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Bowes, Jeremy and Jones, Peter

# Synthesis Maps: Systemic Design Pedagogy, Narrative, and Intervention

*Peter Jones and Jeremy Bowes, OCAD University, Toronto, Canada*

## Abstract

This paper presents a framework and process for a visual language that is developing as a systemic visual method, and to integrate and outline aspects of this synthetic map formulation as the "synthesis map" both with reference to contributing authors, but also as a comparison to design principles and the method of visual design language. In this way the technique's purpose as an emergent and creative tool - method can be illustrated, in contrast to the approaches of infographics, and other visual map making associated with design ideation, and design schema representation. Synthesis maps integrate evidence and expertise in a visual narrative for knowledge translation and communication.

## Keywords

GIGAmap, Synthesis map, Social systems, Systems thinking, Systemic design, Visualization

## Introduction

Design research and education have searched for more effective means of enabling multidisciplinary study and design teams to scan and frame, communicate proposals, and develop responses to the more complex challenges that design disciplines are called upon to address (Norman & Stappers, 2016). Norman makes the observation that designers must learn and collaborate with a range of diverse disciplines now necessary to formulate and develop the products, services and systems in a complex, increasingly instrumented society.

Today's highly integrated platforms and data-driven systems demand a wider range of design, research, facilitation and craft skills and knowledge. Systemic design, as most design disciplines, requires a range of design roles and typically multiple areas of expertise to effectively inform complex systems projects in service platforms, healthcare, large IT systems in sociotechnical systems, architecture, and urban design. While many design programs have advanced their skill development in graduate and emerging design disciplines, tools and methods for effective design and communication of systems and social policy arrangements have not kept pace. From a design research perspective, disciplines advancing in the corporate marketplace, such as service design, have nurtured the development of instruments for design and communication of complex artefacts. Systems design, policy innovation, integrated design and transition design have developed their contributions to theory, stakeholder engagement, and design frameworks significantly. There are fewer generally accepted methods toolkits – similar in application to the service blueprint or journey map – generally accepted in systems and systemic design. The GIGAmap (Sevaldson, 2009) and synthesis map are the two types of system maps being developed in the context of complex problem practice research. They have different processes and even intended uses which are helpful to articulate.

The general "systems map" might be considered a baseline artefact for articulating system-level design concepts and frames. However, vast differences of form, meaning, articulation and usage define the gap between systems theory-based maps and the visual models of systemic design.

This paper presents an initial framework and processes adopted by the Toronto-based Strategic Foresight and Innovation program for teaching and practicing system design mapping for complex social systems. Developed from the basis of Sevaldson's (2009) GIGAmaps, the OCAD University method differs in its alignment to systemic design theory (Jones, 2014) and its suitability for integrating evidence and multiple ontologies.

### Design Rationale

Historically in the disciplines of design, architecture, and urban planning, visual compositions of a systemic nature, and visual language has developed to illustrate and solve complex problems of a systemic nature. Mapping design methods have been developed from a myriad of visual design tools and representation frameworks for complex problem understanding, visual analysis, and solution finding.

Synthesis maps are formulated by mixed-discipline design teams as a constructivist approach to visual sensemaking for hypercomplex, or wicked problems. Synthesis maps are developed from a varying mix of primary research and literature evidence, yet are highly constructivist artefacts as the synthesis process develops narratives that re-interpret the relations and meanings of evidence within the system. The maps are products of synthesis, as they represent the choices made by multiple synthesis propositions and configurations that result in a visual integration of multiple representations and system formalisms. These representations are chosen by designers to facilitate sensemaking by the "content stakeholders" or decision participants of the problem space.

### Differentiation of Synthesis Maps

Synthesis mapping was developed over several years of studio education and formative process enhancement at OCAD University's Strategic Foresight and Innovation (SFI) graduate program. The SFI program adapted the GIGAmap process in its Systemic Design course over a two-year period of development and teaching, in collaboration with Oslo School of Architecture and Design. The authors co-teach the SFI Systemic Design course using a mixed-studio and seminar pedagogy. Unlike the AHO GIGAmap studio process, the SFI program does not have sponsored studios, and the system maps are developed for course-based problems. This constraint on the program, as well as the fairly short course period, limits the extent to which students can develop maps as a rich solution design space for constructive, real problems.

Following the AHO method as closely as feasible, given differences in purpose and pedagogy, the first two cohorts developed effective GIGAmaps for social systems design contexts such as urban transportation, citywide infectious disease management, urban-rural wild ecosystem management, and childhood obesity. The maps were constructed in six weeks' time by teams of (typically) four mixed-discipline graduate students self-selecting to project teams based on mutual interest in a selected "wicked problem" topic.

