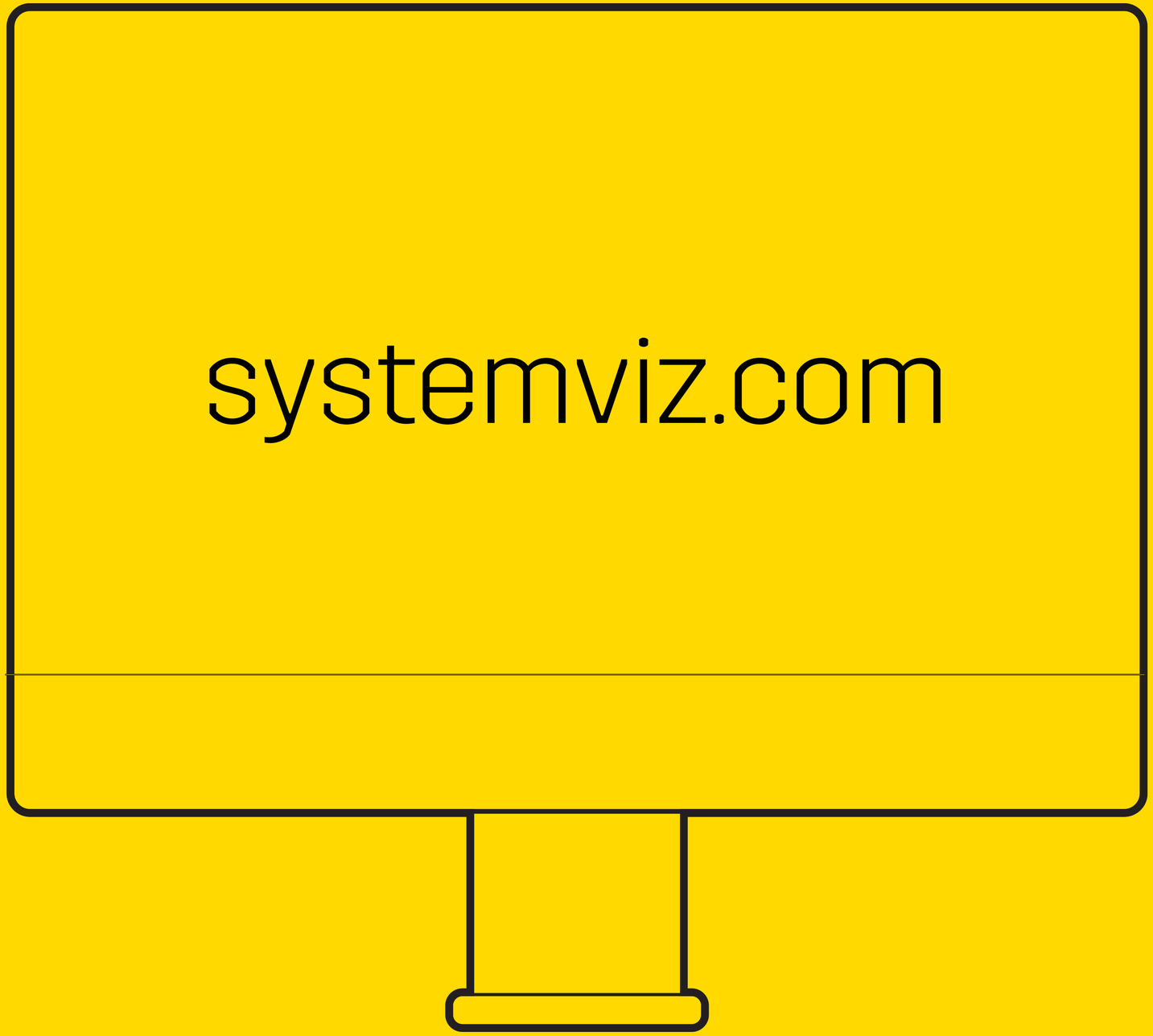


a visual vocabulary of systems at your fingertips

PETER STOYKO

65TH MEETING OF THE
INTERNATIONAL SOCIETY
FOR THE SYSTEMS SCIENCES

1 2 • 0 7 • 2 1



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PETER STOYKO

INTERDISCIPLINARY
SOCIAL SCIENTIST

MANAGEMENT CONSULTANT

INFORMATION DESIGNER

the journey

TRAVELS AND TRAVAILS
OF A VISUAL THINKING
KNOWMAD


MINDING BOTH PARTS AND WHOLES OF SYSTEMS …
BEING COMFORTABLE WITH AMBIGUITY BUT NOT HAND-WAVY ABOUT SUBJECT-MATTER
grasp

the project

VISUAL
VOCABULARY
OF SYSTEMS

NEW
NOTATIONS
FOR SYSTEMS

MOTION+
MAPPING
OF SYSTEMS

the tangle

WE'RE EMBEDDED IN
A TANGLE OF SYSTEMS

THE COMPLEX WAYS
THESE SYSTEMS
INTERACT IS HARD
TO GRASP

specialities

WE TEND TO STUDY ONLY A FEW THREADS AT A TIME UNDER IDEAL CONDITIONS

application

SPECIALISTS THEN BECOME BEFUDDLED BY MESSY REALITY

OR JUST IGNORE THE UNANTICIPATED CONSEQUENCES OF THEIR PARTICULAR LINE OF WORK

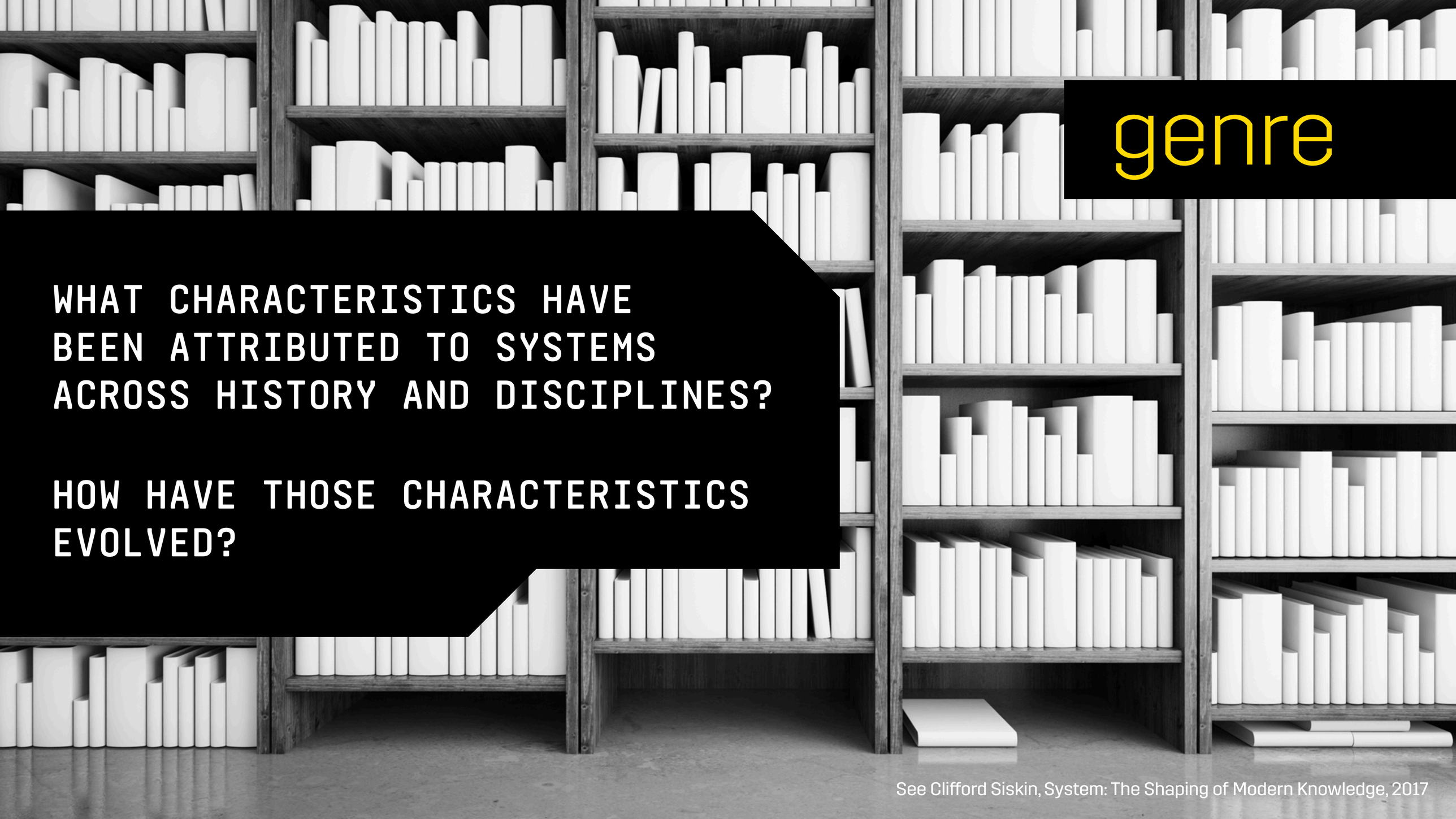

TEAM MATES CAN'T TALK
TO ONE ANOTHER BECAUSE
THEY LACK A SHARED
LANGUAGE FOR SYSTEMS
multidisciplinary teams

synthesis

TIME TO PULL THE THREADS TOGETHER

across disciplines

NATURAL SCIENCES, SOCIAL SCIENCES, DESIGN, AND MANAGEMENT



genre

WHAT CHARACTERISTICS HAVE BEEN ATTRIBUTED TO SYSTEMS ACROSS HISTORY AND DISCIPLINES?

HOW HAVE THOSE CHARACTERISTICS EVOLVED?

See Clifford Siskin, System: The Shaping of Modern Knowledge, 2017

units of analysis

elements + **dynamics**

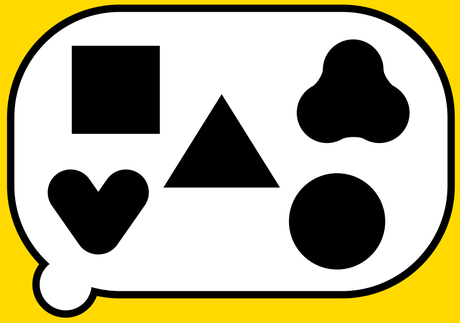
NOUNS VERBS

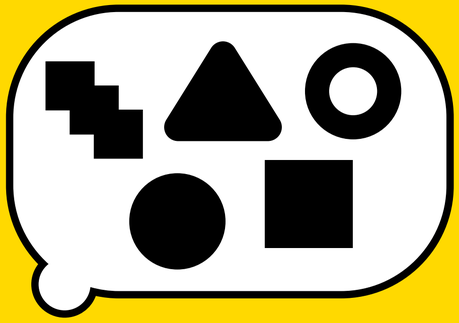
CROSS-OVER

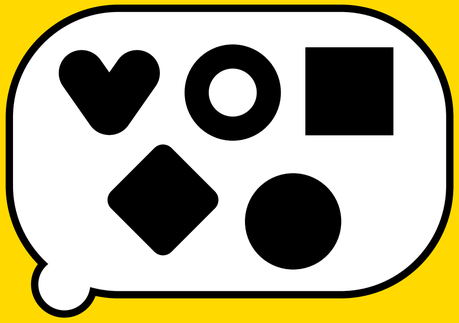
DISCIPLINARY

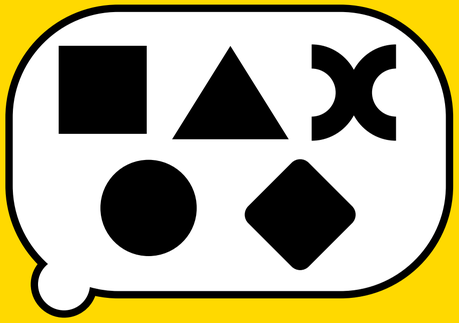
COMMON

ANALOGOUS





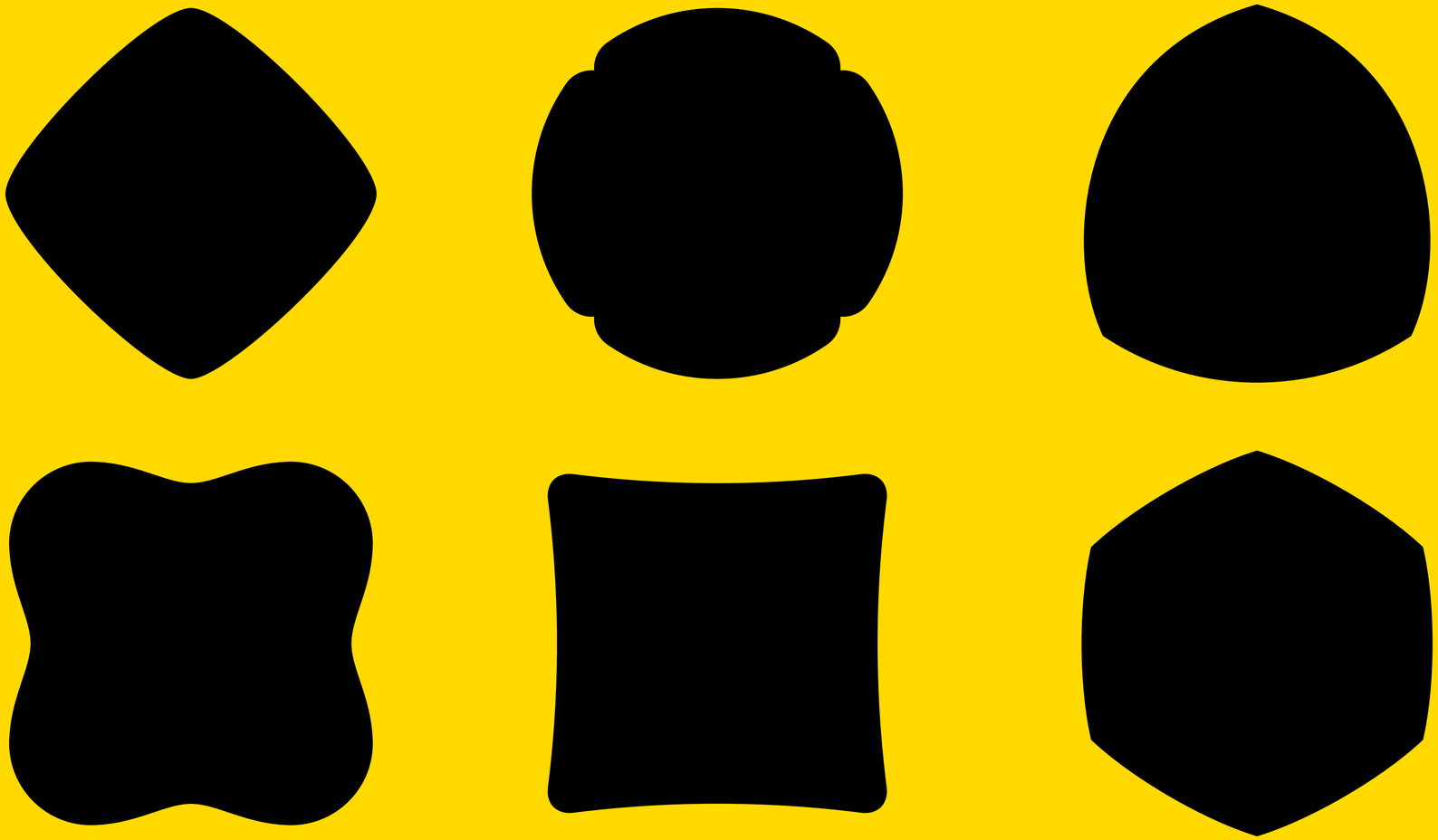




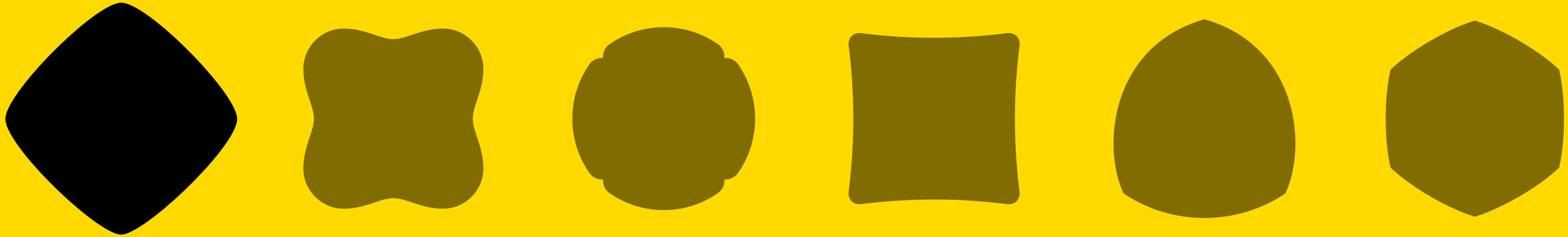
... ETC

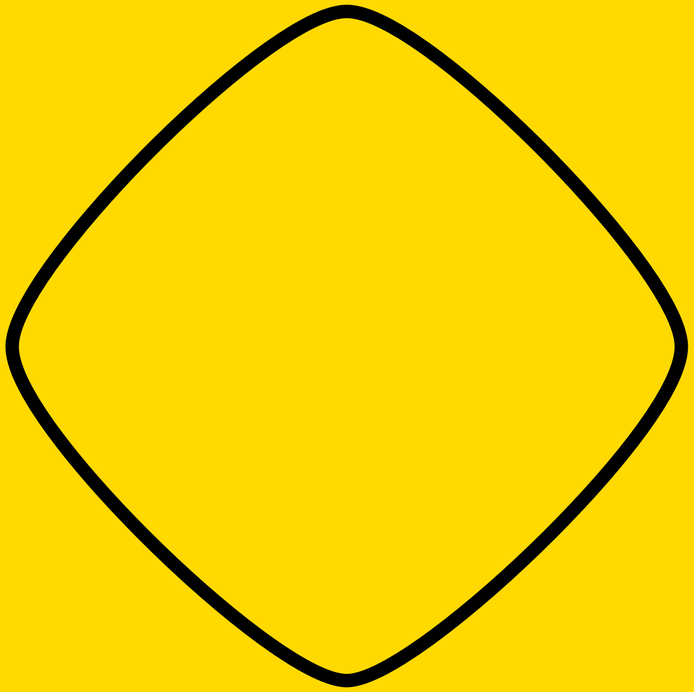
ECONOMICS BIOLOGY ENGINEERING LOGISTICS

taxonomy



DRIVERS SIGNAL STATE BOUNDARY RELATION DOMAIN

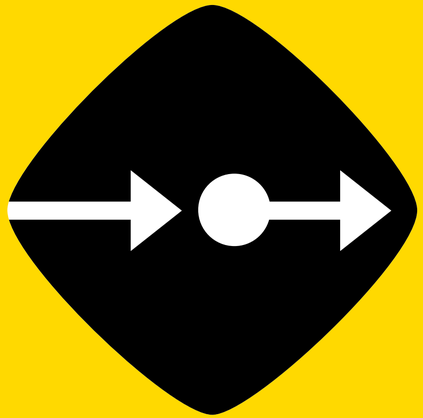




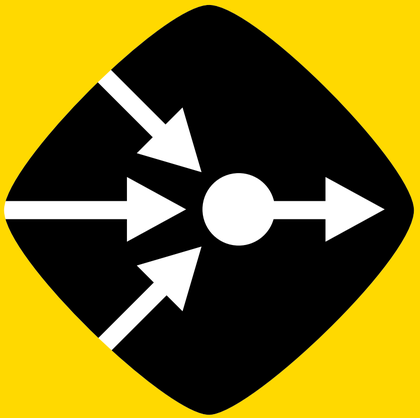
AN **ACTIVE CAUSE**
OF SOME **HAPPENING**
WITHIN A SYSTEM

MOTIVE FORCE, MOVER, FLOW,
AGENT, ACTANT ...


