

System Dynamics Overview

The Helios Alliance

System Dynamics modeling, developed at Massachusetts Institute of Technology by Jay Forrester, is an approach to understanding the non-linear behavior of complex systems over time.

This presentation will provide an overview of System Dynamics, its development and use, as well as how it has been successfully been applied to issues of public health and use disorder.

Jay Forrester

World War II Engineer

During World War II, Jay developed servomechanisms, radar controls, and flight-training computers for the U.S. Navy. He also led Project Whirlwind, one of the first digital computing projects.



MIT Graduate

Jay Forrester entered graduate school at the Massachusetts Institute of Technology in 1939, following a degree in electrical engineering from the University of Nebraska-Lincoln.



Magnetic Core Memory

While working on Project Whirlwind, Jay developed magnetic core memory — essentially, the first computer processor.



Development of System Dynamics Methodology

As a professor at MIT in the 1950s, Jay first conceived the approach to thinking that would become System Dynamics — a model-based approach to analyzing complex organizations and systems. This methodology was first publicised in *Industrial Dynamics*, which was published in 1961.



MIT Professor

In 1956, Jay began his career at the MIT Sloan School of Management, where he stayed until his retirement in 1989.



Legacy

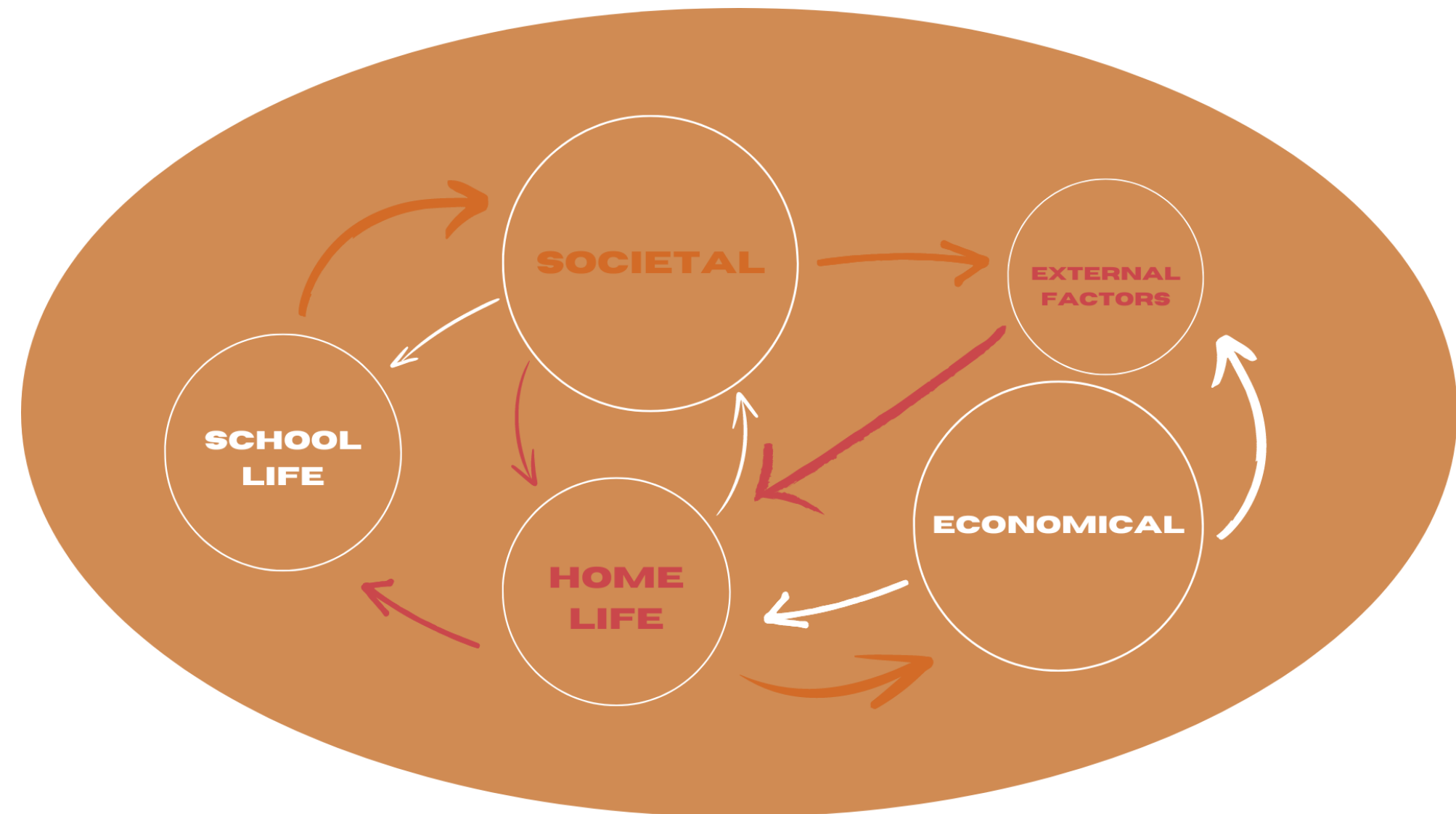
Upon his death in 2016, his MIT colleague John Sterman observed: “From the air traffic control system to 3-D printers, from the software companies use to manage their supply chains to the simulations nations use to understand climate change, the world in which we live today was made possible by Jay’s work.”