Subsequent cohorts (up to 10 more since) have been taught with an adapted methodology that takes into account the SFI program objectives, the one-term duration, and the fit to concurrent courses, that also demand intensive team projects. The synthesis map methodology has emerged from these constraints and requirements as much as it reflects a different methodology. For one, the SFI program promotes the integration of learning across disciplines for complex problems with societal benefit as well as an engaged learning process. To actively support student learning across courses, the Systemic Design course has been paired with the most suitable, synergistic other course in its current term. For most years of the program, this has eventuated in students maintaining consistent design teams between Systemic Design and the Innovation Research Methods course. For some cohorts, the paired course was the Strategic Foresight Studio. In the in the Research Methods course synthesis maps have been constructed to reveal social systems and dynamics reflecting primary field research often conducted in that course. As teams work from their own research evidence collected and analysed in the research course, their visual interpretations of similar findings in the synthesis maps accrue both internal coherence to a real-world situation and external validity perceived by stakeholders in the domains of interest. Because the maps are synthesized from design research and social science research, they are uniquely responsive to the field research context, yet developed within a continuous interactive studio process (both student team organized and guided by a series of tutorial and advising sessions with faculty).

The SFI program is inclusive of multiple disciplines in a 20-person cohort, and it's typical that each map team might have only a single classically-trained visual or industrial designer. The mix of business, social science, arts, and sciences within a design course enables a wide intersection of problems and interventions, which is further strengthened by a course that teaches a range of systems thinking mapping formalisms and systems theory in the first half of the term. These visual formalisms, discussed below, have become an essential bridge between the progressively-developed systems pedagogy and the visually-informed design practice. We believe that, for a first course in systems thinking that produces systems maps as outcomes, the synthesis map approach provides unique value of a map artefact that captures and represents the quality of team learning and the reasoning practices of systems thinking applied to complex social or policy contexts.


*Figure 1. Student team sketching early-stage system map.*

In this article we propose that the synthesis map differs significantly enough from the GIGAmap, even if by process more than artefact, to warrant a supported explanation. While similar map types are developed by studio practices using both methods, key process distinctions might be summarized as follows in Table 1.

*Table 1. Criteria describing GIGAmaps and Synthesis Maps*

| CRITERIA / Model | GIGAMap | Synthesis Map |
|---|---|---|
| **Size and scale** | Large maps, multiscaled, macro-micro | Large, can be multiscaled. Well-bounded. |
| **Visual models** | Highly varied, often architectural, 3D Often used to create design languages | Typically 2D, clear frame, often grid-based Can be visually simplistic, if narrative-led |
| **Theoretical models** | Not strongly theoretical, More process | Systems models explicitly structure narratives |
| **Approach to Evidence** | Directly relevant to a design problem | Often developed from research evidence without extensive stakeholders or solution space |
| **Approach to Narrative** | Separates process and communication. Can be used only in design thinking. | Often strongly narrative-based. Narratives selected early in mapping process. |
| **Stakeholder Role** | Often stakeholder led in studio / research | Stakeholders often discovered after research and mapping, allowing for post-interaction |

## Systems Theory Visual Models

Systems theory and systems engineering have developed a number of well-known visual modelling formalisms typically used for distinct functional representation. Visual formalisms also convey their epistemological frames in the constraint and expressive power of the chosen modality. We have seen a number of visual tools developed to illustrate and aid in the understanding of complex systems, most of which have emerged from the domain of systems thinking. Visual formal models have been developed as methodologies for systems analysis and/or problem structuring. Following Jackson's (2007) typology, most visual formalisms have represented methods from both hard systems (system dynamics) and soft systems (e.g., Checkland, 1981). Hard systems models such as causal loop diagrams for systems dynamics, require reductionist approaches that restrict variables and follow well-defined rules. Soft systems methods draw from an interpretive epistemology that recognizes that a common understanding of a problem area is enabled by an integrated multimethodology (Midgely, et al, 2013) and an explicit motive of learning and action planning. Soft systems methods encourage flexible, organic representations that facilitate problem understanding and structuring. Hard systems methods are generally utilized as technical modelling techniques for analysis and system representation.

Systems thinking and theory has not led the design of novel visual sensemaking methods. Few, if any system *design* models have emerged from systems sciences or systems thinking, including the schools of critical systems or even complexity theory. Cyclic and nested models that abstract natural systems processes have been defined as ecological system models. These include the panarchy adaptive cycle (Gunderson & Holling, 2002), Bronfenbrenner's (1979) socioecological system, and others.