SALE
SALE
SALE
SALE
SALE

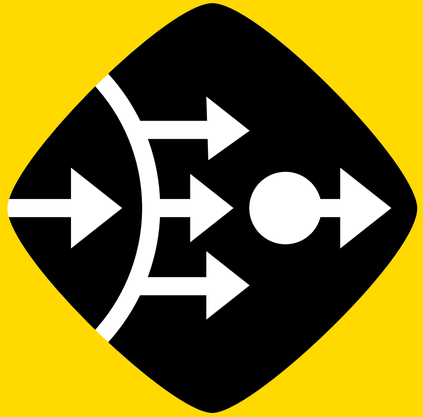


PROXIMATE DRIVER

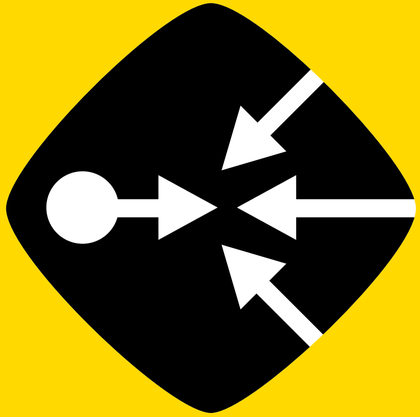


ENABLER

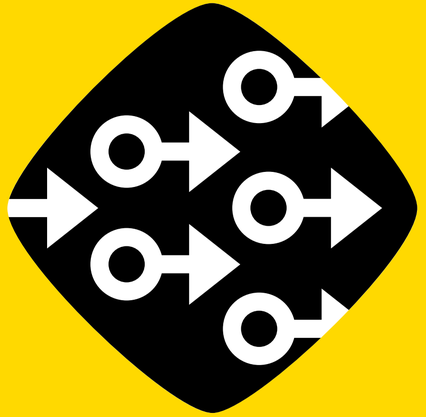
CASCADE



DISTAL DRIVER

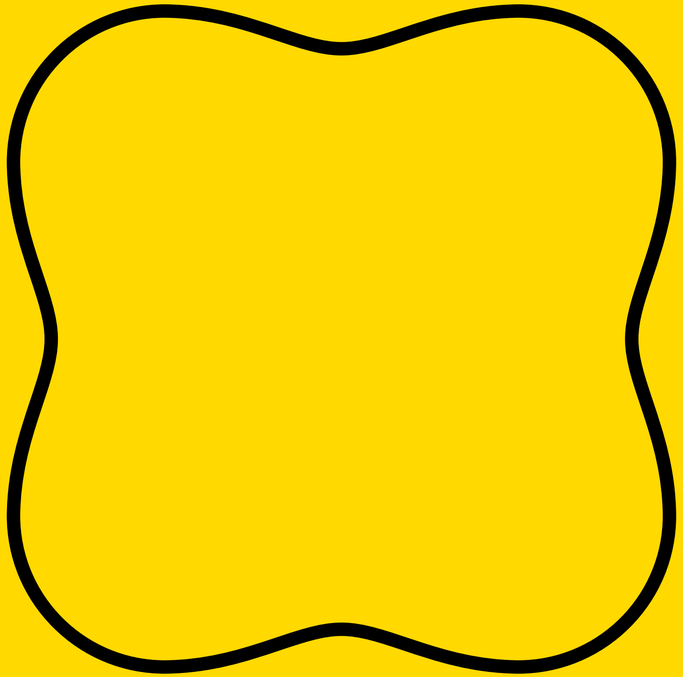


OPPOSER



DIFFUSION

DRIVERS **SIGNAL** STATE BOUNDARY RELATION DOMAIN

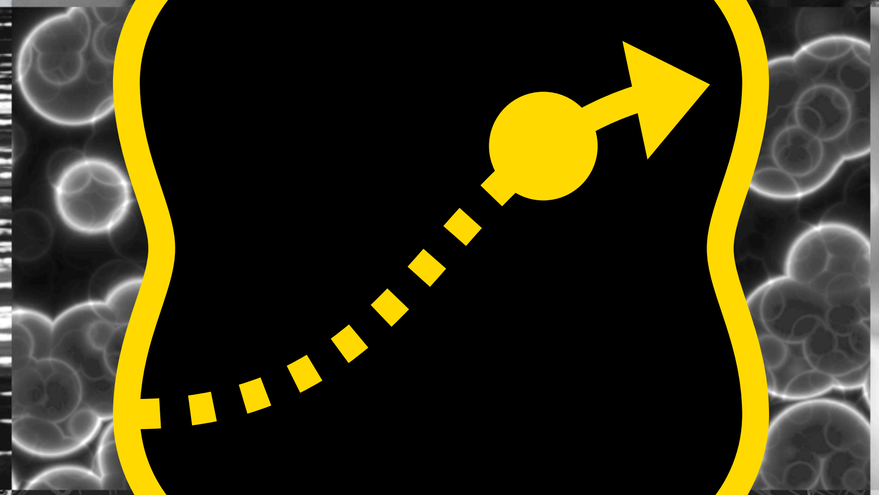
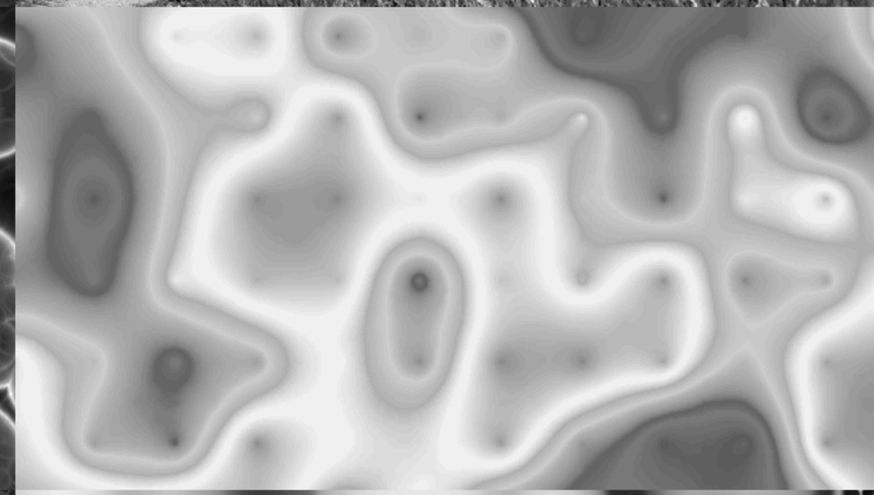


A **COMMUNICATION** THAT
CAN POTENTIALLY **TRIGGER**
SOME ACTION

SCENTS, SOUNDS, VISUAL STIMULI
ELECTRICAL PULSES, MESSAGES ...



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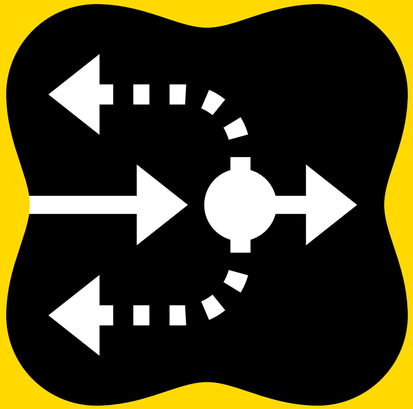
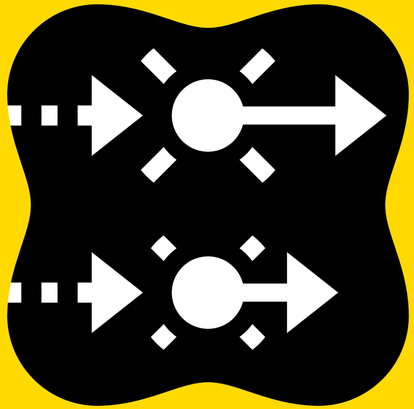
14

RECEPTIVITY

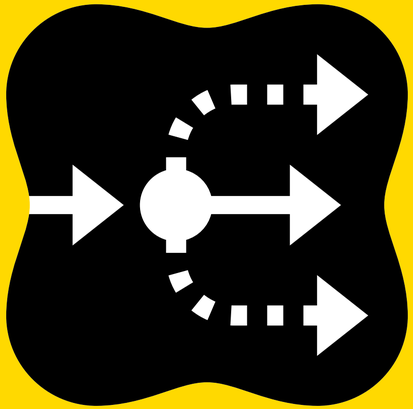


FEED-BACK

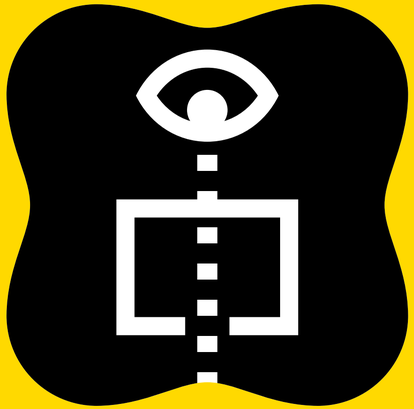
PERSPECTIVE



REACTIVITY

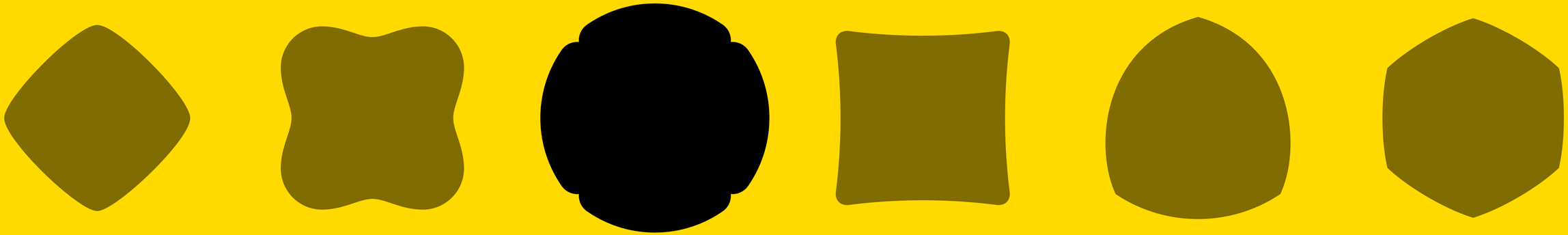


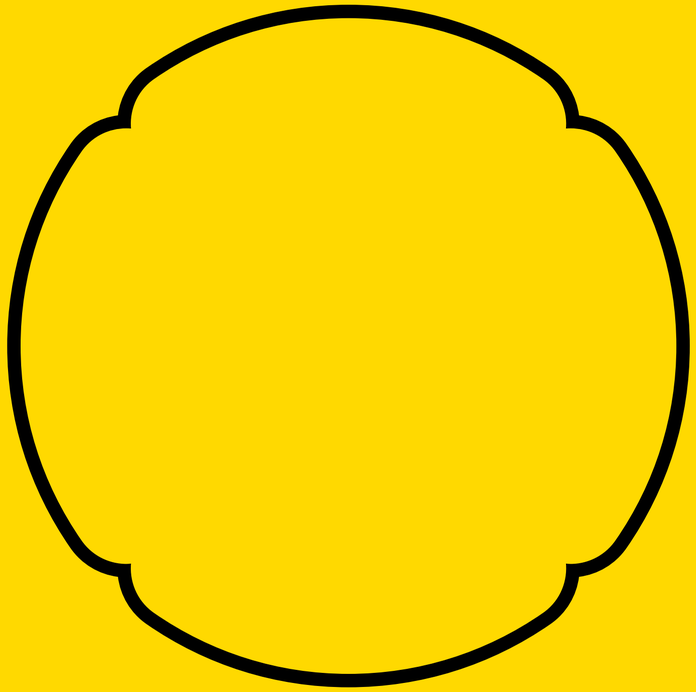
FEED-FORWARD



FRAMING

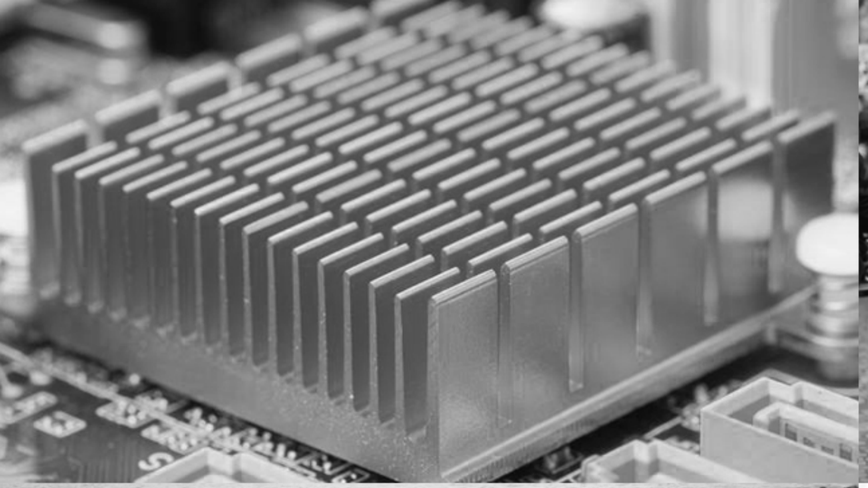
DRIVERS SIGNAL **STATE** BOUNDARY RELATION DOMAIN



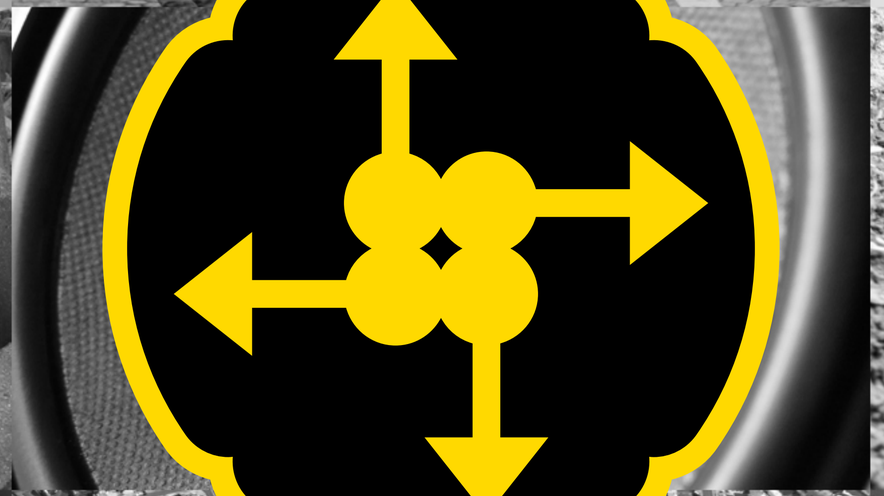


A **CONDITION** OF A SYSTEM OR OBJECTS WITHIN IT

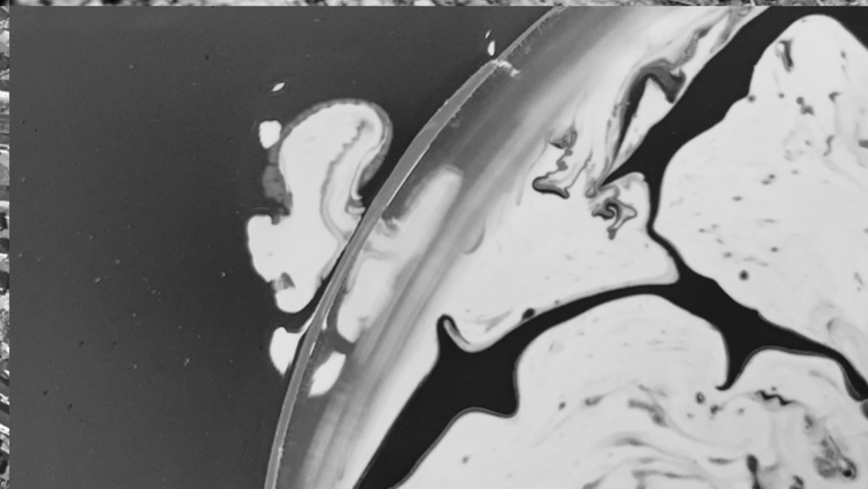
MODE, PHASE, STATUS ...

