

## NGI101x - 4.3A - System Dynamics I

Hello, my name is Erik Pruyt. I'm a methodologist at Delft University of Technology.

This week is about modeling techniques. In this weblecture we will look at one of these techniques, the System Dynamics Modeling and Simulation method what it is used for; how it is used and what is specific about SD?

We will also briefly look at two examples.

So, what is System Dynamics? It is a method for modeling and simulating dynamically complex issues or systems characterized by feedback and accumulation effects. I will come back to that later.

So, what is System Dynamics used for?

Quantitative SD modeling is used to model systems and issues and to simulate their behavior. Models can then be used to experiment in a virtual laboratory. As such, System Dynamics models are also extremely useful for model-based policy analysis and for adaptive policy design. They can be used to identify root causes of problems, identify adaptive policies to solve problems at the root, and to test the effectiveness of policies across a wide range of assumptions.

So, what are the application domains?

Well, SD is used for many complex social-technical and policy problems.

For example in health policy: Based on a SD study by KidRisk, the WHO was convinced that polio could be eradicated worldwide and the Gates Foundation decided to co-fund the eradication effort.

System Dynamics models have influenced and driven energy policies and infrastructures in the US and elsewhere since the 1970s.

The same is true for resource dynamics and management from the moment the first "Limits to Growth" study, commissioned by the Club of Rome, was published in 1972.

In line with the follow-ups of the 'Limits to Growth' and the growing believe that pollution, more than finite resources, poses severe limits to growth, the System Dynamics field also shifted towards environmental policymaking. For instance, the flight simulators and serious games developed by ClimateInteractive to help climate change policy makers understand the impact of climate change policies.

System Dynamics has also been used since Jay Forrester's Urban Dynamics study for studying urban dynamics and policies. Recently, a System Dynamics model of the relationships among many core city systems was developed for the Smarter City project of

the City of Portland, Oregon, USA to better understand urban dynamics, and to identify opportunities to become a smarter city.

SD is also used for education and innovation. For example, a SD model of the Business Higher Education Forum has recently been used to study how President Obama's goal of 1 million Science, Technology, Engineering and Mathematics graduates could be met.

System Dynamics is used for strategic planning and all sorts of business dynamics problems. Think about books like 'Business Dynamics' or Strategic Management Dynamics,

System Dynamics models are also used for integrated risk-capability assessment and Critical Infrastructures Protection.

Finally, SD modeling is also used for many social-economic and public policy issues, such as societal ageing.

So, how are SD models made and used? In other words: what does the SD process look like?

As you can see from this picture, the SD process is very iterative.

Problem owners and stakeholders are involved in many, if not all, stages of the process.

In fact, it all starts from the mental models of problem owners and stakeholders. From this starting point, System dynamicists first distil conceptual models.

These conceptual models are then turned into fully specified formal models, which are simulated, tested and used. Often the purpose is to design adaptive policies and to test their robustness.

But in many cases, the aim is also to generate new insights and improved understanding of the problem.