Other commonly used formalisms or design models include infographics (Horn, 1998), concept maps (Novak and Canas, 2007), process flow diagrams, journey maps, and other design artefacts drawn from information design, information architecture, graphic design, service design, architecture and planning disciplines.

### Hard System Visual Formalisms

What we refer to as hard systems models include the causal loop diagrams (Braun, 2002, Senge, 1997), stock and flow (Meadows & Wright, 2008), systemigrams (Blair, Boardman & Sauser, 2007), and structural/influence maps (Warfield & Staley, 1996). The hard system models often function as standalone analytical representations that define a systemic pattern referenced in a larger study. These formalisms are often included within synthesis maps as discrete models that describe subsystem or archetypal behaviours within an entailed bounded social system.

A significant difference between hard system models and the soft systems school is that hard systems develop a model of causality developed from analysis of current system dynamics. The purpose of system archetypes (Braun, 2002) is to identify and capture recurrent patterns commonly found in social systems and organizations that are defined as causal, reinforcing and balancing loops.

In synthesis maps such models are often incorporated into larger syntheses of multiple processes within a much more encompassing system boundary. The causal loop or systemigram becomes an inset, and serves as a micro-model representing a current function, (often a dysfunction), within social systems narrated by a soft system or idealized approach. The following figure shows the "Shifting the Burden" archetype whereby the longer term, difficult goal of balancing healthcare costs within an institutional budget by creating population care networks is offset by shifting the burden to a short term solution (increasing volume of chargeable tests and procedures) that addresses short term costs but shifts the ultimate costs to the long-term, exacerbating the original problem.

Other hard system or process models are used within synthesis maps for narrative construction and discursive purposes. The intention of adopting mixed methods is twofold: 1) to identify and portray discovered patterns within the complex dynamics of a social system and 2) to convey the sense of complexity in the "actual" social system by increasing illustration density while not sacrificing readability.

The case study presented in this article shows the use of causal loops and process diagrams within a large synthesis map, specifically to convey relationships where interventions might be located in a complex system.

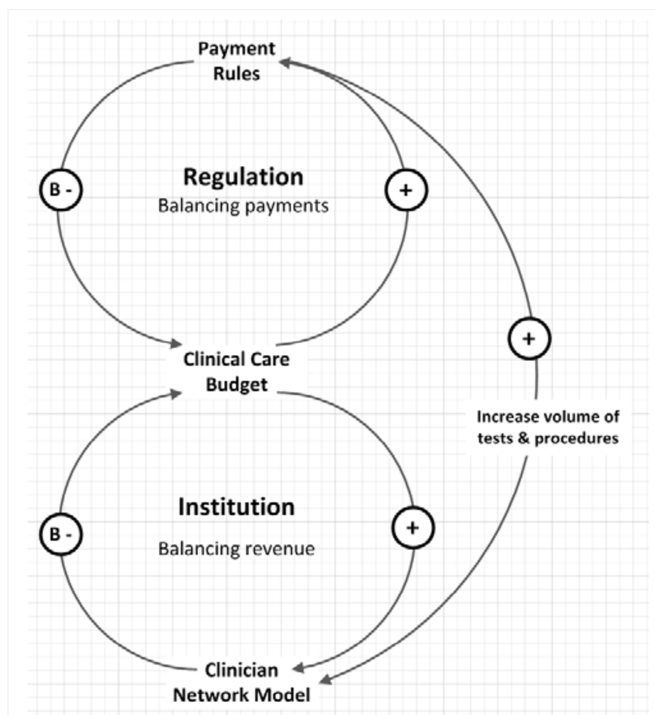


*Figure 3. Shifting the Burden Archetype.*

### The Soft System Rich Picture

The other school of systemic reasoning, soft systems, recommends more interpretive and figurative models. The best known representative approach is Checkland's Soft System Methodology (SSM), known for the rich picture (Checkland, 1981, Checkland and Poulter, 2010).

The classical rich picture approach sketches a visual model of the system as a parallel to the real world situation "as depicted" and is intentionally meant to be a provisional model, subject to change in iterative interactions. The Checkland rich picture presents an idealized model of the preferred system as a way to construct interventions and compare, in a single image, with the real world system as perceived. A typical intention described by the rich picture is to facilitate an ongoing learning context as a continuing process for discovery, through the creation of a common language with stakeholders, in text, image and relationship. The synthesis map adopts this process explicitly in its iterative studio development and engagement with system stakeholders.