Systems Thinking

Systems thinking is a way of making sense of the complexity of the world by looking at it in terms of relationships and the bigger picture, rather than just component parts. It is a holistic approach to describing the interactive relationships of factors within a system, while also considering how the system is influenced by outside factors.

At its core, systems thinking is a way to approach issues by looking at them as part of a connected whole – rather than considering only how to solve an immediate problem, one considers how all of the pieces connect to make the whole.

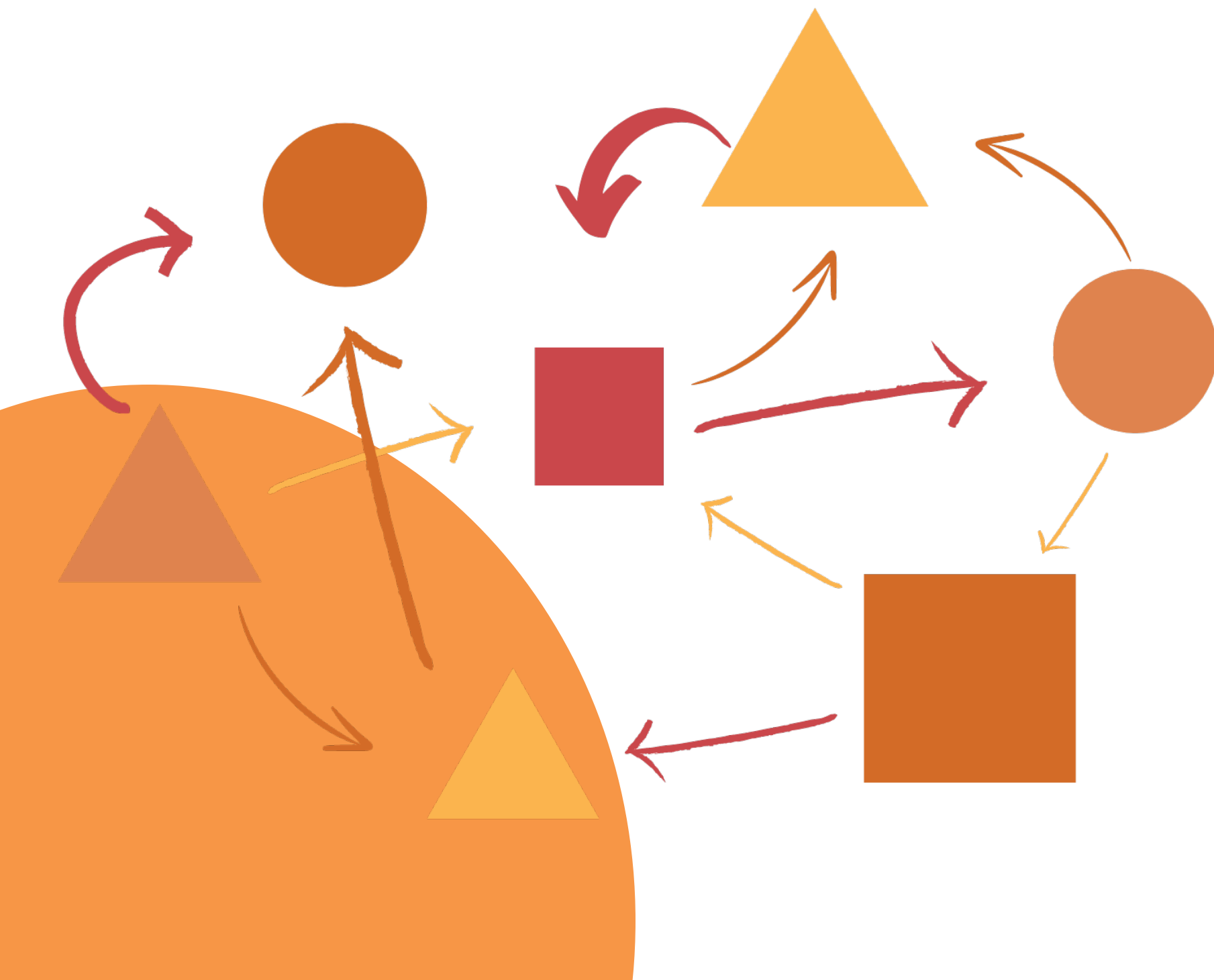


System Dynamics

System Dynamics modeling is a way to quantify the non-linear interactions that Systems Thinking describes and understands. The approach centers on building computer simulation models that are capable of simulating time shifts and behavior changes within a complex system— whether that be biological, political, or social.

It is the preferred approach to solve difficult problems because the methodology explicitly considers all aspects of a complex system: synergies, delays, and policy resistance. A completed and robust model allows for the framing, understanding, and discussion of complex issues and problems.

Since a System Dynamics model can both identify points of leverage for intervention and the unintended consequences those interventions may bring, decision makers are given the most robust view of a system as it exists to make the best decisions for their communities.



System Dynamics Model Development

The System Dynamics modeling approach begins with defining problems dynamically, moves to model building and reliability testing, and concludes with policy, scenario, and sensitivity testing. To put it simply: learn as much as possible about a system, then design and construct a robust and logical system that plausibly explains history, and then test that structure to ensure it acts reliably. This allows a modeler to move from asking “What is the problem? Why is it a problem?” to answering those questions with rules and strategies that can be applied in the real world.