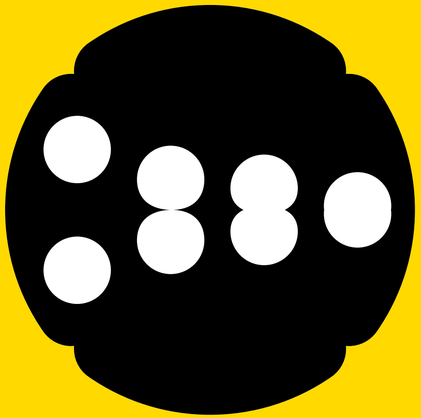


POLICE

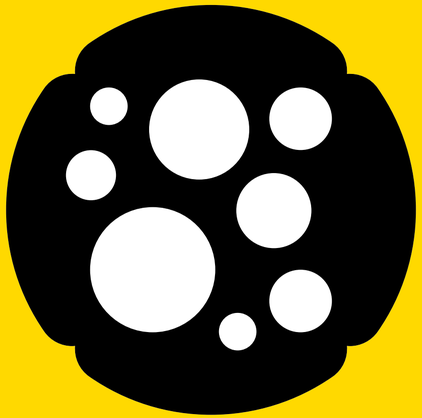





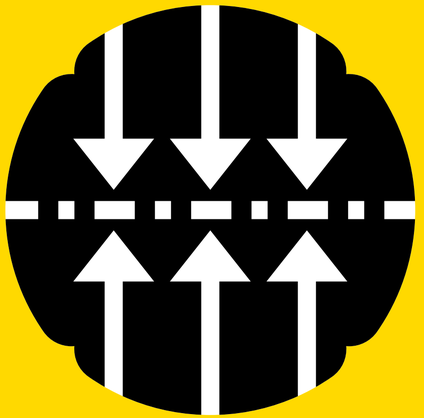




COMBINATION



DIVERSITY WITHIN



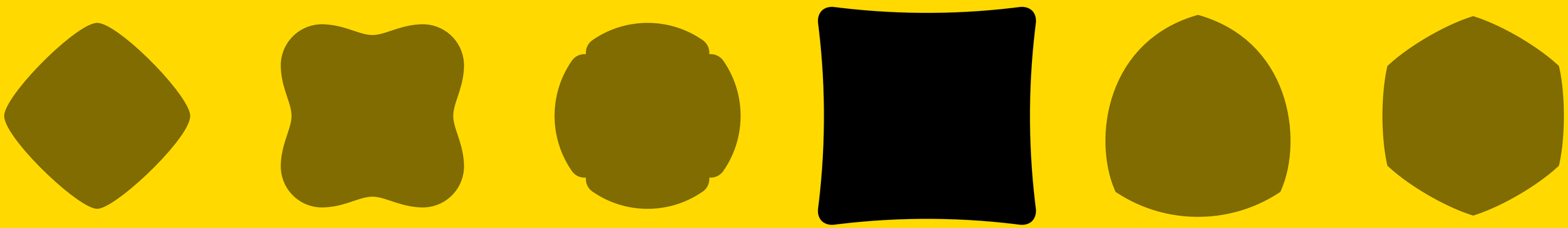
EQUILIBRIUM

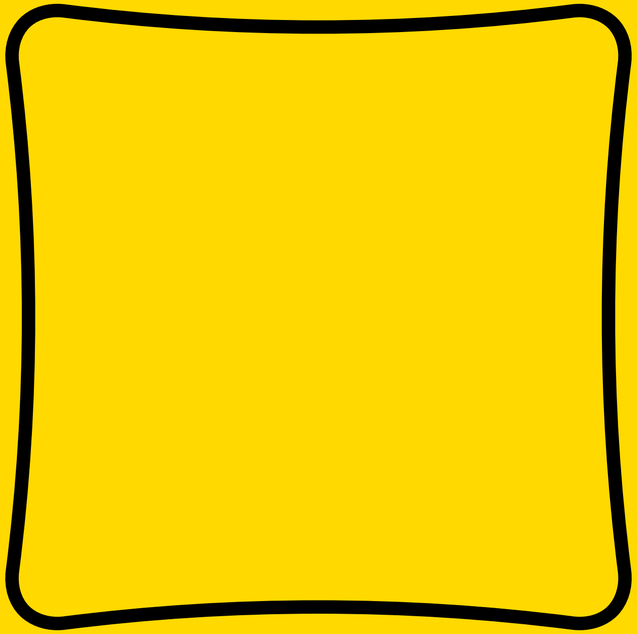
SEPARATION

DIVERSITY BETWEEN

DYNAMIC BALANCE

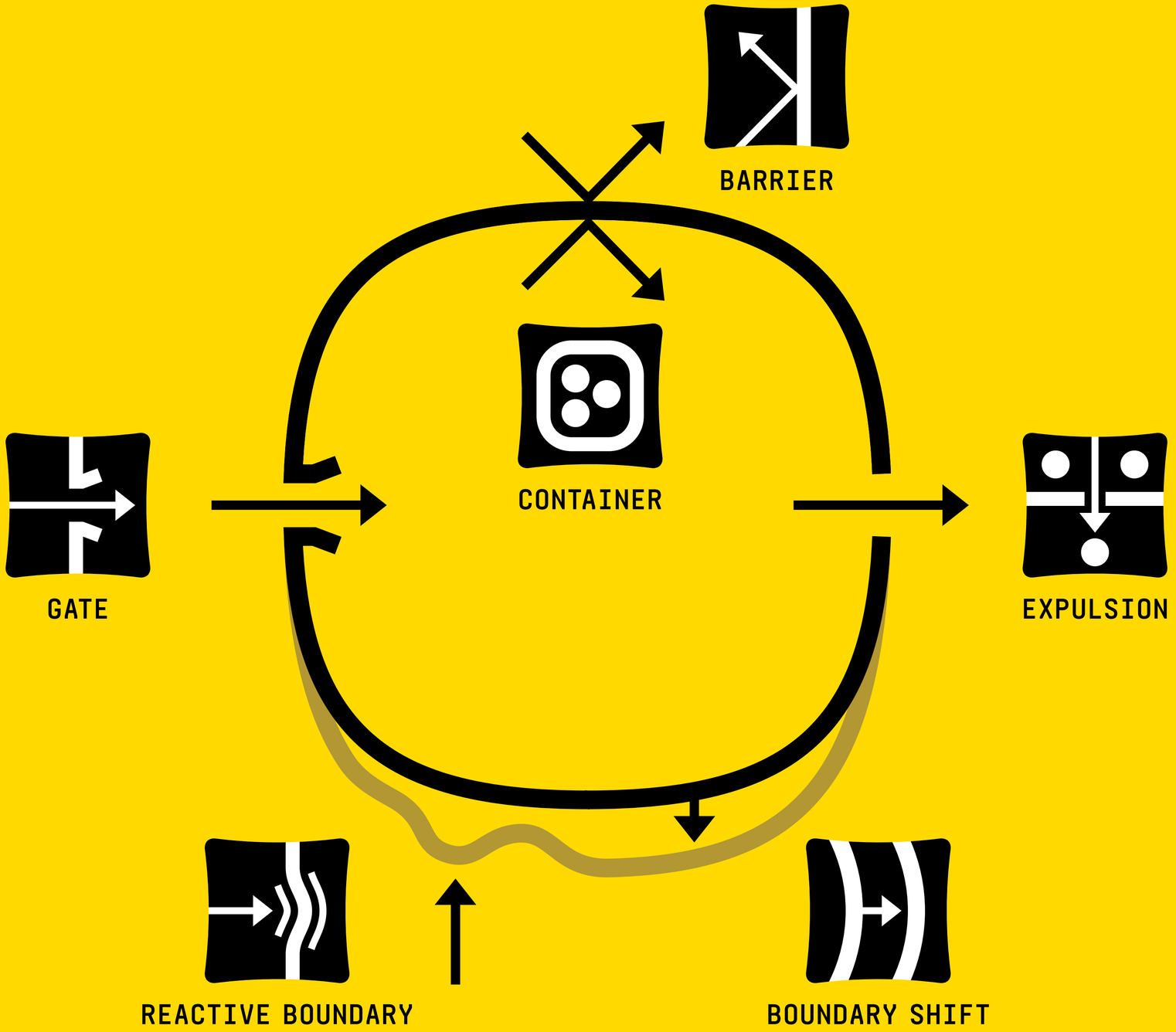
DRIVERS SIGNAL STATE **BOUNDARY** RELATION DOMAIN



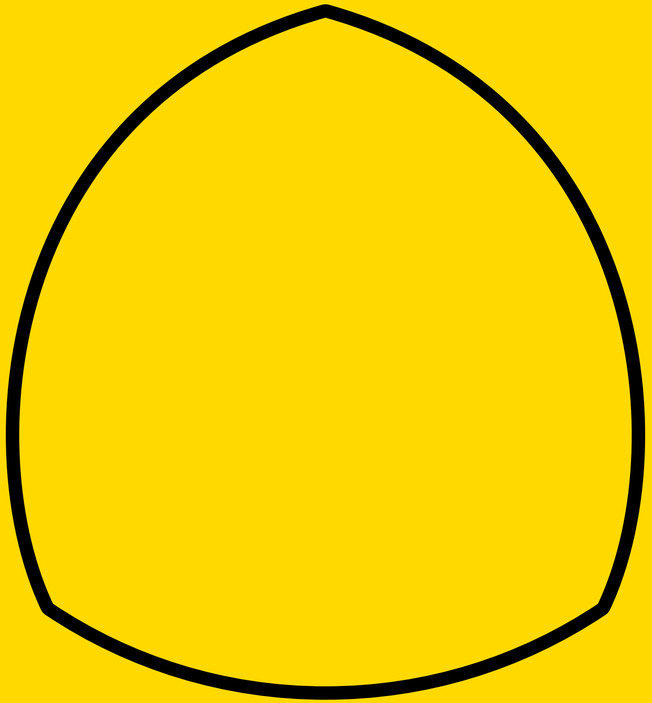


SEPARATIONS BETWEEN DIFFERENT PARTS OF A SYSTEM

FIXED OR MOVEABLE, REAL OR IMAGINARY, IMPERVIOUS OR POROUS ...


BARRIER
CONTAINER
GATE
EXPULSION
REACTIVE BOUNDARY
BOUNDARY SHIFT

DRIVERS SIGNAL STATE BOUNDARY **RELATION** DOMAIN

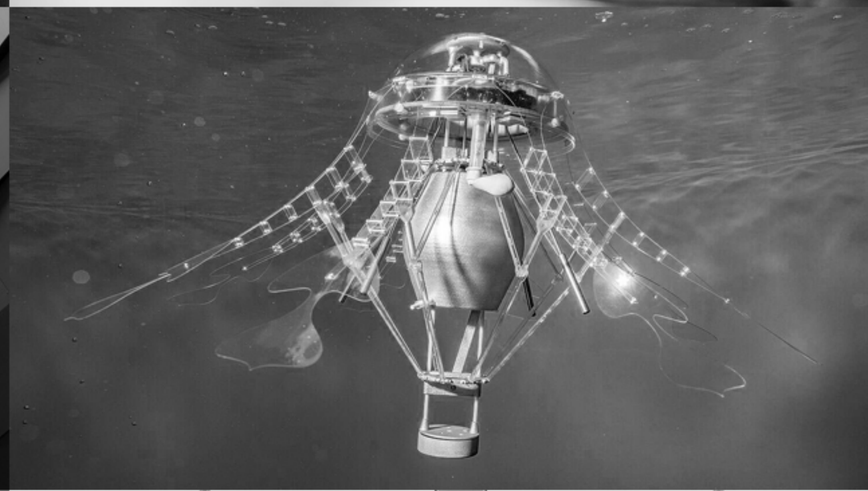


DYNAMIC BETWEEN TWO OR MORE OBJECTS (OR TYPE OF OBJECT) IN A SYSTEM

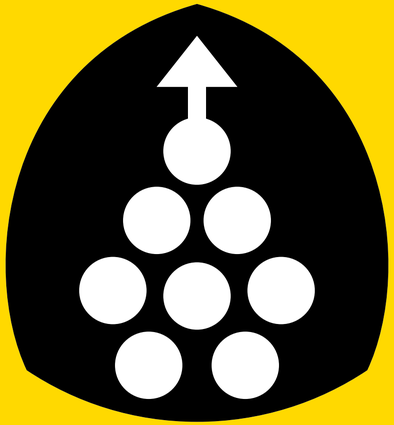
SHORT-LIVED OR ONGOING ...



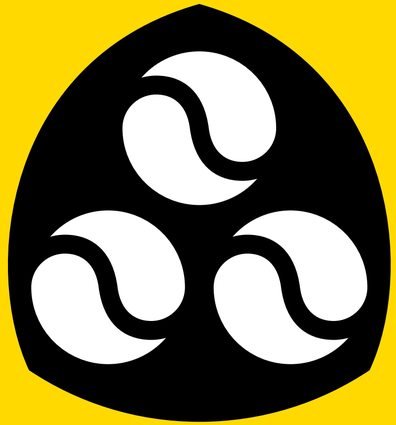


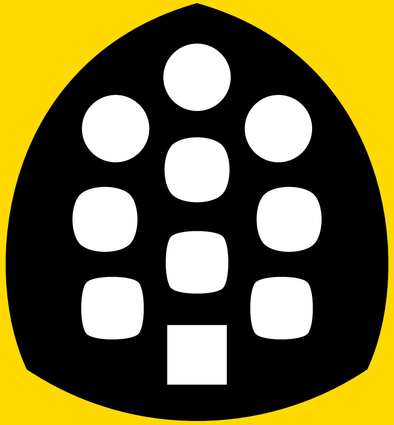

HOMOPHILY



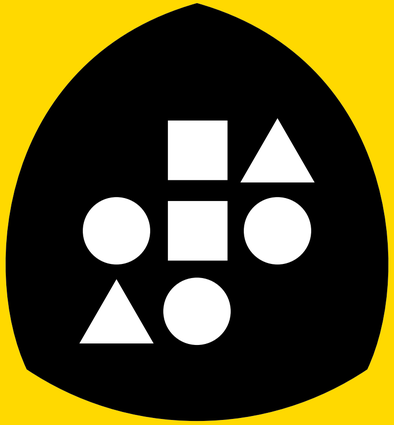
GROUP



MUTUALISM



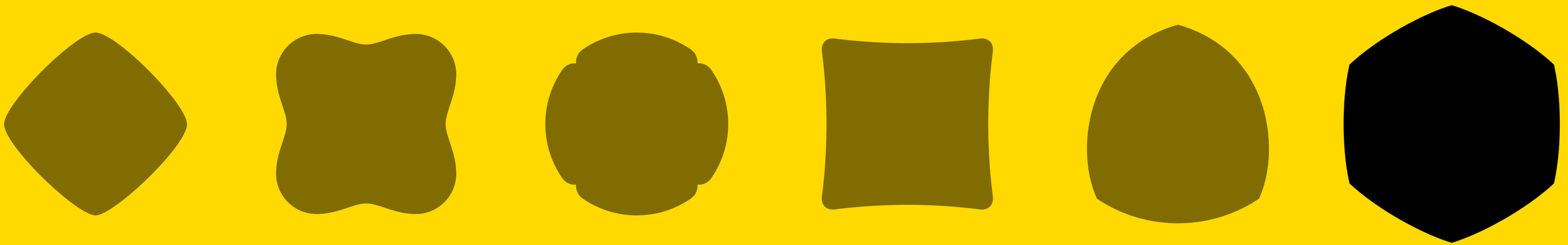
PROPINQUITY

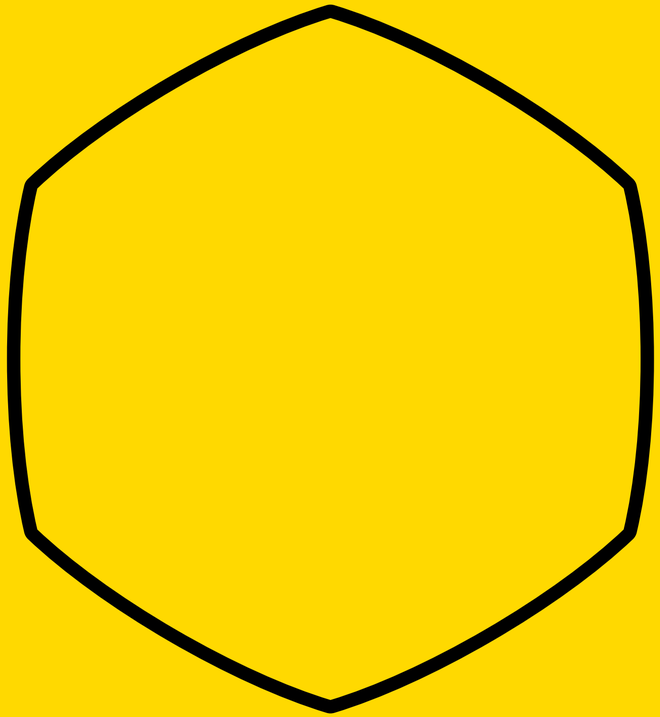


CLUSTER

PREDATION

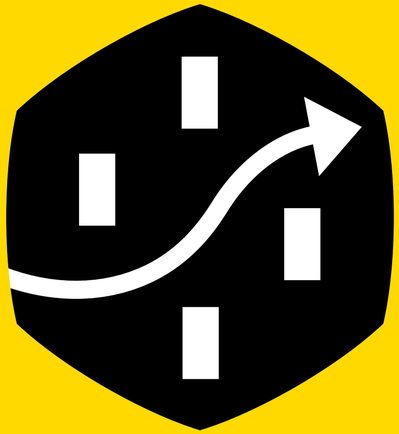
DRIVERS SIGNAL STATE BOUNDARY RELATION **DOMAIN**





THE **CONTEXT** IN WHICH THE SYSTEM (OR PARTS THEREOF) EXISTS

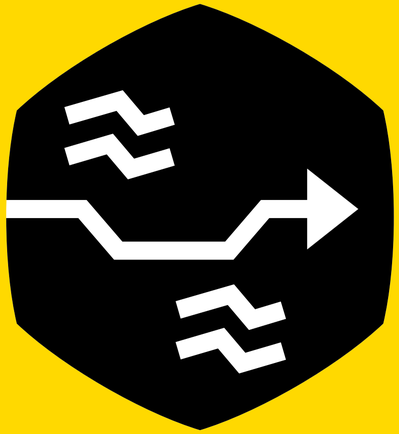
PHYSICAL ENVIRONMENT, SETTINGS, SURROUNDINGS, CONCEPTUAL SPHERES, PARADIGMS, EPISTEMES ...



OBSTACLE

AMBIENT CONDITIONS

ZONE



TURBULENCE

CONDITION SHOCK

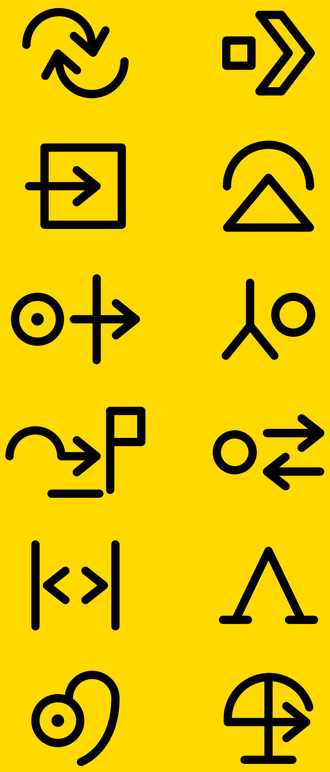
FALLOW


icons

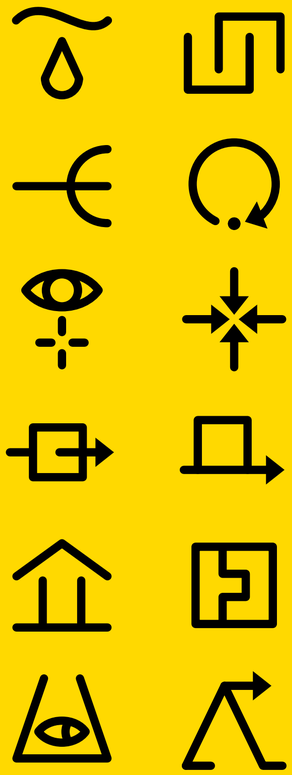
graphical languages

SHORTCOMINGS OF CRYPTIC ABSTRACTION

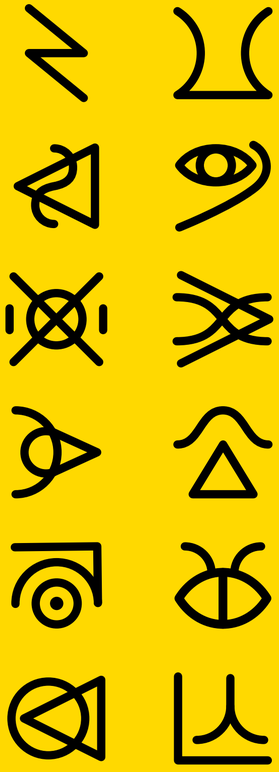
BLISSYMBOLS
CHARLES BLISS
(1949)



LoCoS
YUKIO OTA
(1964)

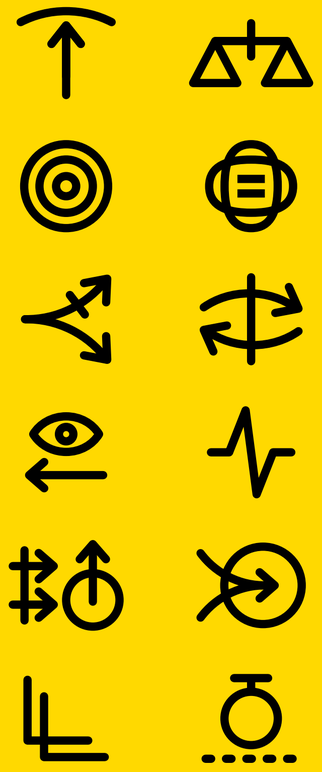


EARTH LANGUAGE
YOSHIKO McFARLAINE
(1992)



THE ELEPHANT'S MEMORY TIMONTHÉE INGEN-HOUSZ (2007)