Synthesis maps significantly extend the rich picture. The conventional SSM model develops a hand-sketched articulation of relationships between a depiction of system behaviours in the world, the actors and worldviews participating in the system, and an abstracted system model that references the real world and indicates its boundaries and behaviour trajectory. Ascribed meanings drawn from the system interpretation are visually depicted by symbolism, metaphor, and representation of site, context, structure, function, processes, and narrative - often creatively juxtaposed or integrated as a creative documentation. The issues, meaning and directions of a complex problem are referenced in referential sketches and visuals to illustrate elements, relationships, and influential dynamic properties. This promotes ideation, and facilitates a complex problem systemic view-point. It is this integrative design process and language that can be integrated into a systemic visual method that builds on successive interpretation and juxtaposition of salient system elements.

### Developing a Systemic Narrative

From antiquity to the present, and with an exponential rate of expansiveness, humans have been obsessed with systematically collecting and reorganizing what in effect already exists, in its own kind of order, or disorder. This desire for control and centralisation of our environment, has no doubt aided us in the past and present. Nevertheless, many believe our institutionalized systems have reached such epidemic proportions that, not only has the digital revolution not been able to solve systemic problems, but it has clearly aggravated it with a combinatorial explosion of fragmented information. All of these systems, the digital notwithstanding, occupy an increasingly huge amount of space and pull resources from the world.

A systemic viewpoint is a foundation for many of the complex problems which our students pursue. The basic actions of any synthesis mapping include defining system boundaries and unpacking system elements and subsystems, following a basic analysis of system processes, structures, functions and goals. To understand the complexity of a problem system, we highlight causal and influencing relations in early system sketches, and define stakeholders and their organizations and networks within the system. This approach is supported by Gharajedaghi's (2011) iterative systemic analysis, employed in the OCADU course. This information allows the construction of initial maps which highlight elements, and subsystem relations, and provide insight into systemic behaviour. The iterative inquiry typically defines the initial system levels and boundaries, and student teams identify the system level for definition from these multiple levels or perspectives, Before initiating the synthesis map, this systems analysis process of multiple mapping methods is extended with causal loops and archetypes, stock and flow diagrams, systemigrams and other systemic visual formalisms.

## The Synthesis Map

The synthesis map approach encourages the selection of visual formalisms appropriate to the scale and function of the problem system, a process that becomes iterative through seminar, teaching, studio application, and in the critiquing process.

The synthesis map becomes an integration of much of the findings from various unpacking, map-making and analysis processes. As a product of the process it integrates the information, findings, and key issues related to the complex system, with a contextual narrative as a synthesis of the issues and information, presented as a design problem. This method of sensemaking provides a way of visualizing the systemic story, and explores the possibilities for design intervention and change -making, with a focus on key change drivers in the solution space.

The synthesis map, like Sevaldson's GIGAmap is an artefact that attempts to document and organize a picture of the complex problem. In the synthesis map the systemic portrayal of system behaviours, and systemic relations tends to be more highlighted. The applied interpretative analysis generates a combination of focal and figural elements providing a narrative picture of the systemic design problem. Because these maps are quite often utilized in the context of strategic foresight and innovation projects, the synthesis maps quite often include a view to future scenarios, and horizons of possible change and outcomes. The final format of the completed map is a visual narrative with organized and synthesized information about the subject domain, supported by primary and interpreted research, statistics, facts, archival information and represented ~~by~~ visual metaphors.

## Principles and Framework

Synthesis maps are used instead of other modes of system mapping in order to describe a complex social system sufficient to the complexity of the domain of interest. We adapt the principle of requisite variety where the problem representation in the map must correspond (if not "control") to the complexity in the socio-cultural system as understood by stakeholders. In course pedagogy we embrace the wicked problem as a context for definition and sufficient complexity. These principles help separate the synthesis map as a genre from infographics or structured and simplified systems maps, where the intent is for narrative readability and clarity of definition. The aim of the synthesis approach is to be both as visually complex as the domain it represents, and as understandable as possible to intended audiences, which are often stakeholders not involved in the mapping process.

Multiple purposes can be embraced by a mapping project. Communication of the social system problem area as researched and understood is a starting point. Another purpose is to be able to effectively identify cycles and process in social systems that might represent productive areas for intervention or for system and service design. Course-based synthesis maps do not usually venture into system redesign as these are typically created without the benefit of extensive system stakeholders on the team. The necessity of stakeholder inclusion becomes clarified when student projects attempt to propose intervention and design changes without their access to the team. Course projects typically describe first steps toward future redesign proposals based on principles and analysis, and where possible, on a deep understanding of the problem domain.

## Synthesis Map Technique

Through reflective studio and teaching practice as well as sponsored research, we have developed a distinctive process with preferred techniques for rapid team construction of synthesis maps. What follows is an outline of aspects of this synthetic map formulation, highlighting the approaches, process, and elements through application examples.