Another unique strength of System Dynamics is that, once the historic case is articulated and validated, the model can be used for forward-thinking policy evaluation: potential interventions can be simulated, costs and benefits can be estimated, and unintended consequences can be flagged.

There are many demonstrable benefits to using System Dynamics as a method for assessing complex questions – for example, prevention education in school-aged children. A complete model can compute the full impact of events and conditions over time, including the indirect causes of actions.

Evolution of System Dynamics Modeling Applications

Since System Dynamics was first developed and *Industrial Dynamics* was published, System Dynamics has expanded its application into areas beyond business management, and it is now used in such fields as policy development, dispute resolution, and organizational culture by groups as varied as large multinational corporations; local, state, and national governments; think tanks; and militaries.

Corporations like Coca-Cola, MasterCard, and General Motors have employed the methodology to solve some of their most complicated business issues, while organizations like the U.S. Centers for Disease Control and Prevention and the World Health Organization have used System Dynamics to attempt to solve some of the largest public health issues of our time: cardiovascular disease, polio, HIV/AIDS, and addiction.



Case studies of how System Dynamics has been used can be found [here](#).

Case Study: MasterCard

MasterCard once held a dominant US market position with one primary competitor, Visa. After six consecutive years of steady decline in revenues and market share, it had lost its leadership position. The company was stymied. Despite multiple initiatives to slow or reverse the decline, nothing worked. Modelers, working with organization leadership, worked to find a solution to reverse this market share decline.