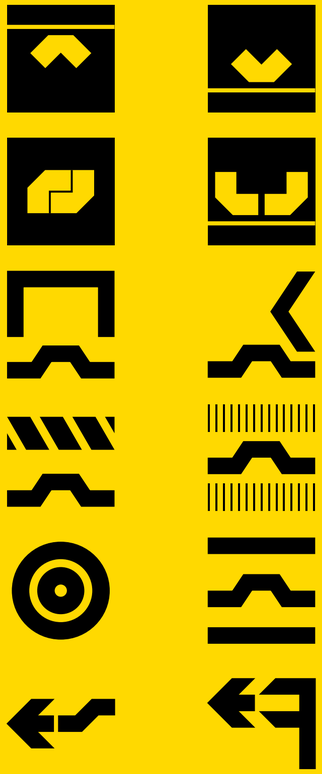
NOBEL UNIVERSAL GRAPHICAL LANGUAGE
MILAN RANDIĆ (2009)



system icon sets

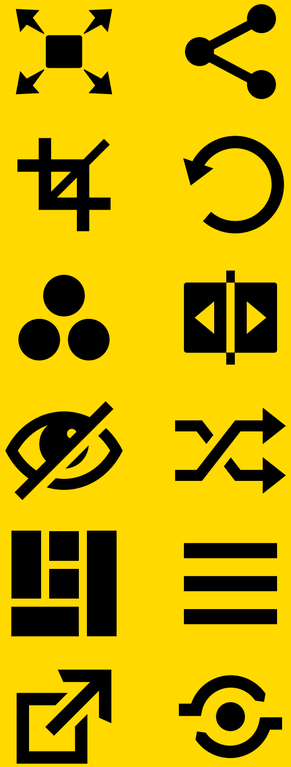
THE LIMITATIONS OF DOMAIN SPECIFICITY

NEW ASPECTS OF INFORMING (1970s) RADOMIR VUKOVIĆ TRANSPORTATION

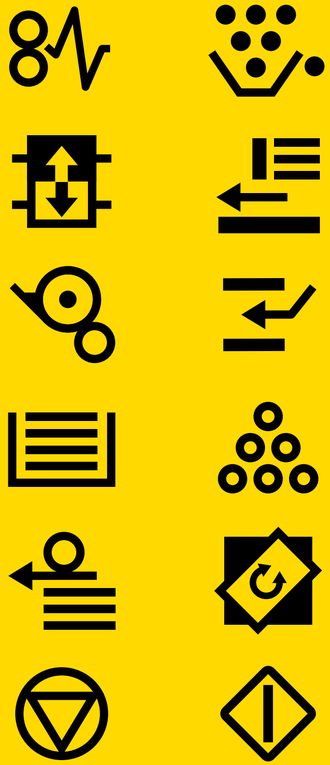


THE HOBO CODE (1870s) WAYFINDING SIGNAGE

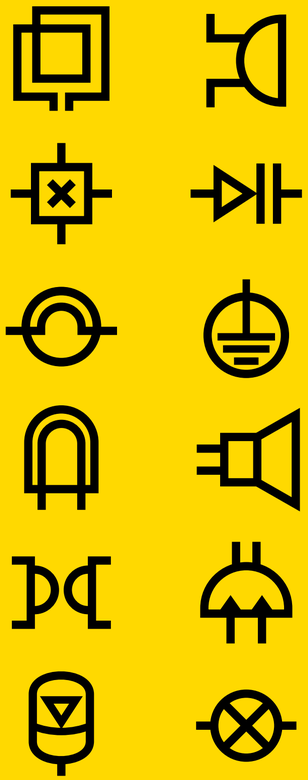
WEB INTERFACE IDEOGRAMS (1990-2000s) SCREEN INTERFACES



COPY MACHINE IDEOGRAMS (1970s) MACHINE INTERFACE



ELECTRICAL IDEOGRAMS (1960-1970s) DIAGRAM NOTATION

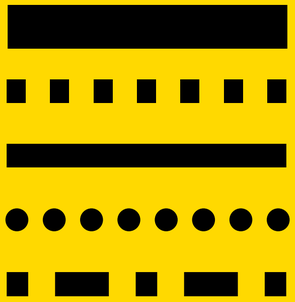


building blocks

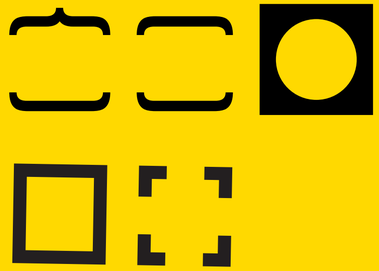
CONSISTENCY, CROSS-CULTURAL MEANING, AND EASE OF ASSEMBLY

PRIMATIVES

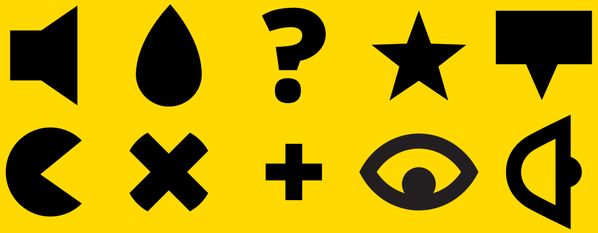
LINES



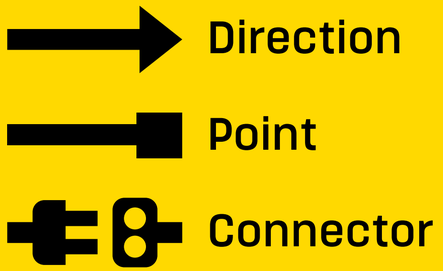
FRAMES



COMPLICATIONS

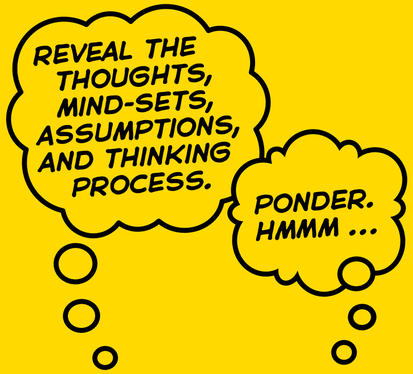


LINE ENDS



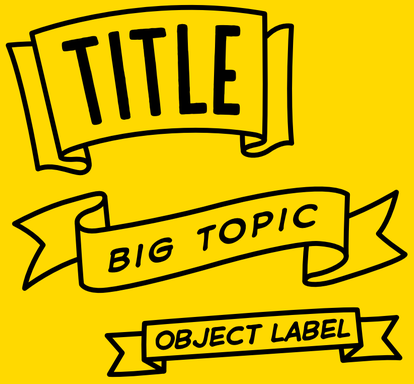
AFFIXES


CODEX
™



THOUGHT BALLOON

WHISPER BALLOON



BANNER

THEMED LETTERING

MOTION LINE (SHAKE)

codex

ON

OON

BURST BALLOON

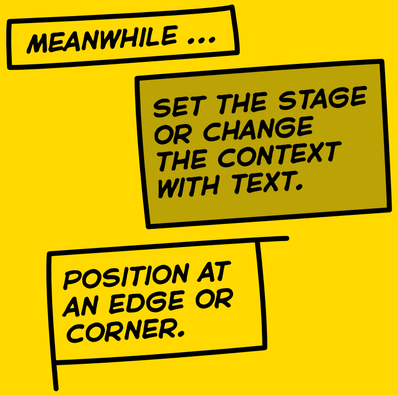
SYMBOLIC CAPTION

EFFECTS LETTERING

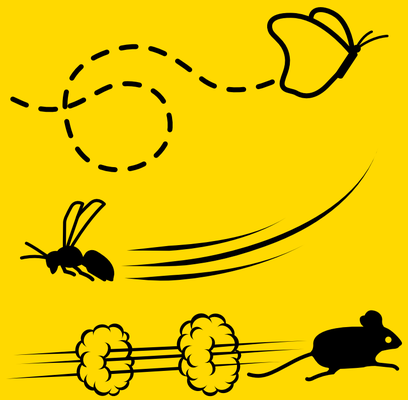
MOTION LINE

EMANATION LINE

SYM



EFFECTS



MOTION LINE (TRAIL)

SURFACE LABEL

visual vocabulary

SYSTEM TAXONOMY
Six broad categories of system element cut across the various literatures about systems. Any holistic discussion of system should touch on each of them.

TYPES OF SYSTEM
System elements are grouped loosely into three broad types of system. The groups are additive (complicated includes simple, complex includes all items).

01 DRIVER
SHAPE: SUPERELLIPSE
A DRIVER IS THE ACTIVE CAUSE OF SOME HAPPENING WITHIN THE SYSTEM. IT CAN ALSO BE THOUGHT OF AS A MOTIVE FORCE, MOVER, FLOW, AGENT, OR ACTANT DEPENDING ON THE SYSTEM. IN ALL CASES, THERE IS AN ACTOR AND AN ACTION, ALTHOUGH ONE OF THOSE MAY BE SOMEWHAT IMPLICIT.

02 SIGNAL
SHAPE: EPITROCHOID
A SIGNAL IS COMMUNICATION THAT CAN POTENTIALLY TRIGGER SOME ACTION. A SIGNAL CAN TAKE MANY PHYSICAL FORMS: SIGHTS, SOUNDS, VISUAL STIMULI, ELECTRICAL PULSES, MESSAGES, ET CETERA. A TRANSMITTED SIGNAL IS NOT NECESSARILY RECEIVED NOR INTERPRETED CORRECTLY.

03 STATE
SHAPE: MOKKOGATA
A STATE IS A CONDITION OF A SYSTEM OR OBJECTS WITHIN IT. MODE, PHASE, AND STATUS ARE TERMS OFTEN USED FOR STATES. THE CONDITION MAY BE STATIC OR DYNAMIC, ALTHOUGH MANY STATES THAT APPEAR "STEADY" CAN MASK A LOT OF UNDERLYING TURMOIL.

04 BOUNDARY
SHAPE: ASTROID
A BOUNDARY SEPARATES DIFFERENT PARTS OF A SYSTEM. BOUNDARIES CAN BE FIXED OR MOVEABLE, REAL OR IMAGINARY, IMPERVIOUS OR POROUS. THE MAJOR DISTINCTION BETWEEN OPEN AND CLOSED SYSTEMS DEPENDS ON THE EXCLUDING CAPACITY OF THE SYSTEM'S OUTER BOUNDARY (OR EDGE).

05 RELATION
SHAPE: OVATE
A RELATION IS THE DYNAMIC BETWEEN TWO OR MORE OBJECTS (OR TYPE OF OBJECT) IN A SYSTEM. A RELATION MAY BE A SHORT-LIVED INTERACTION OR AN ONGOING SERIES OF INTERACTIONS. THE PATTERNS OF INTERACTION ARE WHAT MAKE A SYSTEM PREDICTABLE OVER TIME.

06 DOMAIN
SHAPE: HEXAGON
A DOMAIN IS THE CONTEXT IN WHICH THE SYSTEM (OR PARTS THEREOF) EXISTS. THE PHYSICAL ENVIRONMENT, SETTINGS, OR SURROUNDINGS WILL INFLUENCE HOW OTHER PARTS OF THE SYSTEM ACT. CONCEPTUAL SPHERES, PARADIGMS, OR EPISTEMES SHAPE CONSTRUALS WITHIN THE SYSTEM.

CODEX
DESIGN + VISUAL THINKING

SYSTEM VIZ

V. 1.5.1 BY PETER STOYKO

SIMPLE

COMPLICATED

COMPLEX

SIMPLE

ATTRACTOR — An object that draws other objects towards itself; a bias in favour of an appealing position, object, or state; the value in a growth pole.

REPELLER — An object that pushes other objects away from itself; an aversion to an undesirable position, object, or state; a feared danger or harm.

FEED-BACK — Information about the outputs of an action are routed back as inputs to further action (or inaction).

INSTRUCTION — Algorithms that determine agent (inter)actions; procedural (declaration- and learning procedures; encodings or protocols.

STOCK — A discrete collection of consumable or expendable resources for future use; storage or pooling of materials.

TRANSITION — Changing from one state to another, often depicted as phases or stages of change; the process of developing a new attribute.

CONTAINER — A boundary that groups and isolates objects; the restriction of movement to a confined space or domain.

DIVIDER — A boundary that keeps two or more distinct objects or concepts apart from each other; a hard distinction or separation.

CLUSTER — Elements defined as a group by virtue of proximity and coexistence; a neighbourhood or conglomeration.

MUTUALISM — A relationship whereby both parties benefit; reciprocity, or beneficial cooperation; a relationship characterized by an absence of conflict.

DOMAIN SPACE — The physical or virtual area in which a system (or parts thereof) exist; the parameters defining the extent of the operation.

CENTRALITY — The hub around which activity concentrates; the concentration of power or control within a core of activity.

PROXIMATE DRIVER — A necessary and sufficient cause that directly affects another variable; a cause that is immediately evident in time and space.

GOAL SEEKING — The objective or target of a part of the system or the system itself; even within designed systems, goals may not align perfectly.

TRAIL — Residual left behind after an action that accumulated effects of past actions showing a pattern; traces left to coordinate (stigmergy).

THROUGH-PUTTING — The transmission of signals through a chain, with the potential for the signal to change at each juncture; serial signalling.

CAPACITY — The finite ability to handle a particular quantity of activity or items; the optimal volume(s) at which a function operates.

STANDARD — A set of items made more or less uniform; conformity to a set of basic criteria of acceptability; interchangeable commodities.

SEMI-PERMIABLE — A barrier that blocks some objects or substances while allowing others to pass through; a filter.

BARRIER — A boundary that prevents objects or substances from passing through from one domain to another; a defended front or border.

GROUP — An affiliated collective of actors that share patterns of behaviour or thinking; a collective acting according to a shared logic (herd).

RANK — The hierarchical status bestowed on an object or actor; vertical ordination based on criterion deemed salient to system operation.

PERIPHERY — Existing on or near the outer edges of a space, boundary, group, or field of activity; the hinterland of a domain; an area of relative neglect.

OBSTACLE — A discrete impediment to be overcome or obstruction to be circumvented in order to proceed.

ENABLER — A contributory cause; can encourage change (promoters), consolidate gains (reinforcers) or reduce resistance (enforcers).

AMPLIFIER — A combination of factors or process that increases the magnitude of an effect; a source of leverage; a reagent or accelerant.

TRANSMITTER — An object that sends out a signal; the encoding of meaning for purposes of communication.

RECEPTOR — An object that receives a signal, often ignoring or filtering irrelevant signals; the decoding and interpretation of signals.

LOAD — A stock of items being processed under constraint conditions; the controlled transportation or distribution of objects.

(RE)DISTRIBUTION — The dissemination or circulation of resources throughout a system, including the reallocation of stocks in the future.

GATE — A controlled opening in a barrier; a barrier opening that allows passage of objects that meet certain criteria.

PATH CONSTRAINT — A barrier that limits the flow or trajectory of agents; the contained channelling of substances within certain parameters.

DOMINATION — The continual exertion of power and control over a set of objects or actors; overwhelming power of domain or system.

COMPATIBILITY — Capable of useful connection or transfer between two parts of a system; a functional interface; interoperability.

FRICTION — A source of passive resistance that hinders activity within a domain; a mild drain of energy because of effort needed to overcome.

ZONE — An area or place amenable to, or specifically devoted to, a purpose; a context with a special functional quality.

CYCLE — A repeating process or iterative effort towards a goal; an ongoing circulation or recycling of elements within a system; loop.

DAMPENER — A combination of factors or process that reduces the magnitude of an effect; a muting, sapping of energy, fuse, or momentum.

STATUS DISPLAY — Regularly updated information about a particular object; an identifier for verification; an indicator of intent or receptivity.

SIGNS — Physical or virtual annotations in the environment; information found in context to guide action.

REDUNDANCY — Multiple stockpiles or parallel sub-systems that act as a back-up, fail-safe, or extended capacity.

(DE)ACTIVATION — The transition from passive object to active entity, or vice versa; emerging from, or descending into, a dormant or latent state.

PROTECTOR — A barrier preventing damage to an object by blocking or reflecting unwanted forces.

NOTIONAL BOUNDARY — A conceptual boundary or delineation; can be tangible in its effects; includes useful distinctions and mental categories.

DIFFERENTIATION — A contrast between actors in a system; establishing a productive niche; progressive specialization.

SET — The complete collection of components for a functional assembly; a group of objects necessary for an organizational unit.

REFERENCE POINTS — Features in the context that can act as orienting devices, including markers (features singled out for special consideration).

SUPPORT STRUCTURE — Infrastructural support (including underlying or hidden infrastructure) that enables activity.

OPPOSER — A factor discouraging or resisting change; a counter-entity or counter-balancing agent; an antibody; an antithetical influence.

ANTICIPATION — An expectation or prediction of a future happening; an imagined future or scenario; may itself trigger actions, including self-fulfilling ones.

MONITOR — Active scanning of a process or domain to compare with an expected state; the detection of anomalies; localization of inputs.

DECAY — The declining usefulness of information and data over time; the weakening of signal caused by distance and impediments.

ASSEMBLY — Building blocks with which system structures are formed expediently but with integrity; the materials and componentry of a system.

ROLE — The performative function an actor adopts in the moment to complete responsibilities or tasks; division of labor.

GAP — Separation of objects; a discontinuity in a conduit; the distance that prevents mutual exposure or contact.

EDGE — Outer boundary that defines the scope of domain or system; an isolating barrier of a closed system or an open-system demarcation.

INTERSECTION — The point of contact between two entities; the cross-roads at which actors, forces, or ideas coincide.

COMMENSALISM — An arrangement in which one party is dependent upon another but that dependence is neither harmful nor helpful.

RESOURCES — The availability and access to the factor inputs needed for a system; sustainable and predictable supply of resources.

DESERT — A space in which resources have been depleted or are scarce to begin with; harsh environment for production or activity.

GENATOR — The original impetus or catalyst of a sequence of events; an initiating cause or stimulus; a foundational event or seed object.

CONDUIT — A path along which actors are expected to move; the medium that connects nodes in a network or process.

RECEPTIVITY — Selectively attending to signals based on their compliance with protocols or compassion of qualities needed for interpretation.

CUE — A signal about the appropriate timing to begin or end a process or activity; a timing marker to coordinate activities.

ORDERING — Putting items into a formal arrangement that serves system requirements; sequencing or prioritizing items in a process.

RESET — Returning to original conditions or a earlier state; reboot or redo that restores default settings or recalibrates using new data.

TERRITORY — The boundaries between control structures; the demarcation of spatial area with a particular meaning or symbolic significance.

BRIDGE — A passage over or across one or more boundaries; a connection between different domains separated by boundaries.

COORDINATION — The orchestration of actors in the execution of tasks and processes, either through self-organization or management.

HOMOPHILY — The self-sorting of actors into homogeneous groups; the tendency of like-actors to affiliate with like-actors over time.

SYMBOLIC MILIEU — Widely shared and observed symbolic meanings imparted throughout the context; linguistic conventions for sense-making in a domain.

STRATA — Levels of activity and location that overlap and underlie, including hidden layers; sub- and super-strates of a system.

MOTIVE — The underlying motivation of an agent to seek a goal; can be internal (instinct, need) or external (incentive, inducement, persuasion).

CONTROL POINT — Contact between a subject and object whereby power or influence can be exerted; a time and place where direction is imposed.

LOAD BALANCING — Redistributing activity or items to even out capacity in use across a system; shifting burden from overto under-utilized subsystems.

DISSIPATION — Emanate outwards; scatter; Reduce in concentration or disperse a substance into the surroundings for functional reasons.

EXPULSION — Removal of materials, agents, or threats from a bounded space; disposal; exile.

CHECK — Cross-regulating actors; keeping activity of opposing actor within an acceptable range (inhibiting excess or bolstering deficiency).

ASYMMETRY — Imbalance of power, risk, resources, access, or opportunity; unevenness can cause realignment within the system.

PERIOD — Demarcation of time into discrete spans, often with each assigned a meaning; specified intervals; temporal domains between epochs.