### Techniques within the Basic Method

Studio practices emphasize a number of different activities that can be proposed as starting points in the synthesis map process. The following techniques are in relative order of their significance to the reasoning and early production of iterative system mapping for synthesis map construction.

1. Synthesis maps are often initiated as projects based on a wicked problem of topic of authentic concern to the group that proceeds, with or without access to stakeholders. In studios, teams conduct and aggregate appropriate research, perform analysis and summarize knowledge. This is often based on the evidence from stakeholder analysis. Iterations of stakeholder analysis of primary (direct), indirect, institutional, and social (community) stakeholders are conducted to identify the social actors in the social system.
2. In coursework we often link the synthesis map project to another, research-based course that affords access to stakeholders and participants for interviews, observations, experts, and rigorous inquiry into the problem domain. A research question or problem statement might drive the mapping process in this case. This helps define the project scope and system boundaries of the social system or service.
3. There follows an iterative unpacking of bundled subsystems and relationships. Maps often develop a configuration of the functions, structures and processes within a defined system boundary. Clarification of the system purpose and contexts is typically formed as an emergent process in successive mapping iterations. The system boundary is interrogated in studio based discussions to identify the best framing for continuing with system mapping.
4. Preferred system mapping formalisms are often introduced to construct system behaviors and "proposals" for problematics and regularities in a social system. Systemigrams, causal loop diagrams, influence maps, rich picture, iterative inquiry, process flows, panarchy, ecological system maps and others are employed to represent appropriate system relationships.
5. At the same time, teams are encouraged to organically explore and visually represent the salient and theoretically significant aspects of a social system. Stakeholder tables, organizational breakdowns, architectural maps, structural and process views are composed to represent wholes and parts in relation to each other.
6. An abductive process of representation, reasoning, testing, and re-representation is promoted. Students are not always able to gain access to appropriate experts or the field to assess their hypotheses and employ a visual reasoning and simulation process to evaluate the fit of concepts and system proposals.
7. Complete map visualization is typically done close to the point of version completion. Visual metaphors are sketched and considered for bringing the map to life. Narrative proposals are tested against the map and gaps are identified from the narrative or process flows.
8. Many synthesis maps are formed with definitive timelines or temporal models over long horizons. The long horizon maps generally integrate foresight models into the system framework. Three Horizons (Curry and Hodgson, 2008), roadmaps and outcome maps are often used to elaborate anticipatory models into the system view.
9. While some synthesis maps identify interventions early in the cycle of design, most teams complete a significant version of the map, reaching a point of shared understanding and a narrative before defining options for systemic design intervention and change proposals.

## Course-Based Map Case

An exemplary synthesis map representing the process and product of the OCADU course is presented in Figure 4, the Biomimetic Economy map developed by a student team, a futures-based system model subsequently presented at RSD4 (Church, Benifand & Ahmed, 2014).