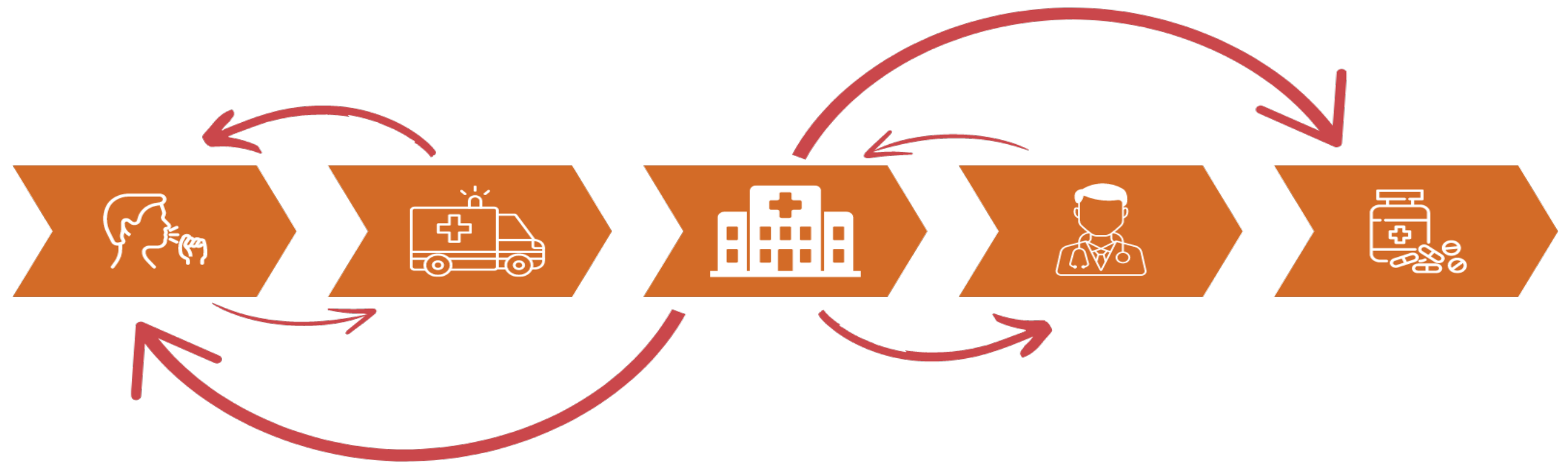
System Dynamics was chosen because of the ability to look at a problem in a new way: there were competing interests within the corporation, and a more holistic approach for the organization was necessary. System Dynamics provided perspective by looking at the system analytically and impartially.

The team designed, built, and tested a model of the US credit card industry and market – cardholders, choices they made using different cards, and the businesses that accepted the credit cards. The model simulated MasterCard performance and that of each of its main competitors – Visa, American Express, Discover. Analyses identified four factors that, when combined, would have a significant, lasting market share benefit. This quickly morphed into “co-branding” as a strategy that would “pull all four levers”.

Co-branding revolutionized the credit card industry. Co-branding proved to be a win-win-win: a win for consumers, as the “points” gained by consumers provide noticeable discounts on their purchases; a win for co-branders, who achieved higher customer loyalty as a result, and a win for MasterCard, gaining almost exactly the market share and the timing predicted by the modeling.

System Dynamics and Public Health

System Dynamics is appropriately suited to address the dynamic complexity of many public health issues because models can adequately assess the multiple interacting diseases and risks, the interaction of delivery systems and impacted populations, and matters of national, state, and local policy. It has been used extensively since the 1970s, considering questions of population health including infectious disease policy, chronic disease policy, local-level health agency planning, health system reform, health care systems delivery, and as applicable here, substance use and abuse.



The Helios Approach

In June 2023, a group of national leaders gathered to form the Helios Alliance – an alliance of likeminded individuals and organizations who have committed to use innovative, transformative, evidence-based technologies and methodologies to address systemic issues related to health, safety, and the quality of life. Together, Alliance members bring decades of experience in not only the technologies that will be used to create a first-of-its-kind simulation platform, but also in health economics, stigma reduction, prevention and education, and opioid advocacy.

The Helios Alliance is at the forefront of addressing the opioid crisis through a multi-disciplinary approach, combining cutting edge advanced intelligence with time-proven methodologies to provide comprehensive solutions to the systemic challenges of the epidemic. By integrating System Dynamics modeling with predictive analytics, our team can better understand the complexities posed to individuals, communities, states, and tribal nations ravaged by opioid use. Beginning in late 2017, we have had deep – and successful – experience at the national, state, local, and tribal levels.

The Helios Alliance has three priorities, and one of them is to apply this approach and technology to shift the prevention paradigm in our schools to meet students where they are. Here, the Helios Alliance is developing Project Empower, a tool to provide students with the necessary education, support, and tools to achieve the strategic goal of creating a Culture of Wellness starting with substance use prevention. While much of the prevention education currently focuses on individual drugs or proscribed behaviors; we propose to shift that to a holistic and empowering approach that is grounded in a simple idea: doing the right thing is more protective and permanent than not doing the wrong thing.



Selected Resources

System Dynamics

- [MIT Professor John Sterman on System Dynamics](#)
- [System Dynamics Society](#)
- [Universities and Colleges with System Dynamics Curriculum](#)

The Helios Alliance

- [Resources page](#), which includes information about our methodology and applications of System Dynamics
- [YouTube page](#), which includes videos from our partners and information about our work
- [LinkedIn](#)