COMPLICATED

LAG — A time delay or perceived delay between cause and effect that has implications for system behavior; looseness of timing; latency time.

SIDE EFFECT — Incidental results of an action, often unanticipated; an externality, with benefits or harms not accruing to the causal agent.

INTERFERENCE — Signals competing for attention or distortion caused by mixed or conflicted signals; potentially harmful dis- and misinformation.

ALERT — A warning signal intended to provoke a response; attention grabbing notification caused by an input; a defensive signal.

EROSION — The decay of an object due to repeat exposure to accidents; degradation of system parts due to wear and tear.

MULTI-FUNCTION — The ability to perform more than one type of task and make judgements about task suitability; contrast with unitasking function.

BUFFER — A boundary or zone that diminishes, delays, or otherwise alters a driver or its impact while passing through.

BOTTLE-NECK — A boundary that limits the passage of objects to a narrow gap; constraints forcing a flow to concentrate at a point or opening.

COMPETITION — Striving in self-interested pursuit of a goal shared by rivals; attempts to best others by acquiring power, status, or resources.

MIMICRY — A situation whereby one actor copies or simulates the behaviour of another; using one type of system as inspiration for another.

LEVELS OF SCALE — System attributes at different orders of analysis and abstraction; different levels of detail from zooming in and out.

TURBULENCE — Scattered environmental disturbances that jostle and stress actors; irregular, abrupt changes in flow; diffuse pockets of energy.

OUTLIER — An atypical case that a system has to handle; a rare edge case; an improbable occurrence or condition.

KLUDGE — A work-around or coping strategy used to overcome blockages; a temporary or makeshift augmentation that endures over time.

EXCHANGE — Communicative interaction between two agents, including the rituals and negotiation of the terms of engagement.

INDICATOR — Indirect or partial signal of status; a symptom of a deeper cause; a summary of a set of items.

STANDBY — Capacity held in reserve until it is needed, often as a back-up or in case of surging demand; readiness for emergencies.

MAINTENANCE — The restoration of operations after a malfunction; ongoing preservation activities to retain functionality.

REACTIVE BOUNDARY — A boundary that responds to forces and acts as an actant in its own right; a dynamic boundary.

LEAKAGE — The escape or inadvertent release of items from a containment boundary; the gradual seepage of items out of a space or domain.

PROPINQUITY — The process by which affiliated actors become more alike over time; the homogenization produced by conformity processes.

NETWORK — An arrangement of interconnected parts that interact directly through common linkages; the constellation of connections.

DENSITY — The relative proximity of system elements to each other; the size or the concentration of objects and activity.

NESTING — Embedded subsystems or systems inside other systems; causality and influence without being fully integrated necessarily.

BRANCHING — The divergent path of an agent or process; a bifurcation point can be controlled or way unstable depending on the type of system.

WAVE — Unevenness (surge or flux) in activity occurring within a system; the build-up of factors acting in concert or with similar timing.

NOISE — Meaningless observations that distract, making detection of useful signal difficult; false signals that can potentially overwhelm.

ECHO — Inadvertent signal generated by actions; residual signs of presence and activity that get transmitted; data exhaust.

FAULT — A malfunction or error that impedes system activities or causes general failure; often unnoticed or creates problems downstream.

FAULT DETECTION — Self-diagnosis, self-monitoring, and system-problem identification; detection, prognosis, diagnosis of problems.

LAYER — The combination of two or more component boundaries, each of which may have different functional qualities.

INTERCHANGE — A multi-lane boundary for the two-way movement of traffic; the connection point between conduits that can be traversed.

TRADE — The exchange of something for something else under particular terms, often through a third medium of exchange.

COUPLING — The tightness or looseness of ties between parts of a system; the degree of freedom of a particular actor in a relationship.

DOMAIN OVERLAP — The existence of more than one domain or partial domain within the same physical or virtual space; boundary distinctions.

TRAFFIC — The volume of activity flowing through a system; the constraint caused by the congestion of activity within a domain.

DISRUPTOR — A factor causing a system deviation or breakage, either internal contradiction or outside perturbation (endogenous or exogenous shock).

PARALLELISM — Concurrent processes that complement each other; the division of tasks into subtasks that are handled simultaneously; superposition of states.

FEED-FORWARD — Information about an impending action is sent out ahead of time to cause a response.

CO-PROCESSING — Pairing of signals and encodings across several interpreters; joint deliberation; collective interpretations and conventions.

DIVERSITY WITHIN — Differences within a particular category of object; the variation of shared attributes within an otherwise like group.

DIVERSITY BETWEEN — Differences between categories of object; the categorical distinctions reflect a variation in kind or fundamental property.

ABSORPTION — A barrier that allows passage through at a gradual rate based on a capacity to process or make use of; controlled seepage into.

DIRECTED BOUNDARY — A boundary that functions differently depending on what side is facing; boundary sides with different qualities.

INTEGRATION — Connecting systems or parts thereof in order to increase interoperability; translation layers between subsystems; incorporations.

MEDIATION — The mitigation or reconciliation of conflict between parties; adjudicate, referee, or resolve tensions in a legitimate fashion.

SCOPE — The mechanisms by which a system is able to expand or contract; the extension of system edges.

AUTO-ENVIRONMENT — A context that responds to presence and configures to requirements; a context with controlled conditions; climate control.

INFLECTION — A turning point or critical juncture; a change in direction caused by circumstance or a shift in priorities; a pivot.

EQUIFINALITY — Multiple activities lead to the same outcome because of a system dynamic or arrangement of constraints.

META-MEANING — Inferences derived from a set of signals about more general patterns; big-picture patterns that affect system activity.

REACTIVITY — Sensitivity to signals, risks, or drivers; reactions can differ in magnitude, speed, and so forth; potential for overreaction.

FAULT RECOVERY — Correction or compensation that minimize impact of faults on a system after the fact; the activation of workarounds and fail-safes.

SCALABILITY — The ability to expand capacity; the conversion of increased ability to handle volume of processing or traffic.

BOUNDARY SHIFT — The movement or negotiation of a fixed boundary; the expanded parameters of an edge.

COMPARTMENT — Some dynamics within a system are contained in sub-systems or modules, with constrained dynamics across modules; partition.

COMPLEMENTARITY — Different actors or objects are able to do more together than they would otherwise; synergistic or positive-sum bonds.

ALIGNMENT — Disparate agents or activities share a common or complementary direction but not necessarily full coordination.

AMBIENT CONDITIONS — The continually changing physical environment or cultural milieu with the potential to affect system operations.

TOPOLOGY — The variable contours of an environment or space; an x-scape, with "x" being a physical, cognitive or symbolic spatial variable.

RECURSION — Complicated activities broken down into smaller, iterative, repeating actions; propagation through patterned repetition.

DERIVATION — Predictable result from a combination or set of conditions; variation inspired by preexisting source(s).

CORRESPONDENCE — Perceived to be of a kind; how well an object can be matched with like objects or classifications; strictness or looseness of categories.

TRANSLATION — Conversion of one type of signal into another, expressing a message or encoding using a different medium.

PHASE SPACE — All the possible states of a system given its many variables; possibility space; each point can be thought of as a system micro-state.

ACCUMULATION — The build-up of items or experiences over time; can affect system gradually or once the build-up reaches a threshold; a memory bank.

PERMISSIONS — The control of activity within a bounded area; the formal or informal rules of access to a domain; bounded activity.

BOUND POSSIBILITY — A system stuck within subset of possible states due to mental or physical limits; phase states unexplored or deemed problematic.

INTER-MEDIATION — A go-between two or more actors or processes that serves a function; a mechanism of translation, matching, or brokering.

SYNCHRONY — Harmonious or coordinated activities in space and time; patterns of activity that coincide at particular moments.

CROWDING OUT — When the presence of one system drives out others; a group occupation of finite space that fills capacity.

FALLOW — Recovering from use by setting aside or curbing use for an interval; reaccumulation or depleted resources; restoration.

ENTRAINMENT — Changes to an actor apply to a related sub-set of objects; actors caught up in another actor's activities (or aftermath); direct following.

DYNAMIC BALANCE — Maintaining balance while undergoing change; continually compensating for varied forces that push towards a state of imbalance.

TOLERANCE — Permissible variation in precision or accuracy allowing continued operation; ability to cope with anomalies or faults without interruption.

AGGREGATE — A group of objects or actors of the same type based on characteristics relevant to the system; taxonomy or folksonomy.

COMPLEX

DISTAL DRIVER — An indirect, ultimate cause of a changing variable; a "big picture" cause that is seen at a high level of abstraction.

AGGREGATE AGENT — A collection of agents take on the characteristics of a singular agent; agent-like behavior of collectives at higher levels of analysis.

PERSPECTIVE — The vantage point and field of view by which a system (or parts thereof) is perceived; accumulated experiences affecting interpretation.

SITUATED MEANING — Signals that require context to be fully interpreted; the meaning given to something in the moment or circumstance.

EQUILIBRIUM — The balance or steady state created by opposing forces; the axis around which sorts by a balance is maintained; return to a set-point.

MUTATION — A reconfiguration of an object caused by an error or exogenous factor; usually noticed when bestowing an advantage or disadvantage.

FUZZY BOUNDARY — A boundary with edges that are hard to detect or are otherwise ambiguous; a boundary with inexact demarcation.

LIMINALITY — Moving into the space between domain boundaries; the reorientation that comes from travelling across domains.

CROSS-POLLINATION — Aspects of two or more objects are combined to create a hybrid; the purposeful breeding of a new type of entity.

HOLON — When the whole of the system is replicated within the parts of the system, usually as a means for the system to propagate.

GOAL SHAPING — The way an environment influences the goals of actors within; context-derived needs, wants, motivations, and objectives.

UNCERTAINTY — Aspects of a domain that remain unknown or poorly known; outstanding questions to be resolved about an aspect of the system.

CASCADE — A sequence of knock-on effects; a chain reaction; a succession of secondorder, third-order (and so on) effects.

CONFOUND — An unexpected, unwelcome factor persisting in a system; a free radical or ghost in the system; unplanned-for case causing difficulties.

FRAMING — An interpretive paradigm which makes the system understandable; managing language and mental models that guide sensing and interpretation.

DIVERSION — False or misleading signal about an actor's status, qualities, or intentions; a feint, smokescreen, or pretence; an evasion.

EMERGENT PROPERTY — A characteristic or function that comes into being without direction; multiple objects have qualities the parts alone do not have.

SEPARATION — The division of a part into two or more parts; the extraction of constitutive elements from a mixture.

CONTAMINATION — An unwanted mixture of items; the taint of an outside object or agent across a containment boundary.

FLEXIBLE BOUNDARY — A boundary that changes configuration in response to conditions; a boundary that is not in a fixed shape, configuration, or position.

ADJACENCY — Parts (or potential parts) that are near or adjoining; nearby opportunities or risks; a proximate or related niche.

PREDATION — Attacking or plundering of one entity by another or by a process; the use of another actor as a consumable resource.

CIRCUMSTANCE — The confluence of contextual factors at a time and place affecting system activities; exigencies to be dealt with in the moment.

CONDITION SHOCK — Circumstances at the edge or beyond what system can ordinarily cope with; major temporary contextual stressor.

GOAL SHIFT — Evolving objectives or targets, including losing sight of raison d'être; an ongoing shift in priorities affecting system activities.

MULTI-FINALITY — Acting upon an object may produce different outcomes depending on the state of the system or contextual factors.

OBSERVER INFLUENCE — Reactions to surveillance, even if subtle, unknowing, or unintended; biases caused by observation or measurement.

COMBINATION — The synthesis of two or more objects or substances; bringing together the capabilities of multiple agents.

REPLICATION — When an object is copied, reproduced, or divided into two or more analogous objects.

OPACITY — Extent to which sensing through boundaries is possible; a matter of degree of openness, transparency, or hiddenness.

BREAKDOWN — The failure of a boundary to function as designed; the damaging of a boundary by a force; the dissolution of a boundary between domains.

PARASITISM — A relationship in which one party is harmed or destroyed while the harming party benefits or is unaffected; amensalism.

SYMMATHESY — Simultaneous contextual learning or influence between entities through mutual exposure.

ENTROPY — The existence of disorder or chaos in a system; sources of disarray within a system and the extent to which they hold sway.

CRUFT — The build up of additions, patches, and work-arounds, many of which out-live an original purpose; legacy parts or sub-routines.

DIFFUSION — A multiplicative effect or diffuse spread; a ripple- or viral effect; the widespread distribution of an element throughout a system.

FIELD — Influence projected from an object that diminishes over space; an intermediate force that acts on others from a distance.

CRITICALITY — The threshold beyond which a dynamic becomes self-sustaining; critical mass necessary for an activity to take place.

TIPPING POINT — The threshold beyond which rapid, large-scale change happens; the dynamic impacted by a sudden force imbalance.

(RE)APPROPRIATION — Bi-products of activity (e.g. waste, detritus, residual) used by others; repurposing of outputs by scavenging or tag-along agents; bizarre.

CROSS-DOMAIN RISK — A driver in one domain has a knock-on effect resulting in a vulnerability in another domain due to complex inter-connectedness.

TENSION — An opposing tendency or trade-off between forces, priorities, or goals; how it is resolved, balanced, or ignored affects system.

OBJECTILE — An object that changes state according to a function; not defined by static form but as a continuum of variation.

EXAPTATION — The repurposing of existing functions beyond their original or intended use; make-shift adaptation to new domain conditions.

from silos to buckets

The idea of a general theory of systems has gone in and out of fashion over the last century. The pendulum has swung away because of the narrowing of academic and professional disciplines. We now have many specialized vocabularies for describing systems. Indeed, the very notion of what a system is has fragmented. This development runs counter to a core premise of systems thinking: the world is understandable only insofar as we see how parts relate to wholes. How far can we get if only a thin sliver of the whole is considered at once? Even if a unified general theory is unrealistic, the value of an ongoing conversation across disciplinary silos is clear. Yet without common points of reference, how can such a conversation take place?

This inventory offers common points of reference in the spirit of visual-vocabulary building. The inventory began by looking at system as a genre across disciplinary literatures; that is, as a set of persistent features over time and across contexts (Siskin, 2017). Everything from mechanical control systems to natural ecosystems has been taken into account. The various system elements and dynamics were grouped, abstracted into generic classes, and organized into six buckets. Much "lumping" and "splitting" is going on here. Despite best efforts, the inventory is nonexhaustive; there will inevitably be something missing, so this inventory is in no sense "done." The labels and distinctions are ones "in good currency" (Schön, 1970), which may not be the freshest coinages nor reflect the nuances of every school of thought. But they can usefully help us point to a common reference.

system sight

We learn much about our world by singling out particular patterns for special consideration and assigning labels. We are visual creatures, so we add an archetypal image to that label in our memory—the "dual code" theory. The process of selection and abstraction distinctions, we would glance past much of what we see as insignificant noise. That is how a large visual vocabulary makes us more discerning observers.

Systems are a challenge to study because there are so many potential dynamics and organizing principles to keep track of. Moreover, systems operate at many different levels of analysis. Even experienced analysts have a hard time juggling all the relevant patterns in the mind. Now consider the difficulties that a diverse group of co-designers encounters. Members often talk past one another without a common vocabulary. A visual vocabulary in document form—a codex—goes even further in stimulating dialogue by offering a handy checklist of things to consider. This checklist is also a useful teaching tool.

design

The inventory icons follow a set of visual tropes and stylistic rules. A trope is a non-literal signifier of something. Many of the tropes used are common to both popular culture and specialist notation. For example, arrows are used for forces, causes, flows, and the like. As another example, brackets are used for sets. The stylistic rules add further consistency across the set. For example, drivers have a different line thickness than boundaries. Plus signals and time delays have different line styles. This design is useful to maintain coherence as others add to, and adapt, the inventory. Each interior icon blocks are shown to the left (method-ological notes available separately).

The design begins with outline shapes for each of the six categories. The contrast between shapes is maximized while maintaining equivalent optical volume so that interior icons appear similarly proportioned. Each category represents a major organizing theme running across the systems theory literature. Those who think of systems primarily in terms of "stocks and flows", or "networks and organizing principles," or "signals and boundaries," or "context and perspective" might not find all categories equally useful. That's fine. But users are invited to broaden their conceptual repertoire.

Each interior icon is not a stand-in for the concept but an evocative instantiation. In other words, even though the meaning of each icon may not be entirely self-evident initially, the shapes are somewhat illustrative. This helps make the concepts vivid in the imagination as the definition is understood. Thus, once learned, the set of icons becomes easy to parse; it has "reference value" as the visuals evoke the concept in the mind more efficiently than words.

CATEGORIES

OBJECTS
Primitives
Complications

LINES
Boundary
Signal
Link / Effect
Time Delay
Axis
Direction Point Interface

FRAMES

REFERENCE. Donella H. Meadows, Thinking in Systems (White River Junction, VT: Chelsea Green Publishing, 2008); Donald Schön, "Change and Industrial Society," Reith Lectures (London: British Broadcasting Corporation, 1970); Clifford Siskin, System: The Shaping of Modern Knowledge (Cambridge: The MIT Press, 2017); Thomas Twaites, The Toaster Project (New York, NY: Princeton Architectural Press, 2011). NOTES. The distinction between diversity within and diversity between, as well as its significance for systems theory, are fully explained in Scott E. Page, Diversity and Complexity (Princeton, NJ: Princeton University Press, 2011). The concept of symmathesy comes from Nora Bateson, Small Arcs of Larger Circles: Framing Through Other Patterns (Axminster: Triarchy Press, 2016). The signals and boundaries distinction, plus the notions of "directed edge" (here called directed boundary) and aggregate agent, come from John H. Holland, Signals and Boundaries: Building Blocks for Complex Adaptive Systems (Cambridge, MA: The MIT Press, 2012). The term "levels of scale" comes from Christopher Alexander's "fifteen fundamental properties of wholeness" (from The Nature of Order, Book 1, Berkeley, CA: Center for Environmental Structure) although other aspects of Alexander's list are not drawn directly from that work; "echos", "roughness", and "strong centers" are different from echo (narrower in meaning), friction (broader), and centrality (broader) respectively. The concept of holon comes from Arthur Koestler, The Ghost in the Machine (New York, NY: Macmillan, 1967). The notion of assembly included here is in the spirit of Alexander Bogdanov's notion of "positive" as a principle for creating sophisticated organization via a "concrescence" of its parts. It together with "expedient integrity." See Simona Poustilnik's "Alexandr Bogdanov's Tektology: A Science of Construction," in Pia Tikka, Culture as Organization in Early Soviet Thought (Helsinki, Aalto University, 2016). PEST analysis is originally attributed to Francis J. Aguilar, Scanning the Business Environment (New York: Macmillan, 1967). For liminality, see Dave Gray, Liminal Thinking (Brooklyn, NY: Two Waves, 2016). Cross-domain risk is based on a literature review of interconnected risk in Nyström et al., "Anatomy and resilience of the global production ecosystem," Nature, vol. 575, 2019. "Objectile" attributed to Gilles Deleuze, The Fold (Minneapolis: University of Minnesota Press, 1993) and Bernard Cache, Earth Moves (Cambridge: MIT Press, 1995).

usage scenarios

The visual vocabulary has several applications for diverse teams of designers working together through dialogue. Dialogue is an free-form conversation in which everyone can express themselves openly to jointly create something worthwhile. Several activities can jump-start the conversations and help them grapple with any multifaceted system.