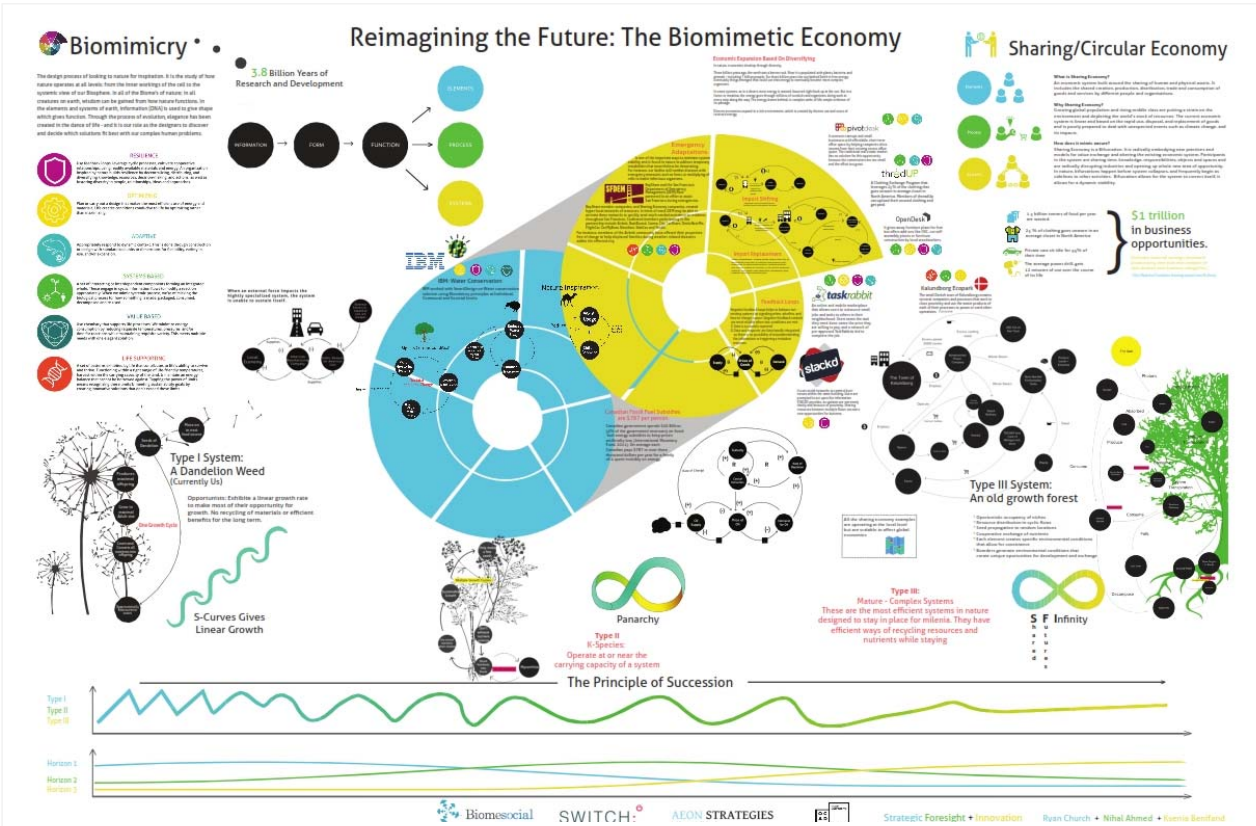


*Figure 4. The Biomimetic Economy*. With permission from Church, Benifand & Ahmed (2014),

The proceedings paper supporting the poster presentation describes the large map and discusses the functions of human economies relevant to and drawing from three natural system ecological regimes. The left of the map presents a kind of legend of the six design principles for biomimicry relevant to economic functions – resilience, optimizing, adaptive, systemic, value-based, and life-supporting. The bottom of the map presets a long-horizon timeline, a typical organizing feature in synthesis and GIGAmaps, here representing the relative period of centuries extending over a Three Horizons model of three economic modes, based on the principles of ecological succession:

- Type I system (Current, Horizon 1), rapid growth cycles to capital exhaustion, represented as S-curves, an unsustainable linear growth model.
- Type II system (Horizon 2), operating near the carrying capacity of the economy, represented as a panarchy cycle of growth that expands to an asymptote, retracts and reorganizes.
- Type III system, (Horizon 3), characterized by a proposed complex continuous cycle sustained without capital growth, similar to an old growth forest ecosystem.

Multiple embedded causal loops narrate the dynamics of each system and their transitions. The central cyclic image represents the emergence of a circular economy, using Jane Jacobs' (2000) model, transitioning from growth enterprises (e.g. IBM) to the "emergency adaptations" of emerging sharing economy firms, and then (proposed) as shifting to true circular economic models.

## Synthesis Map Case Study – Cancer Research

In a recently published medical journal article (Jones, Shakdher, Singh, 2017) we reported an OCAD University collaboration with a multi-year CIHR study, CanIMPACT. Based on qualitative, administrative data, physician and patient interviews and cancer statistics, CanIMPACT was a first-ever study of the efficacy and improvement opportunities for the Canadian cancer treatment system, with a special focus on primary care. Two synthesis maps were developed. The clinical system map (Figure 4), Cancer Care Pathways in Canadian Healthcare, was a large-scale process and system map of the clinical systems of care across Canada designed to communicate the findings from the CanIMPACT study. A second synthesis map -

The Clinical Map (Figure 4) visually represents breast and colorectal cancer processes across Canadian provincial and territorial systems. A roadmap metaphor illustrates a system-wide view of patient flow across the stages of cancer care. Green “road signs” identify clinical cancer stages across the roadmap: Pre-Diagnosis, Peri-Diagnosis, Diagnostic Interval, Diagnosis, Treatment, Rehabilitation, After Care, and Survivorship (with Palliative Care expressed as an end point). The visual metaphor of seasonal trees visually connects these stages to the patient’s cancer journey from pre-diagnosis (summer) through treatment (winter), followed by new growth (spring) in survivorship.

