

Appendix 4a: Introducing system dynamics thinking

The modeling approach that will be used is system dynamics. The introduction to system dynamics thinking on the High Performance Systems website (www.hps-inc.com/index.aspx) states:

“To make sense of reality, we all simplify it. These simplifications are called mental models. We simulate our mental models in order to determine which course of action to implement, which alternative to choose, which strategies will best achieve our objectives. History shows that our choices and decisions often leave us with holes in our feet because:

1. The assumptions constituting the mental models we build are not sufficiently congruent with the reality they are seeking to represent
2. Our simulations of these models do not correctly trace out the dynamic consequences implied by the assumptions in the models.

Systems Thinking is an approach which can help us to construct mental models which are more likely to be congruent with reality and to then simulate these models more accurately.

Systems Thinking thus increases the likelihood that we will produce the consequences that we intend.”

From a system dynamics perspective one is interested in non-linear behavior within a system often explained by feedback loops and time lags.

Appendix 4b: Introduction to STELLA

The system dynamics software used is called STELLA. The software can be found at High Performance Systems, Inc: <http://www.hps-inc.com/index.aspx>

A run-time only version is downloadable free of charge and allows you to run models, but not save the changes to a model.

In STELLA, there are three communicating layers that contain progressively more detailed information on the structure and functioning of the model (Figure 1). The lowest layer contains the difference equation, generated by the model structure in the middle level. This level shows the model structure by icons. The graphic representation of these units are connected and manipulated on the screen to build the basic structure of the model. This process is made transparent to a group when the computer screen is projected.

The middle layer is displayed during the construction phase. Icons represent the basic structure of the model and provide an input pathway for subsequent data. Once the basic structure of the model is laid out, initial conditions, parameter values and functional relationships can be specified. Input data can be entered in graphical or tabular formats.

The highest layer is the "user interface". In the final stage users can easily access and operate the model from this level. With the use of slide-bars, a user can also immediately respond to the model output by choosing alternative parameter values as the model runs. The model output can be generated in tabular or graphical form.

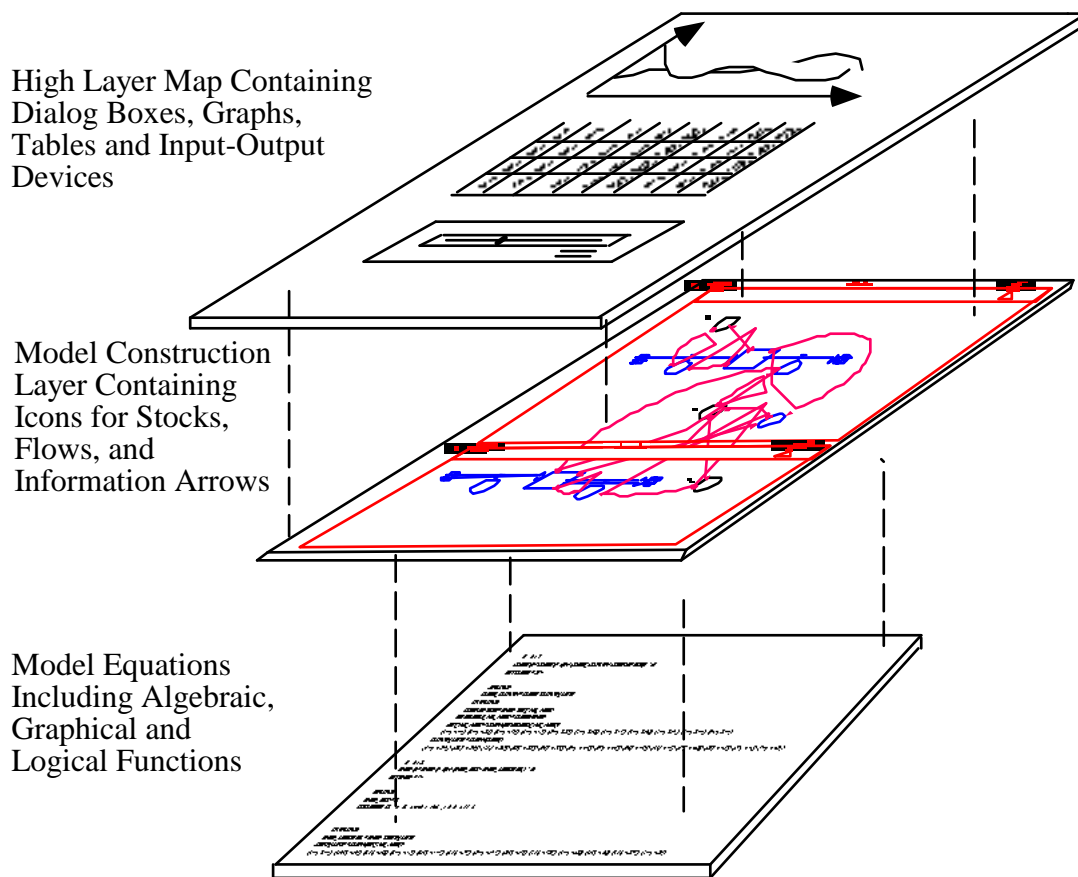


Figure 1. STELLA Modeling Environment
(Source: Costanza & Ruth, 1998)

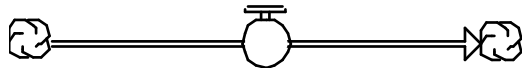
Middle Layer: The four model icons

The first task after defining the questions the model should answer will be to choose some model sectors. These are broad conceptual areas or domains that should be included in the model, guided by the questions the model should answer.

In principle, there are four model building blocks or icons: stock, flow, auxiliary variable, information connector. See figure 2. A stock is a variable important enough to be explained within the model. A stock represents a state variable that embodies an aspect of the system under study. A flow represents the rate of change of a stock. The auxiliary variable defines the rate of change. Information connectors link the auxiliary variables, flows and stocks.

Figure 2 Model icons

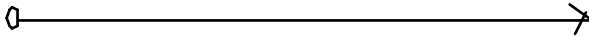
Stock



Flow



Auxiliary variable



Information Connector