CARD SORT EXERCISE

It is often difficult to give a dialogue session an impetus, momentum, and focus without having something to channel attention; something to respond to in the moment. The system elements have been turned into decks of cards or chips, with the six big categories representing suits. A group flips through the deck, singling out particular cards for discussion as they explore a particular system. Relevant cards can then be arranged spatially with notes as a record of the conversation.

VISUAL MAPPING

A group can explore the various parts of a system visually by charting it out on a large canvas. The various vocabulary items can populate the map to show particularly interesting qualities, functions, and dynamics affecting the system. The items can also alert designers to parts of the system that would otherwise go overlooked, which can guide research.

ANNOTATION LAYER

The vocabulary also serves a diagnostic function, as an already visualized system or data display can be further analyzed by matching vocabulary items to parts of the system. This added layer of meaning can shed new light on difficulties or help to explain how a system works on a deeper level. This applies to any visualization, from technical notation to pictorial map to free-style bricolage.

CHANGE
WHAT FACTORS HELP OR HINDER CHANGE?
ENABLER
OPPOSER
AMPLIFIER

VISUAL TEMPLATE

Brainstorming can revolve around individual vocabulary items or small clusters of items arranged in a poster-sized template. Such a template presents an analytical framework with blank spaces for participants to fill in additional information. Visual vocabulary items can be simple tables to elaborate charts, with visual vocabulary items anchoring each cell area. Instead of relying on off-the-shelf templates or "canvases," designers can design their own based on the particulars of the project at hand.

TERTIARY ORGANIZING DEVICE

Analysis can benefit by looking at different types of systems that go beyond the simple, complicated, and complex distinction used above. For example, business strategists often use some variant of PEST analysis (left). Another example is used in Elanica's consulting work, a cross-disciplinary set of "elemental spheres" (right). This framework is often helpful for bridging the worlds of design, social sciences, and organizational science. The example on the reverse side relies implicitly on these distinctions.

Politics, Economy, Social, Technology, Legal, Ecology
Materials, Energy, Time, Inertia, Effort, Interests, Symbolism, Biota

systems thinking

"It's all very simple," we're often told about our messy world just before a pat claim is offered. Or a chronic problem is "boiled down" and assigned a three-step "solution" by a well-meaning "fixer." Or a pundit offers a "hot take" that stridently turns initial impressions into a confident read of the situation. All that to say, we habitually turn to reassuring simplifications to guide us in uncertain times, even when that habit has a dismal track record of success.

Thinking in terms of systems can curb that impulse. Indeed, seeing our world as a tangle of crosshatching systems is quite humbling. Even the simple objects that surround us are the product of intricate systems and subsystems operating behind the scenes. Try tracing the development of that paper-clip on your desk. Can you even fathom the systems that created the metal alloy the clip is made of? And the larger impact of the mining and smelting to the surrounding ecosystem and communities? Thomas Thwaites (2010) famously built a toaster completely from scratch without the benefit of standard manufacturing systems. It took nine months. And that was with help from countless other systems that enabled him to operate in modern society.

Paper-clips and toasters are the product of clearly demarcated and tightly controlled systems. Many of society's difficulties are entangled in far less predictable systems that interact in ways we scarcely understand. The dynamics seem both paradoxical and intractable, perhaps even mysterious. These "wicked problems" are enough to make us throw up our hands in exasperation and settle for short-sighted coping strategies. Not so fast. These are still early days in our attempts to properly tune our way of seeing to adequately grasp how systems affect our lives.

This codex starts from the premise that such understandings are possible. However, if you are looking for quick and easy guide, you've come to the wrong place. The main conclusion I draw from the literature on systems—in the natural sciences, the social sciences, the managerial practices, the design disciplines—is that there are a great many common system elements and dynamics to keep track of. It is worth itemizing what these commonalities are and become familiar with their qualities. That is how we tune our gaze. It's a daunting task, to be sure. It's easy to get lost in the details. The hope is that this codex makes that learning a little easier.

Before proceeding, it helps to stipulate what is meant by "system." As Donella Meadows puts it, "A system is a set of things—people, cells, molecules, or whatever—interconnected in such a way that they produce their own pattern of behavior over time." (Meadows, 2008) She adds that there is a coherent organization to this set, often intended to achieve something (a function or purpose). This codex surveys many aspects of the subject, each with their own conceptions. Nonetheless, Meadows definition is a big enough tent to encompass the various theories, schools, and disciplines that talk about systems.

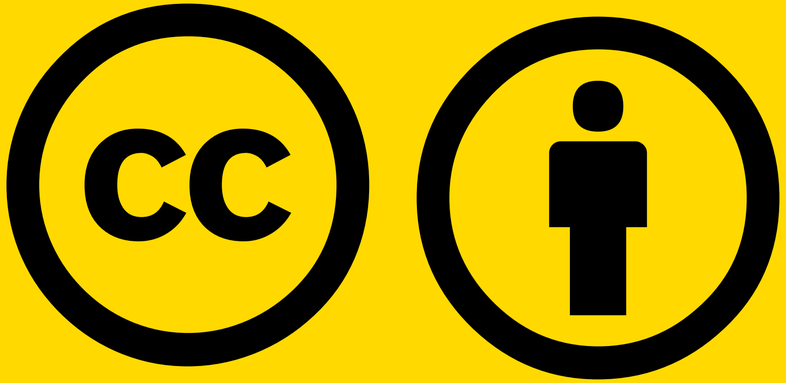
I started by pooh-poohing the crude simplifications we habitually reach for to explain our world. I should clarify one of the analytical priorities of this codex. I do not have anything against reductionism, per se. Indeed, building bridges across the various disciplines is unabashedly an exercise in distillation to some extent. Yet, too many accounts of systems are frustratingly heavy on abstract what specific mechanisms and dynamics are at play. It's easy to get caught up in the deep understanding of how everything fits together. An essential part of learning involves singling out items for special attention, assigning clear meanings, and exploring the implications. Knowing a lot about the trees does not necessarily mean losing sight of the forest; actually, it's quite essential to figuring out how the forest works.

visualizing sy[stems]

Complex systems are ... understand without ...

200 ELEMENTS/ DYNAMICS

open



CREATIVE COMMONS
FREE CULTURE LICENSE

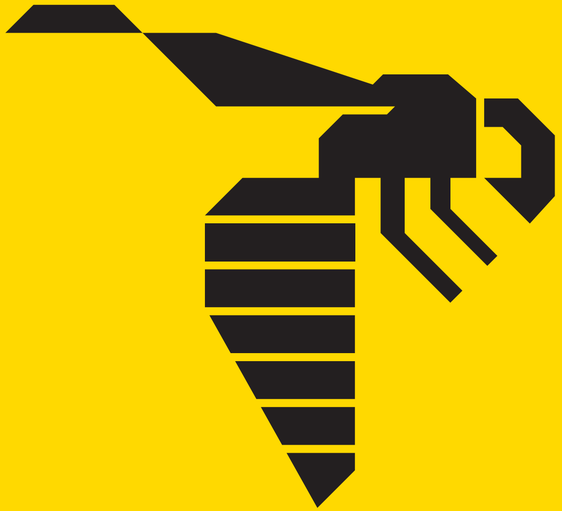
grand theory

à la carte

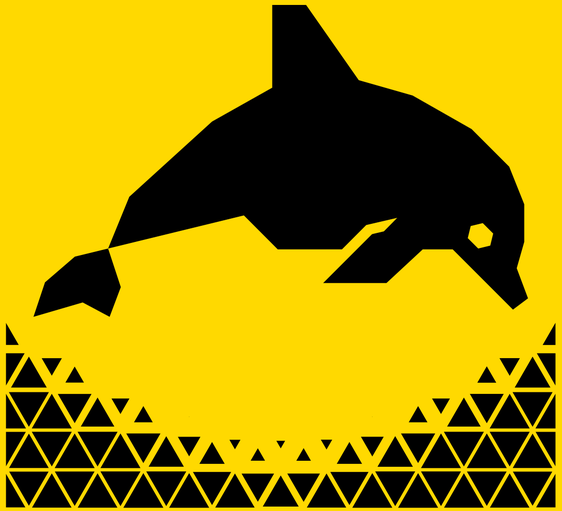
system sight

VISUAL-VOCABULARY BUILDING
TO IMPROVE HOW WE NOTICE
AND INTEGRATE OBSERVATIONS

demo cases



EXURBAN
APIARY



COASTAL
SEAFARM

VIRUS
PANDEMIC

DESIGN CASE

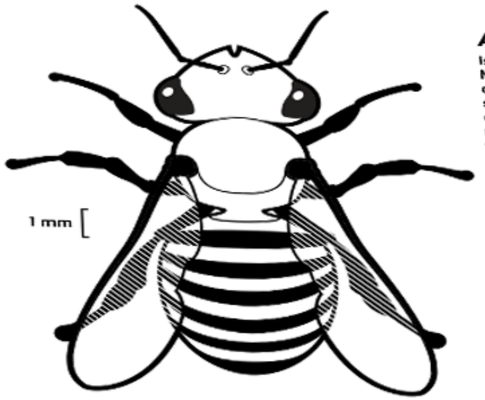
EXURBAN APIARY

An apiary is a place where beekeepers relee colonies of bees. Apiculture is a good case study for several reasons. An apiary is a commercial enterprise with widespread interdependencies across the surrounding ecosystem and economy. Both bees and their colonies are complex adaptive systems in their own right. In recent decades, colonies are collapsing at an alarming rate across the globe; an ecological disaster dubbed "Colony Collapse Disorder." No single cause has been identified. Experts believe the interplay of various factors cause each colony to live precariously on the edge of collapse. It would be useful to map out what these vulnerabilities are. In so doing, a case can be made for a more robust apiary design. The visual vocabulary helps explore that problem space.

This badge labels vulnerable points in the system

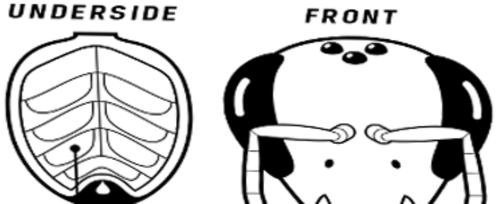
01 body

The body of the honey bee is a complex system that has also adapted to the systems the bee operates within.



Apis Mellifera

is the common honey bee of North America's temperate climate zones. Bees are highly social animals, living in colonies contained within hives. Apis mellifera is semi-domesticated with beekeepers actively managing colonies to produce commercial honey and beeswax. Nectar is gathered by bees from flowering plants and brought back to the hive, where it is stored in wax combs. In nature, a colony produces a surplus of honey as a hedge against loss. It is this surplus that beekeepers harvest. Every animal is a complex adaptive system. Given the social nature of bee colonies, several adaptations to bee bodies have emerged to enable this collective production.

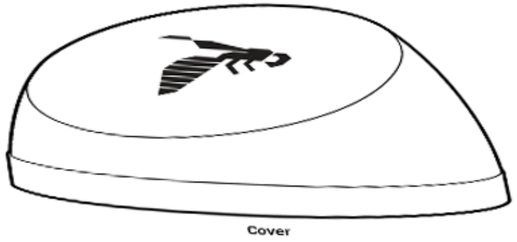


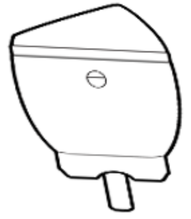
RECEPTOR
Five eyes and two antennae allow bees to sense. They can see ultraviolet light to find flowers more easily.

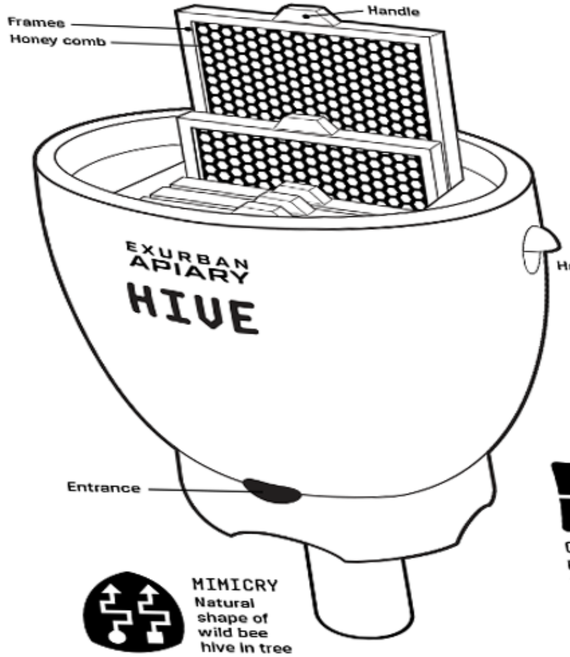
LOAD
A long tongue

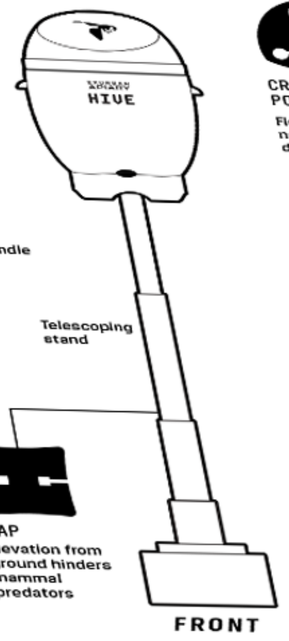
02 hive

The design being explored here is an apiary hive and output products. The hive is the structural foundation of the bee's highly social existence.







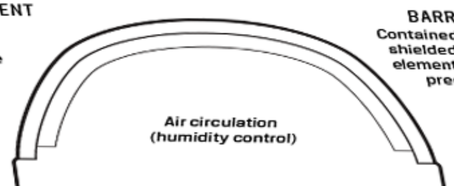


GAP
Elevation from ground hinders mammal predators

MIMICRY
Natural shape of wild bee hive in tree

COMPARTMENT
Controlled dynamics across hive chambers

BARRIER
Contained hive shielded from elements and predators

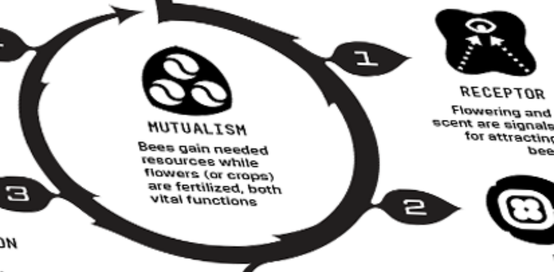


03 forage

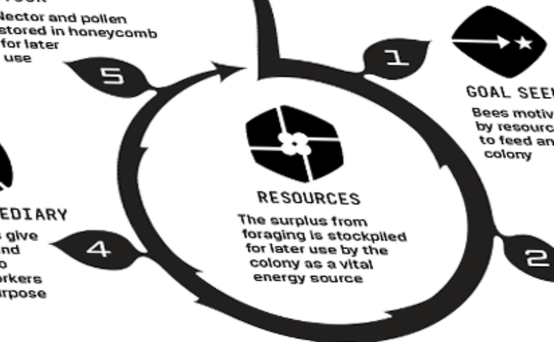
The hive processes and stores resources the bees use to maintain their colony. A collective intelligence emerging from this system.