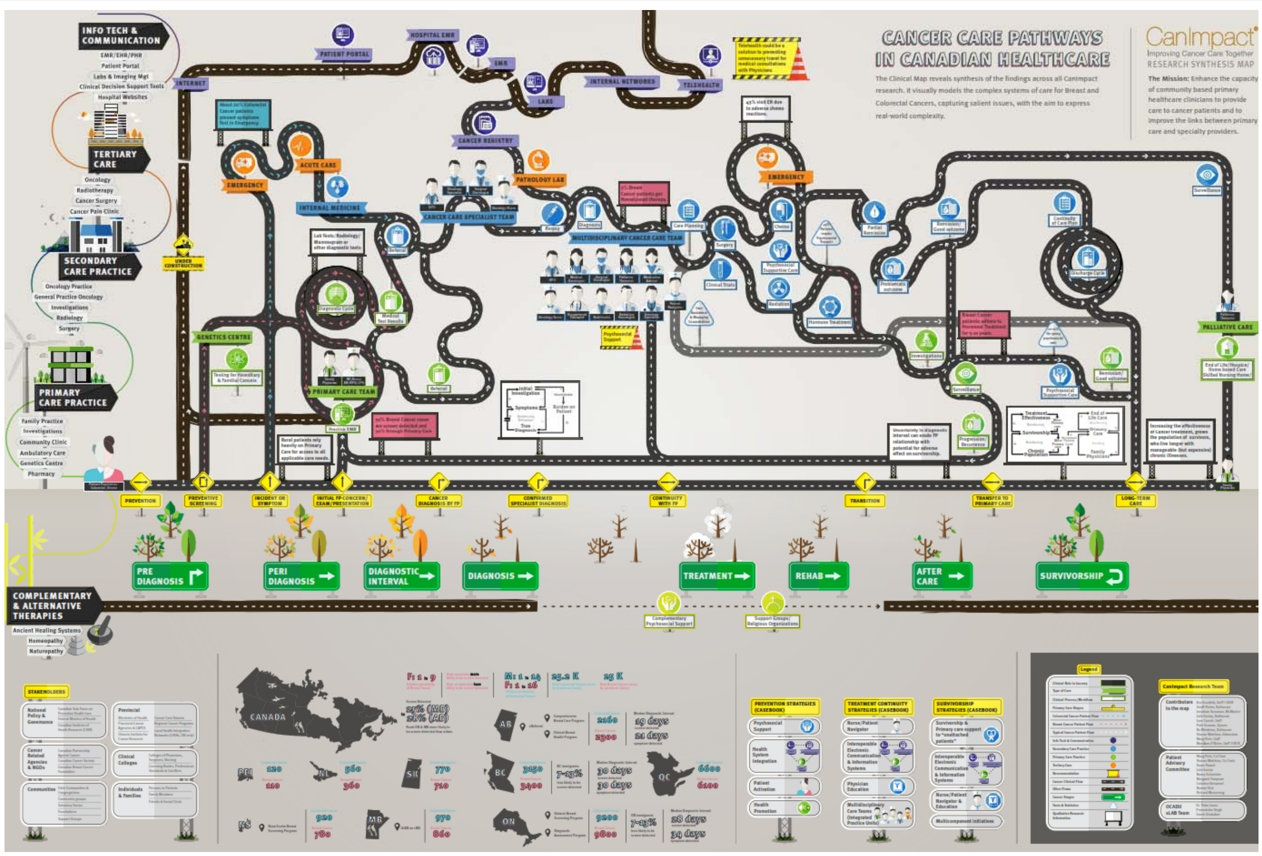


*Figure 5. CanIMPACT Clinical Synthesis Map. © 2016 OCADU Strategic Innovation Lab.*

The levels of primary, secondary and tertiary care guide the vertical dimension. Information and communications technology reaches across levels and stages, but is shown disconnected from primary care. The road-like pathways are colour-coded where experts differentiated care pathways between breast cancer (pink) and colorectal (blue). Where not distinguished (white), the pathways indicate current practices shared across the cancer journeys.

Yellow navigation signs indicate cancer events across primary care pathways. Starting with Prevention and ending with Long-term Care, these events show points for primary care continuity during cancer treatment. A parallel path below the stages indicates where some patients may also employ complementary or alternative therapies.

Significant areas of complexity generalized across cancer care are revealed in peri-diagnosis and the diagnostic interval pathways. A patient can be screen-detected (and then present to a family physician, shown in the breast cancer pathway) or may be initially diagnosed in primary care (white pathway). The circular pathways in the diagnostic cycle suggest multiple possible tests within primary care. With a primary care diagnosis, patients are referred and flow to secondary/tertiary cancer care. The stages of intake, biopsy, pathology, and confirmed diagnosis are shown, and the complex pathways of cancer treatment, shown on the map in a typical (not definitive) order of surgery, radiation/chemotherapy, and continuing treatment through assessment of outcome.

