1.0 Basic Functionality

At their heart, system dynamics models are systems of integral (or differential) equations. We start from that perspective in defining the basic structure of the simulation language. Using this frame, a model is composed of stocks, flows and other equations necessary to compute the flows or initialize the stocks which we will call inclusively auxiliaries. Stocks are also often called levels or states, and flows are often called rates or derivatives. All other computations can include constants, initialization computations, data constructs and other items but that will be distinguished by their defining equations - all will be referred to as auxiliaries. Stocks, flows and auxiliaries will be collectively referred to as variables.

We also base our computational definition on the assumption that a model starts from some well defined initial condition and then computations progress forward in time. Other approaches, such as mixed initial and terminal conditions or simulating backwards in time, can be applied to the models specified in this document but will require extensions of the specification to accommodate these differences.

We will refer to the computation used to determine the values of variables over time as "the simulation." In later sections we will discuss solution techniques for integral equations, but for discussion purposes we will use the notion that time is broken up into finite intervals during this computation. We will call the time between these intervals DT, corresponding the denominator in the *d/dt* notation often used in introductory calculus courses. This discrete time terminology is often used for pedagogical purposes, and is also important in defining computation, especially with some of the added constructs such as queues now common in many system dynamics models.

1.1 Stocks

Stocks accumulate. Their value at the start of the simulation must be set as either a constant or with an initial equation. The initial equation is evaluated only once, at the beginning of the simulation.

During the course of the simulation, the value of a stock is increased by its inflows and decreased by its outflows. Using the discrete time interval *dt*, and subscripted text to represent value at time, we could write

$$stock_t = stock_{t-dt} + dt \cdot (inflows_{t-dt} - outflows_{t-dt})$$

The above computation is notional, though it is used in one of the specified integration techniques (Euler) as will be discussed later.

In specifying a stock we will list its inflows and outflows separately as in:

Stock: Population
Inflows: births immigration
Outflows: deaths emigration
Initial Equation: 100
Units: People

1.2 Flows

Flows represent rates of change of the stocks. They can be defined using any algebraic equation (including a constant value) or by using a table function as will be described later.

During the course of a simulation, a flow's value is computed and used in the computation of levels as described. An example flow would be:

Flow: Births
Equation: population * fertility
Units: Person/Year

1.3 Auxiliaries

Auxiliaries allow the isolation of any algebraic function that is used. They can both clarify a model and factor out important or repeated calculations. They are defined using any algebraic expression (including a constant value) or a table function.

Auxiliaries are distinguished from flows only by their usage. An example auxiliary might be:

Auxiliary: birth_rate
Equation: normal_birth_rate * food_availability_multiplier
Units: Person/Year

1.4 Algebraic Expressions

1.5 Graphical Functions

Graphical functions are alternately called lookup functions and table functions. They represent a functional mapping between two variables. The domain is consistently referred to as *x* and the range is consistently referred to as *y*.