LOOPS
Repetative loops of foraging, fertilizing, and organizing

ATTRACTOR
Plants flower with color and scent adapted to lure bees

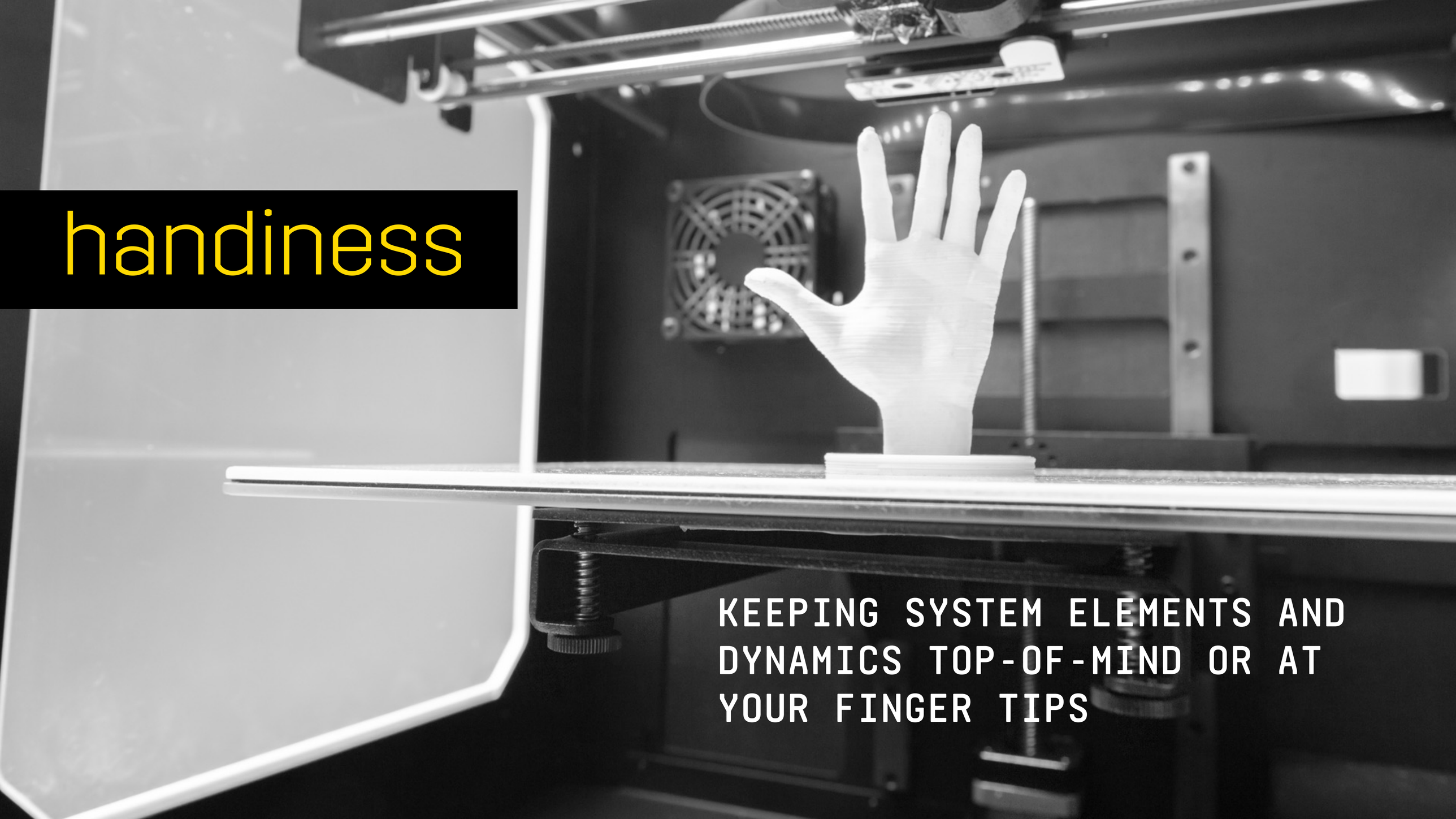


STOCK
Nector and pollen stored in honeycomb for later use



LOAD
Nector moved in bee stomach, pollen moved in hairy leg baskets

Foraging
Ratio of
Energy
Gained
Energy
Exper

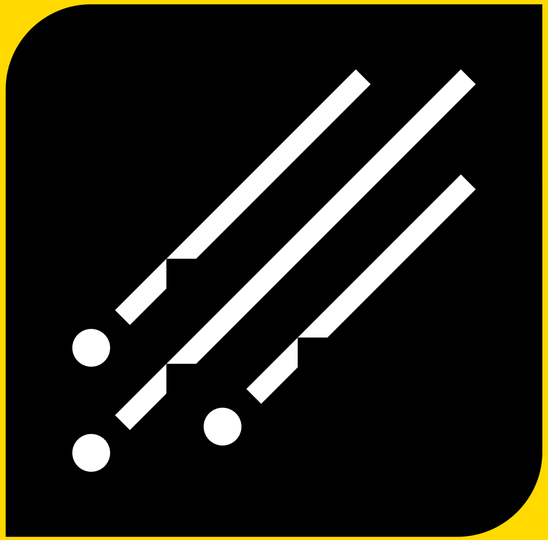


handiness

KEEPING SYSTEM ELEMENTS AND DYNAMICS TOP-OF-MIND OR AT YOUR FINGER TIPS

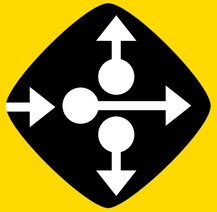
dialogue tools

subsets



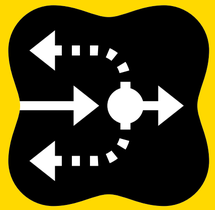
FALLOUT

UNANTICIPATED
AFTER-EFFECTS



SIDE EFFECT

DERIVATION

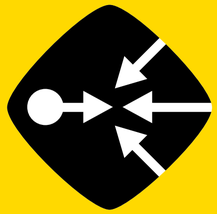


FEED-BACK

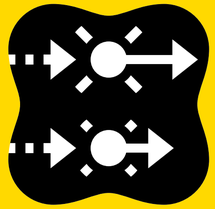
FAULT

(RE)APPROPRIATION

ENTRAINMENT



OPPOSER



REACTIVITY

COMPARTMENT

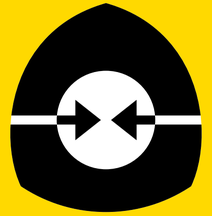
NETWORK

CASCADE

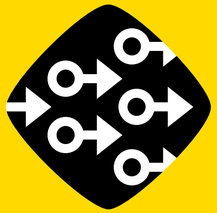
DISRUPTOR

ECHO

CONTAMINATION



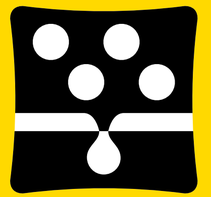
MEDIATION



DIFFUSION

TRAIL

TIPPING POINT



LEAKAGE

CROSS-DOMAIN RISK

strategic change

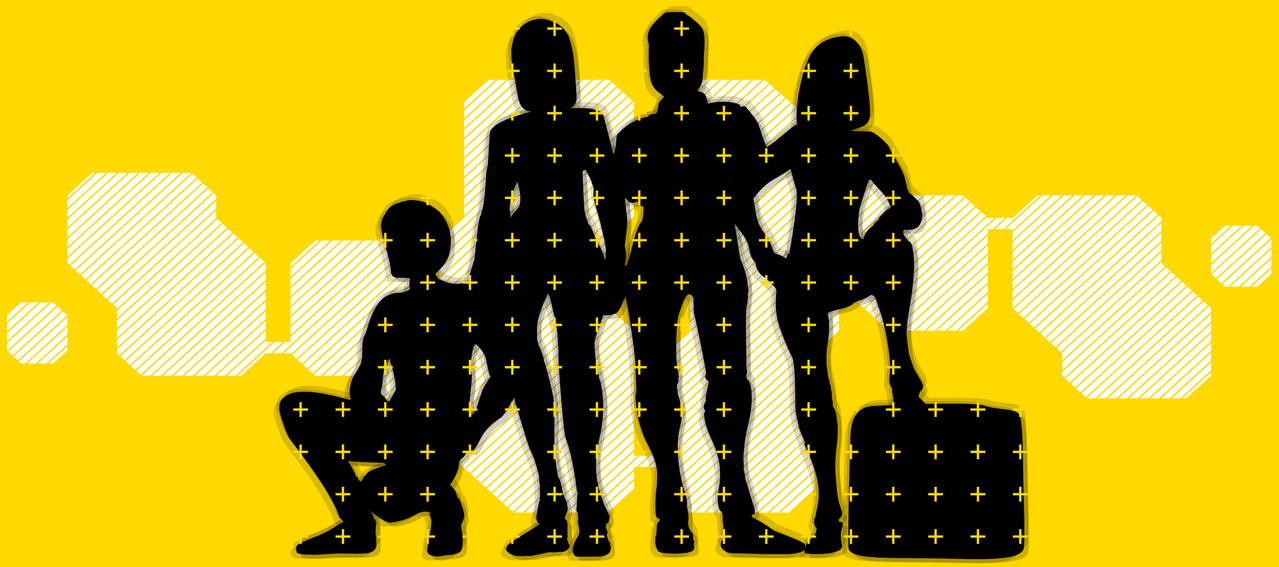
STRATAGEM

A MENTALITY OF “CUNNING INTELLIGENCE … COMBINING FLAIR, WISDOM, FORETHOUGHT, SUBTLETY OF MIND, DECEPTION, RESOURCE-FULNESS, VIGILANCE, AND OPPORTUNISM …”

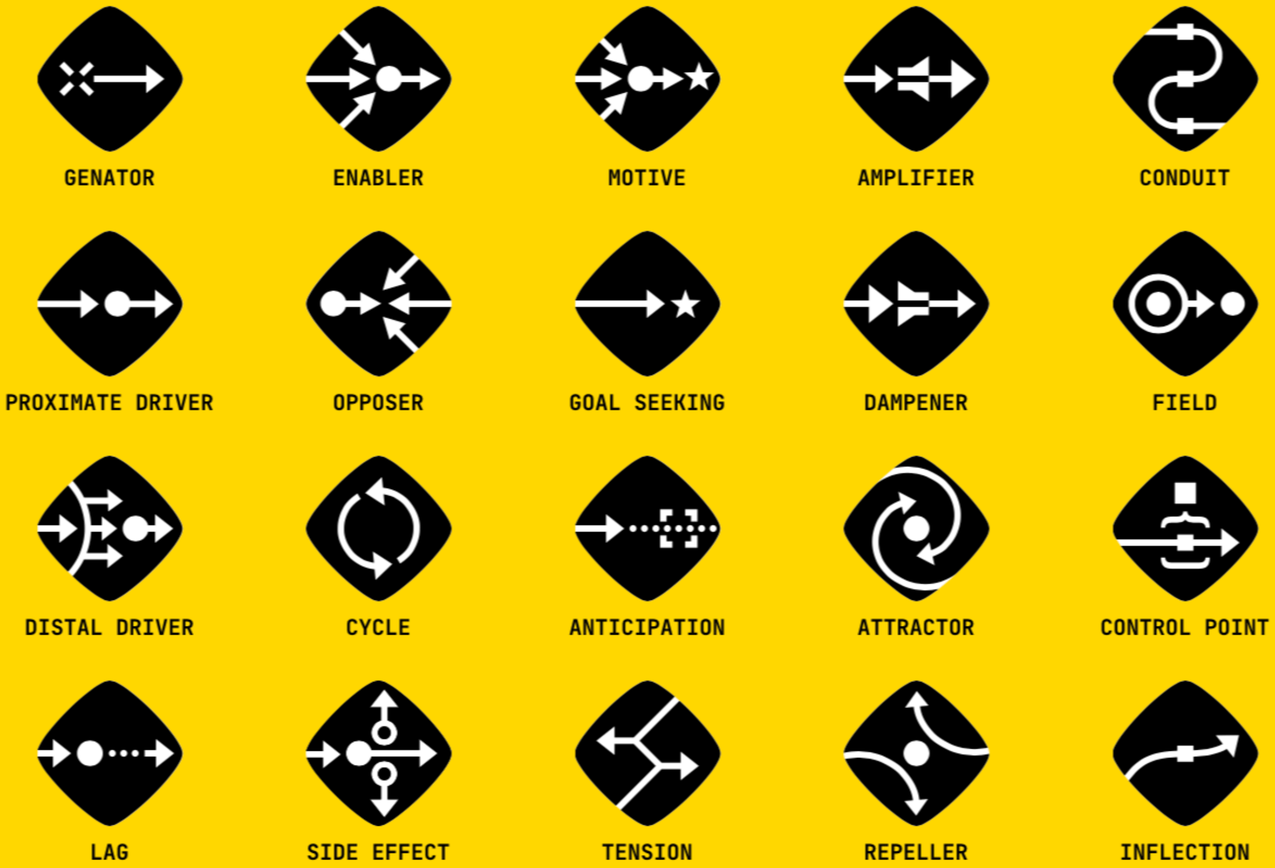
EVERETT WHEELER,
STRATAGEM AND THE VOCABULARY OF MILITARY TRICKERY (2008)

how SMALL players change BIG systems

SMALL MOVER STRATAGEMS

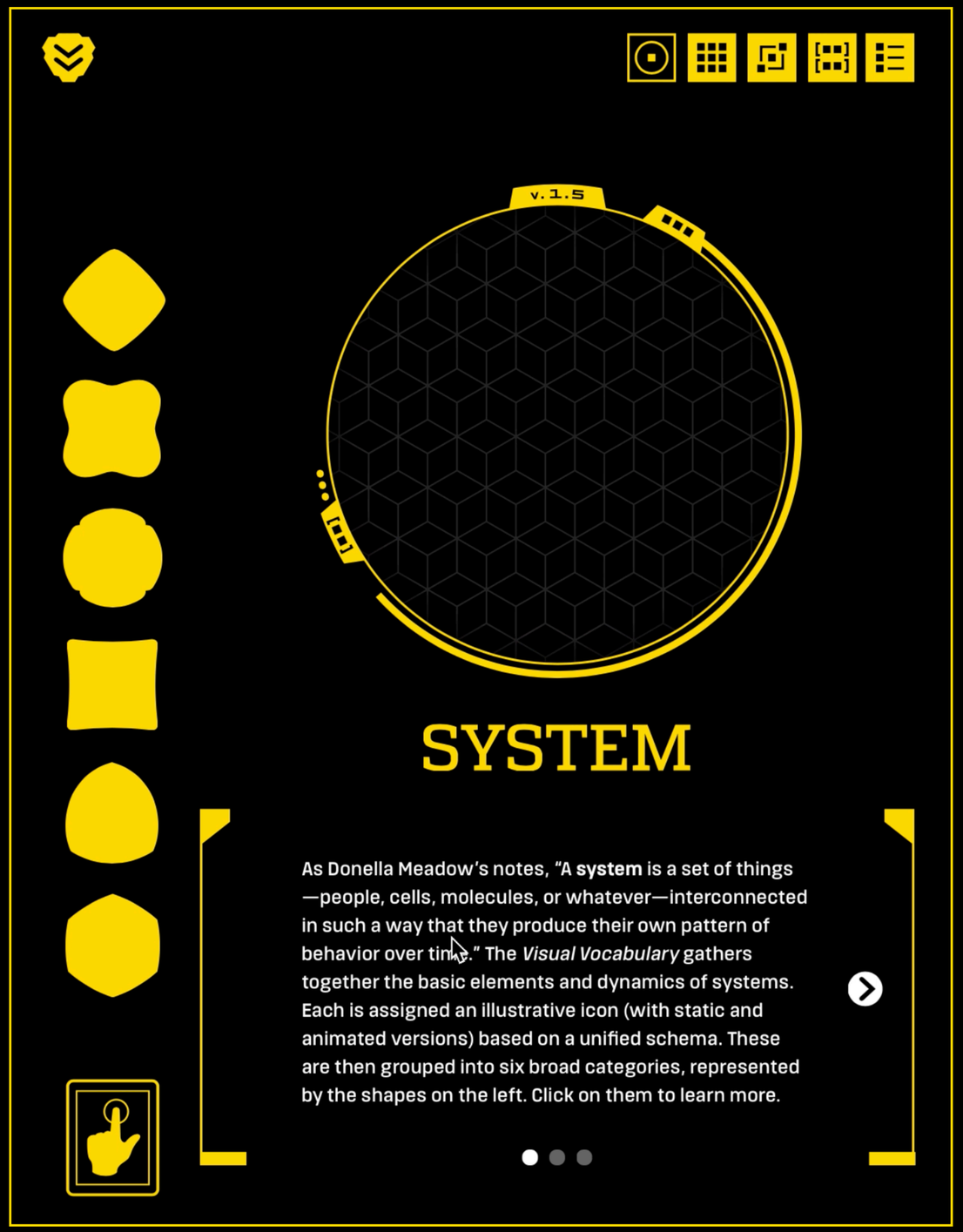


DRIVER



a-z

web app

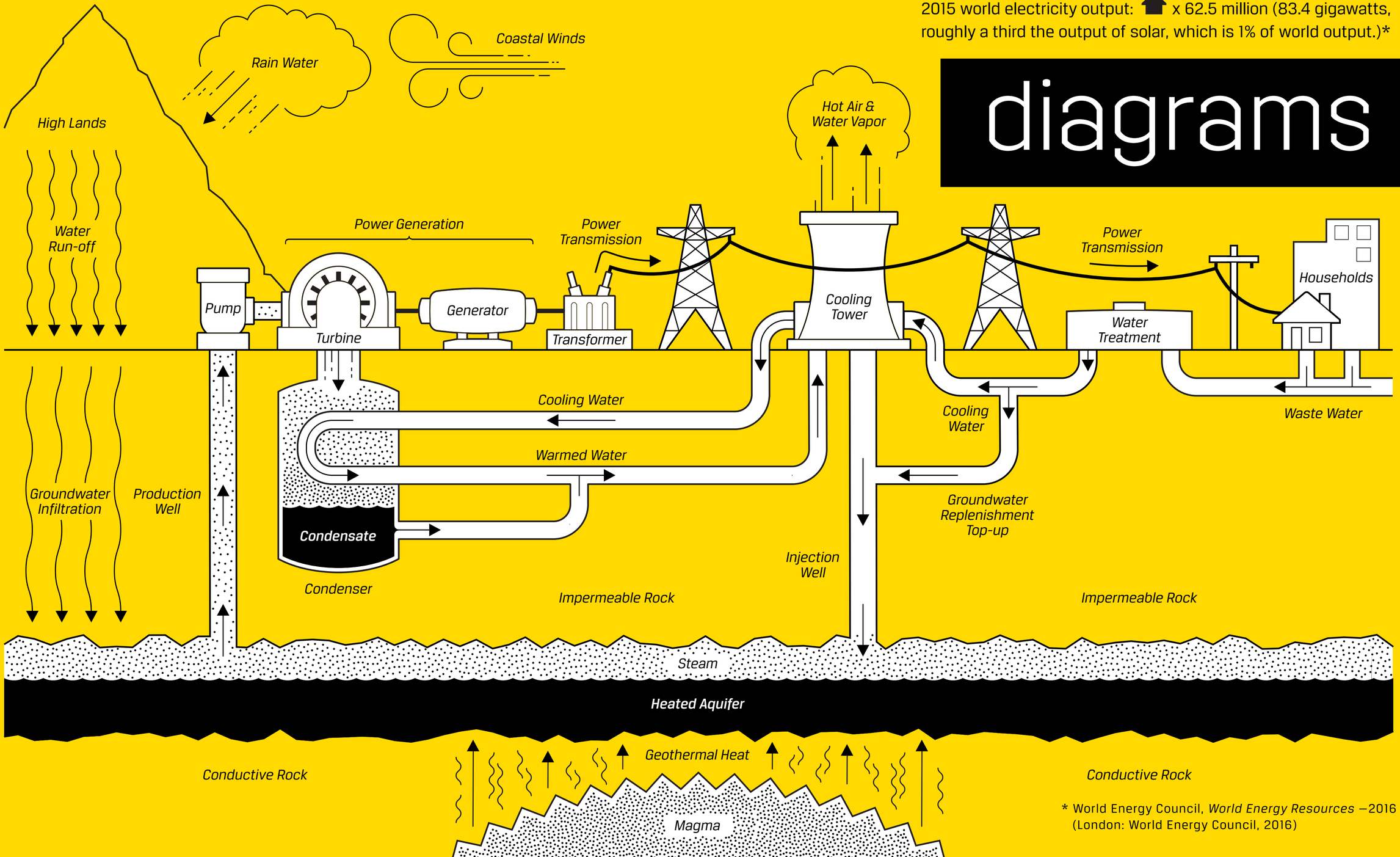

v.1.5
SYSTEM
As Donella Meadow's notes, "A **system** is a set of things —people, cells, molecules, or whatever—interconnected in such a way that they produce their own pattern of behavior over time." The *Visual Vocabulary* gathers together the basic elements and dynamics of systems. Each is assigned an illustrative icon (with static and animated versions) based on a unified schema. These are then grouped into six broad categories, represented by the shapes on the left. Click on them to learn more.

web app

small screen

2015 world electricity output: x 62.5 million (83.4 gigawatts, roughly a third the output of solar, which is 1% of world output.)*