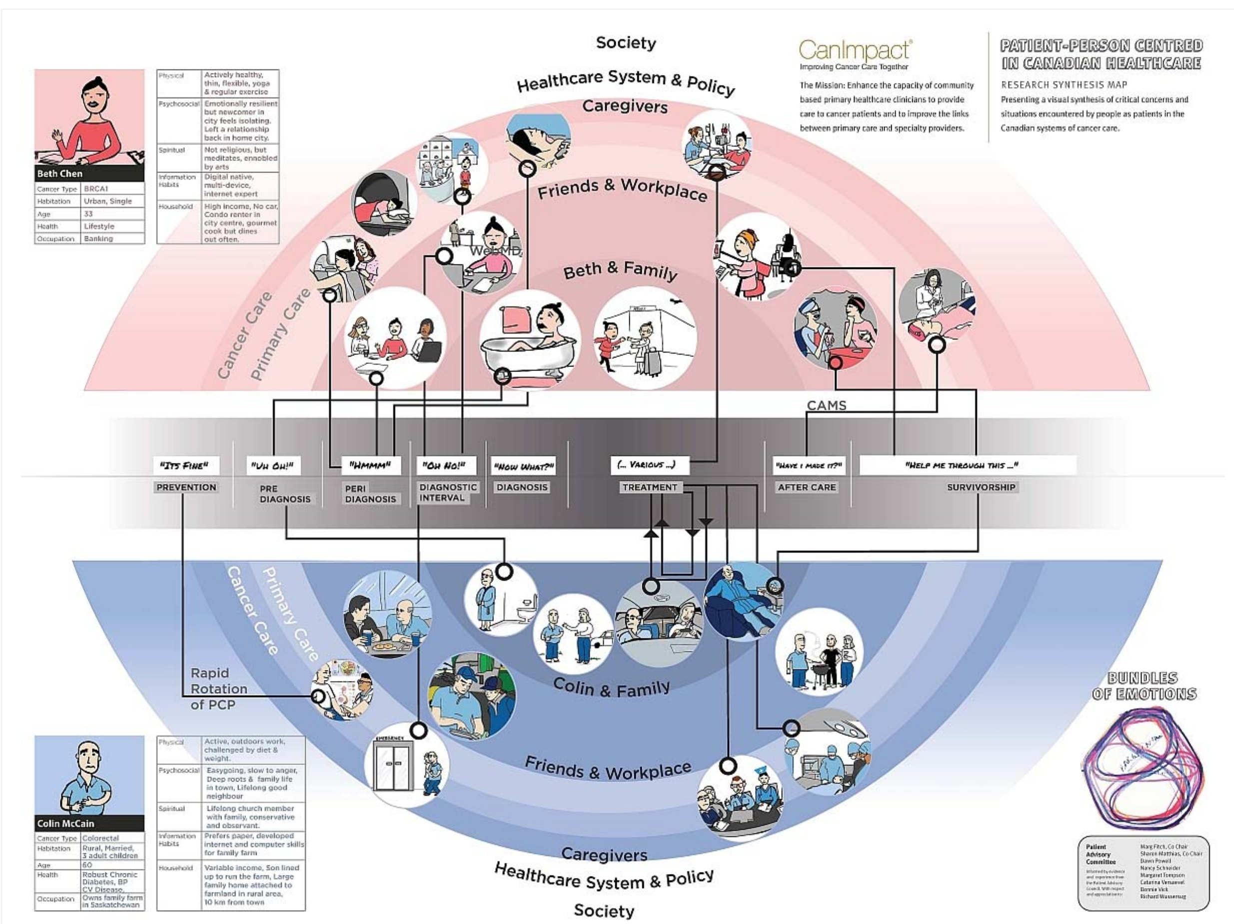


*Figure 6. CanIMPACT Patient-Centred Synthesis Map. © 2016 OCADU Strategic Innovation Lab.*

## Conclusions

We present a description of synthesis maps as developed and taught in a leading university design practice. Synthesis maps, originally based on Sevaldson's GIGAmapping process, can include a wide range of system maps forms and types, too diverse to be fully presented in a proceedings papers. The primary distinction between synthesis maps and GIGAmaps is the reliance on evidence and structured system maps used in the synthesis maps, drawn into the mapping process to support the systems thinking pedagogy of the associated course practice,

As with any system map, the primary purpose of the visual method is to communicate a consensus model of a system of concern to stakeholders and informed audiences. The synthesis map has significant potential as a design artifact to explain and propose through visual composition the emerging problems and regularities as narratives entailed in a complex social system. The open-ended visual modeling approach provides expanded degrees of freedom for system definition and intervention, enabling the synthesis maps to be employed in a wide variety of applications and multi-stakeholder problems.

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