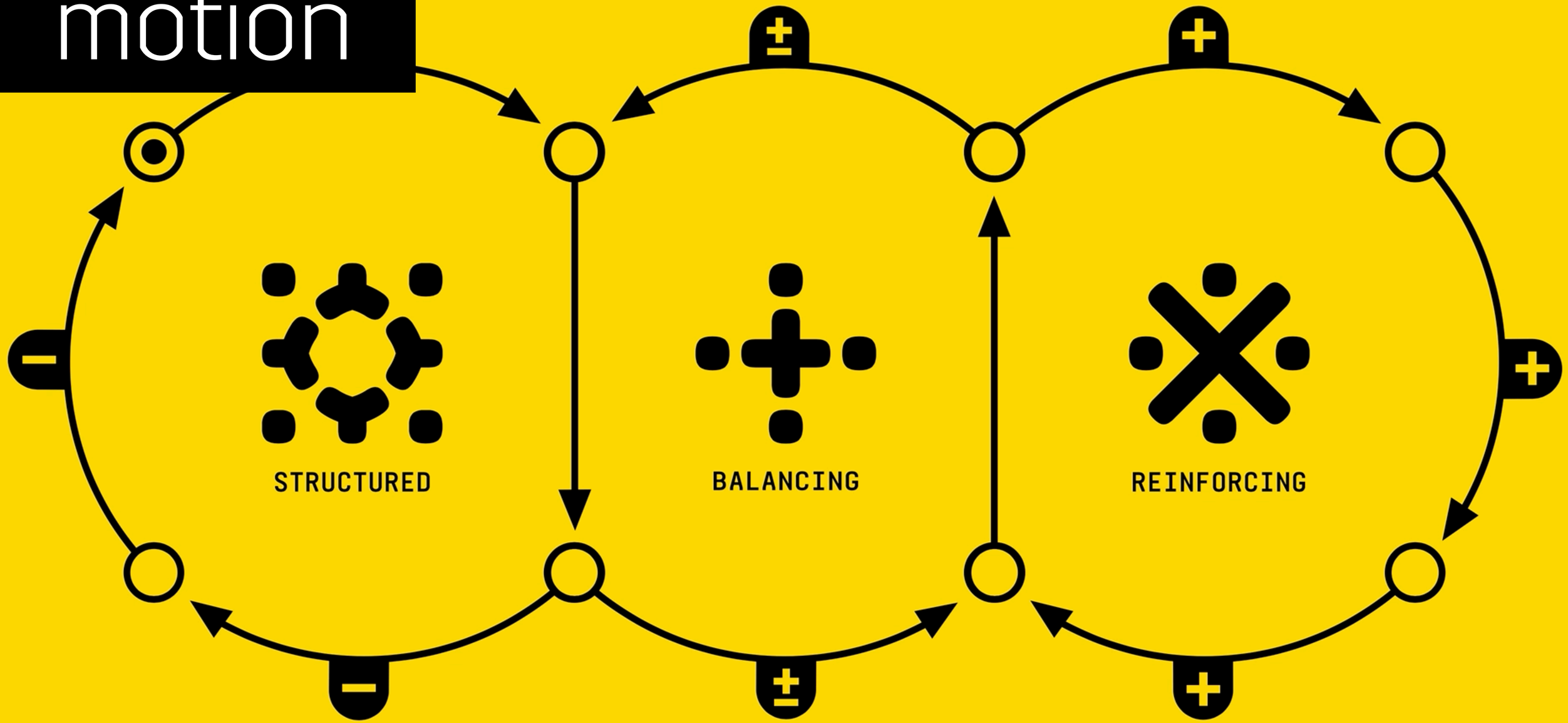
diagrams



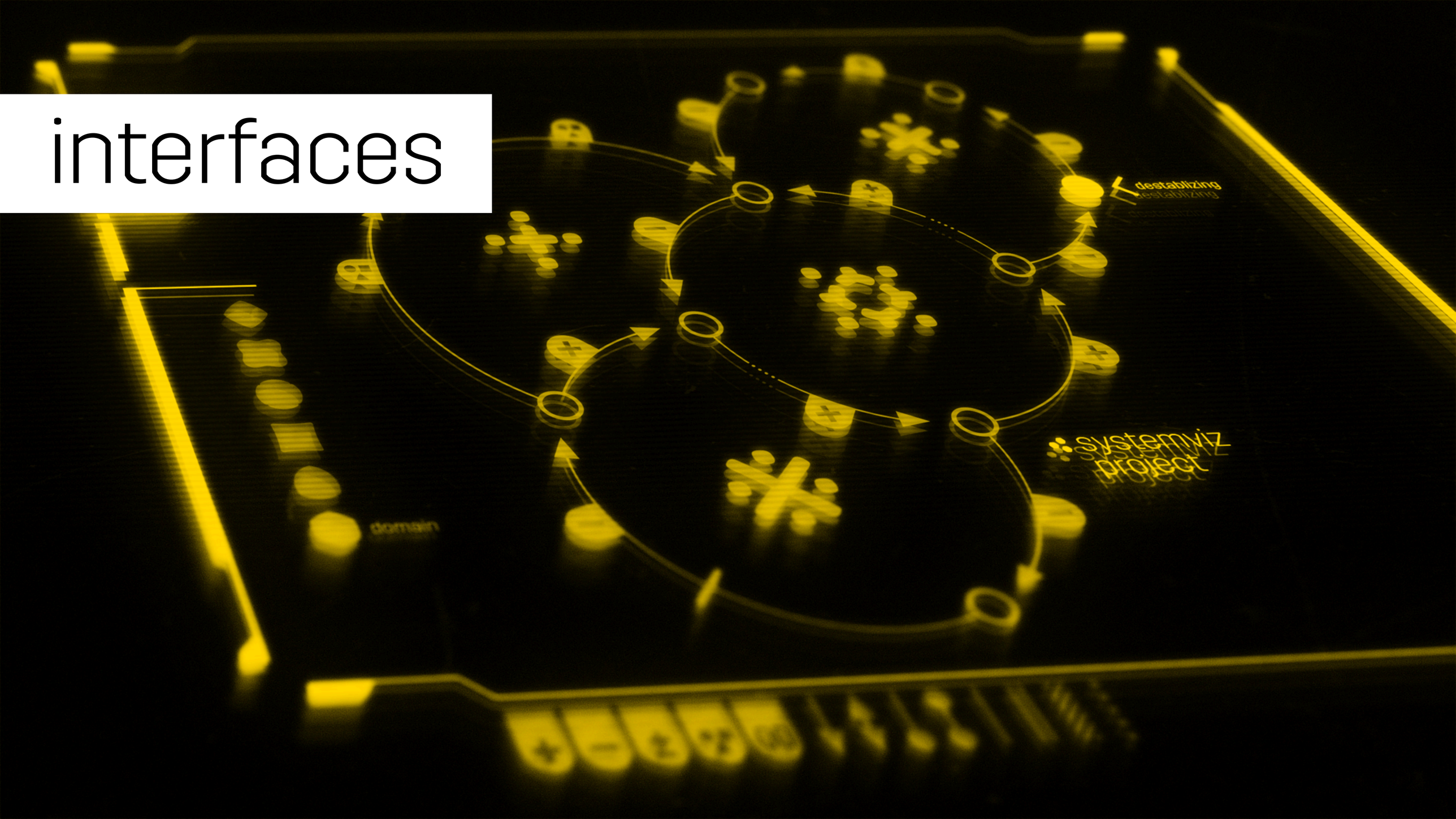
* World Energy Council, *World Energy Resources* —2016 (London: World Energy Council, 2016)


notations
Process
Ready
Flag
Submission
Expedited Submission
References Checked
Add More References
P2
P
A
Market
Soya
Soil
J1
J
Sort
A
B
X
Sort
Iteration
Participatory Research
Study Prepare
Client Needs Assessment
Product Specifications
B1
Integrative Learning
Stakeholder Mapping
Product Launch
Finalization
R3c
Testing
Tester Screening
Outreach

motion



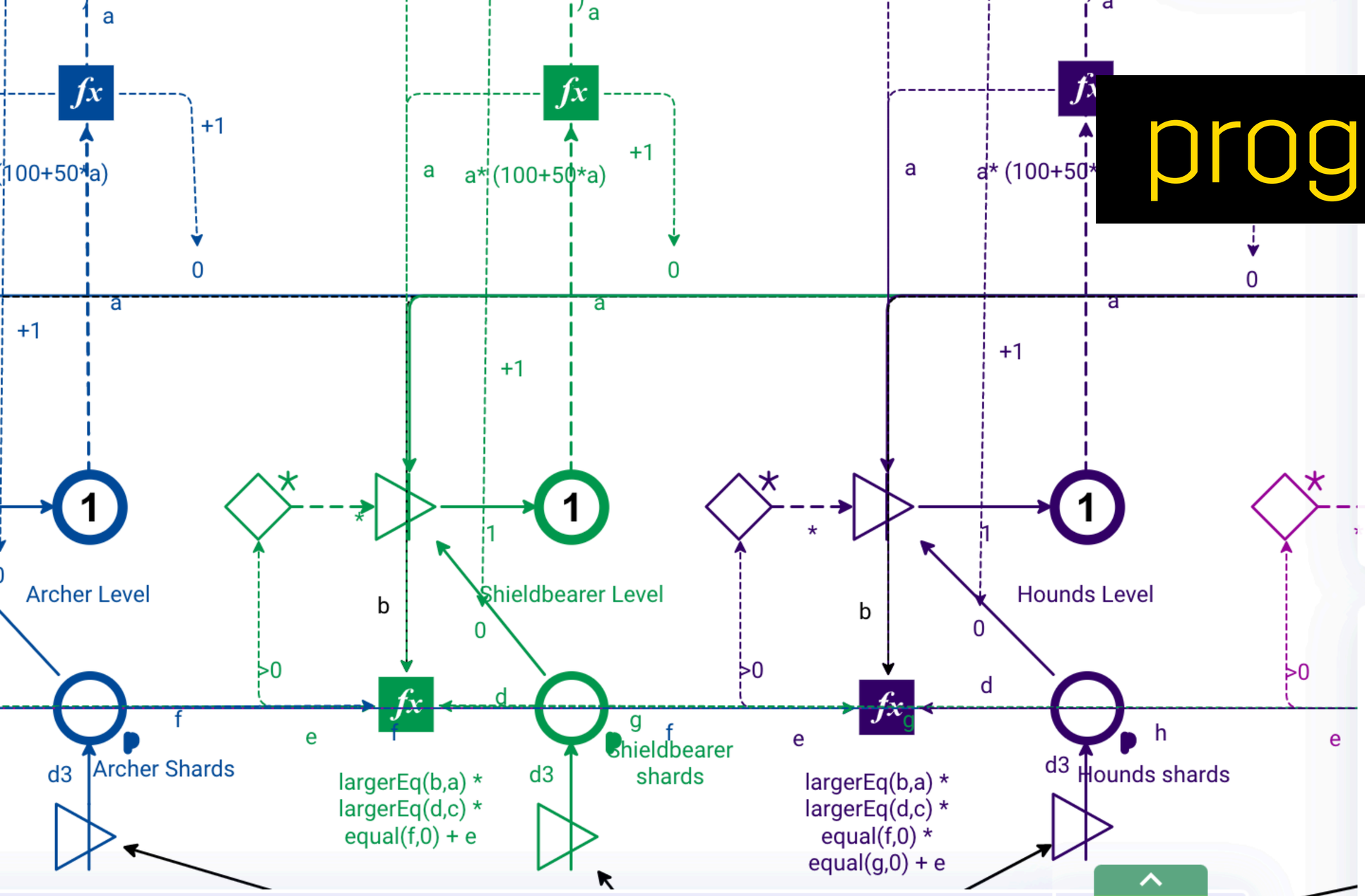
interfaces



visual vernaculars

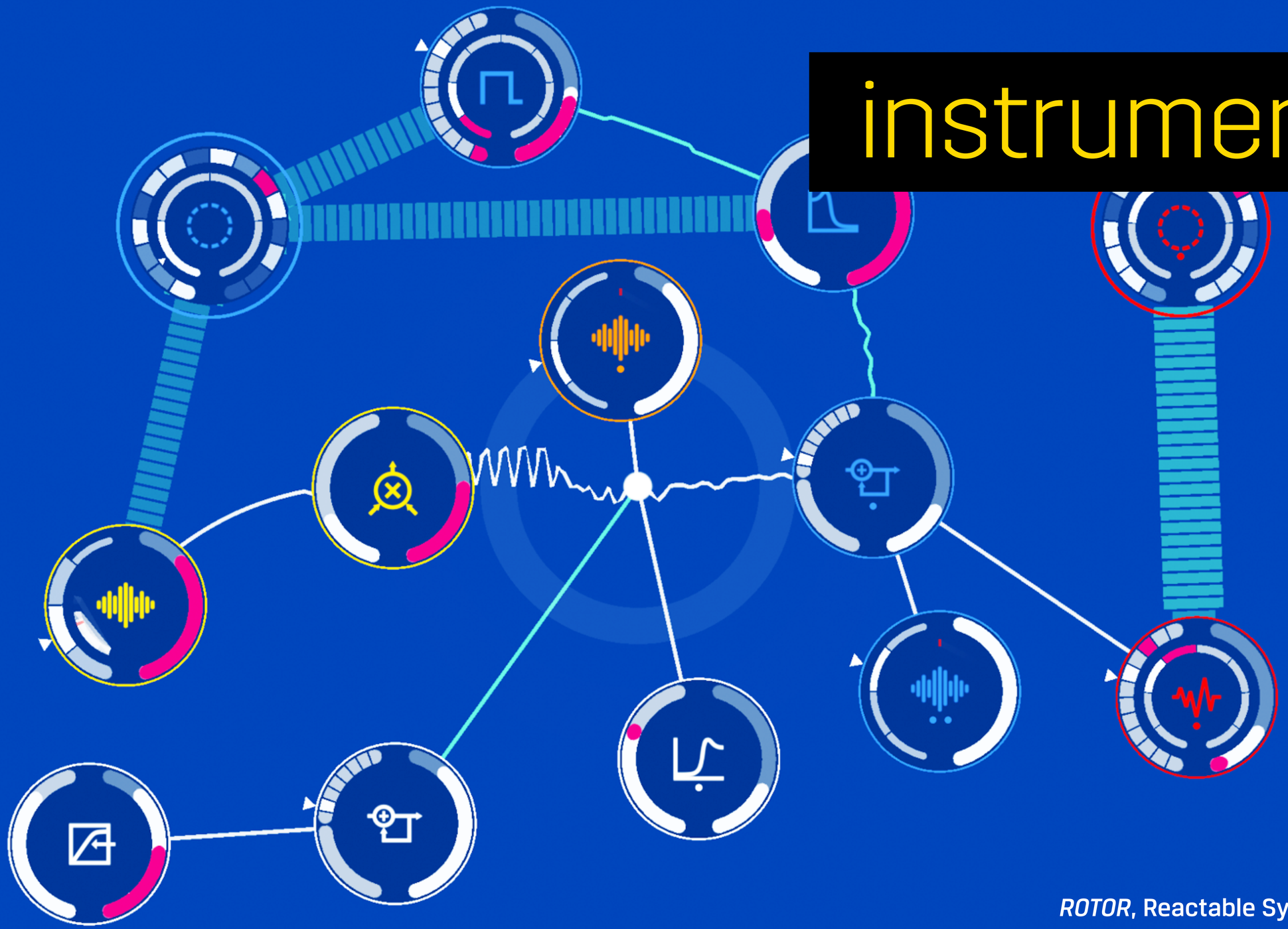
NEW GENERATIONS WILL EXPECT INTERACTIVE AND IMMERSIVE TOOLS FOR SENSE-MAKING

programming



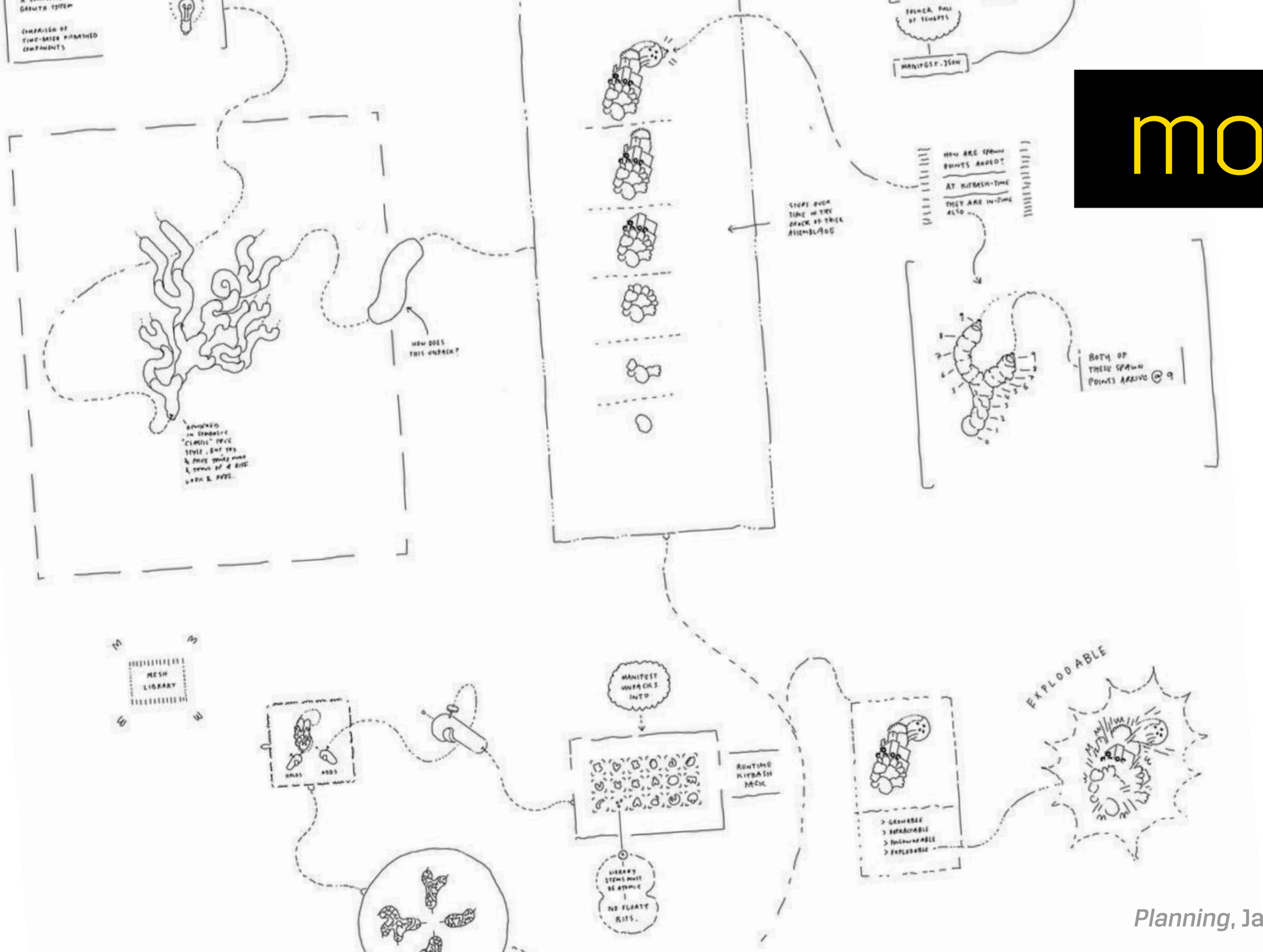
Machinations (software), 2014-present

instruments



ROTOR, Reactable Systems SL, 2017

motion art



Planning, James Paterson (Presstube), 2021

motion art

Sakkāya Ditthi, James Paterson (Presstube), 2021

Stress Botics, 2020, by Fernando Barbanoj

video games

Factorio, 2020, by Wube Software

live canvas

IMMERSIVE

INTERACTIVE

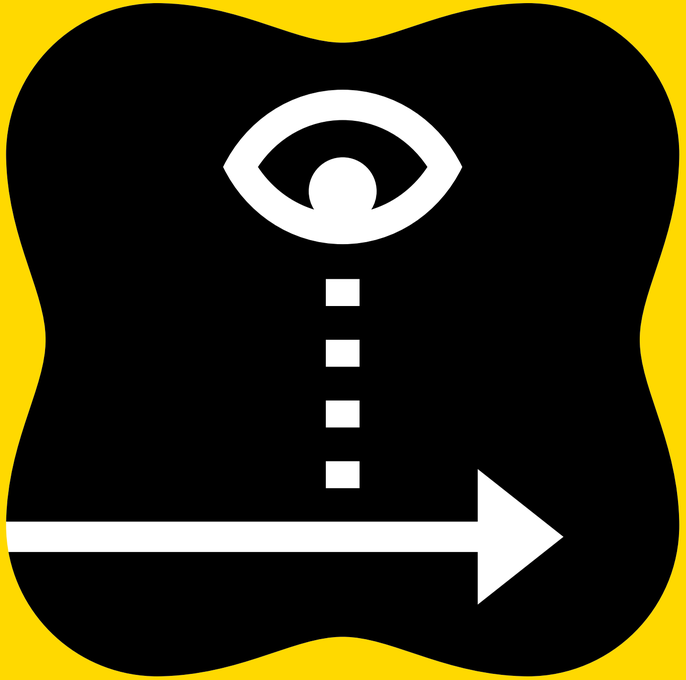
SPATIAL

INTUITIVE

EXTENDING

LIVELY

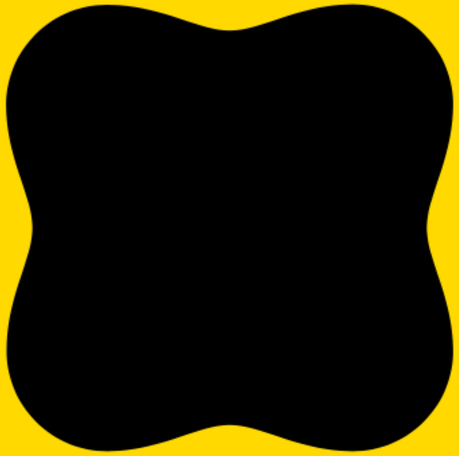
motion icons



MONITOR
STATIC

MONITOR
ANIMATED

ATTRACTOR



TRAIL

LEAKAGE

FRICTION