A Conversion Table of DYNAMO into STELLA II *

Thomas D. Clark, Jr.
Department of Information and Management Sciences
College of Business
The Florida State University (FSU)
Tallahassee FL 32306-1042 USA
    E-mail:tclark@postoffice.cob.fsu.edu

Hironori Kurono
Visiting Scholar of FSU (August,1993 - August,1994)
Faculty of Economics
Kyushu International University
Kitakyushu Fukuoka 805 Japan
    E-mail:PFH02256@niftyserve.or.jp

ABSTRACT

Although there have been many System Dynamics models written in DYNAMO, which are the common property in the society now, there are many obstacles recognized in studying these models using STELLA. This paper shows a conversion table of the basic DYNAMO rules into STELLA II in order to overcome these obstacles.

First, we refer to the recent graduate increase of the papers in System Dynamics Review, etc. which used STELLA or STELLA II, and then we expect STELLA II for Windows will be used more for model building in future. Second, we refer to the general features of five differences between DYNAMO and STELLA II in terms of terminology, an equation, a time script, a time related character, and the relationship of Level and Rate (or Stock and Flow), and then we refer to one similarity in terms of value chain. Third, we show a comparison table of DYNAMO functions with STELLA II functions according to the categories of Delay and Smooth Functions, Logical Functions, Table Functions, Test Input Functions, Random-Number Functions, and Trigonometric Functions, and then we show a conversion table of DYNAMO functions into STELLA II functions using simple examples respectively. In addition, we show the applications of a Sub-model and a Space Compression Object (SCO) of STELLA II functions, which are the new methods available in STELLA II (Mac v3.0.4, 1993).

In conclusion, we successfully convert the model of Saturday Evening Post written in DYNAMO (Hall 1973) into a model in STELLA II according to these our findings in order to estimate them.

Introduction

Since DYNAMO for the IBM 704 computer was written by Phillys Fox and Alexander L. Pugh based on SIMPLE in the Spring of 1959, many System Dynamics models have been written in DYNAMO (Pugh 1983). Based on DYNAMO IV, Professional DYNAMO Plus (PD Plus) for the IBM PC family was released by Pugh and Robert Associates, Inc. in 1986. Nowadays these models are a kind of important common property in the society. On the other hand, STELLA, a kind of visual programming for a Macintosh personal computer, was demonstrated at the 1985 International System Dynamics Conference in Keystone by High Performance Systems, Inc., then it has become popular among a part of system dynamicsts because it utilizes graphical interface for mapping a model on the display of a personal computer. Its manual (Richmond et al. 1987) also has brought about an advanced concept of System Thinking as well as the generic processes for model building, and it was recommended as an educational textbook even when DYNAMO is used (Saeed 1989). Forrester Award committee evaluated STELLA in terms of manual as well as software in 1989. In addition to its nondestructive simulation in the classroom and in business (Long 1990), its mapping makes a team share ideas in the process of building strategic planning (Morecroft, Lane and Vitta 1991). It's also useful for a technology-based curriculum innovation (Mandinach, Cline 1993). STELLA is released as ithink for business area.

Table 1 is the number of the papers in System Dynamics Reviews in terms of what kind of software have been used in a paper since its first issue where Richard pointed out "The growth of system dynamics has stimulated the development of related languages and tools suiting different audiences: DYSMA, ..., NDTRAN, ..., BASIC, ..., FORTRAN, ..., DYAMOD, ..., STELLA, ..., DYNA, ..., Professional DYNAMO, ... Modeling technology is fast becoming accessible to virtually every one, a development that offers enormous oppor-

Software \ Vol.-No.	1-1	2-1	2-2	3-1	3-2	4-1, 2	5-1	5-2	6-1	6-2	7-1	7-2	8-1	8-2	8-3	9-1	9-2	9-3	10-1	10-2, 3	10-4	Total
DYNAMO or II etc.	3	3	1	1	2	2	3				1	1	1	1	1	1						21
PD Plus						1				1		1		1			1					5
STELLA or II						2		1	1	1	1	1	1	1		1	3	2	2	1	3	21
DYSMAP, DYSMOD	1	1	1	1	1																	5
Others	1	1					2	4	1		1	1			2		1			1	2	17

Table 1 Software used in a Paper of System Dynamics Review

tunities for system dynamics (Richard 1985)." Because of this insight on the first page of the first issue, it is regretful that his later paper did not analyze the contents of the System Dynamics Review in terms of tools used in the papers (Richard 1991). Table 1 shows the recent graduate increase of using STELLA or STELLA II in the papers, compared to other software.

On the other hand, some authors have been interested in using more than two software in their research. Clark used STELLA for mapping a model and also used PD Plus for computing the model (Clark, Mitchell and Williams 1990). Hall built the model originally written in DYNAMO (Hall 1976 1983), but recently rewrote them in a simplified form using STELLA in order to study a group policy meeting (Hall, Aitchison and Kocay 1994). Wholstenholme built two models in DYSMAP2 (written by Dangerfield and Vapenikova in 1987) and one in STELLA (Wholstenholme 1990). He used DYSMAP2 for realizing the optimization concept also. Shimada introduced DYNAMO to Japanese students by building a simple pond model written in DYNAMO, PD Plus, DYNAMOP III (written by Kobayashi), BYNAMO (written by Shizuka), STELLA II and BASIC (Shimada edit., 1994).

As STELLA II (Mac v3.0.4) was released in December, 1994 and its Windows version was released in April, 1994, it is expected that STELLA II will be used more for model building than ever before. Unfortunately nobody has compared clearly DYNAMO with STELLA II, so scarce information about the differences between the two has been an obstacle in utilizing many System Dynamics models written in DYNAMO. Because of this, many students have given up studying a model written in DYNAMO using STELLA. In order to overcome this obstacle and utilize the common property of the society, this paper shows the general features of DYNAMO and STELLA, and then provides a conversion table of DYNAMO into STELLA II using simple examples. In conclusion, we apply these findings to converting the model of Saturday Evening Post written in DYNAMO (Hall 1973) into a model in STELLA II (Mac v.3.0.4) for the aim of estimating these findings.

General Features of DYNAMO and STELLA

As the general features of DYNAMO and STELLA, we refer to the differences between DYNAMO and STELLA in terms of terminology, an equation, a time script, a time related character, and the relationship of Level and Rate (or Stock and Flow). Then we refer to the similarity in terms of value chain.

As the first of the differences, terminology of STELLA is different from that of DYNAMO. Saeed evaluated this difference as "an improvement on the traditional system dynamics jargon, as it describes the generic functions of the system elements and the operational means to model it more accurately than the traditionally used terms, which are a bit abstract (Saeed 1989)." Table 2 shows the basic equivalents of DYNAMO to those of STELLA in terms of jargons and their symbols for a diagram. CP (Constant, Permanent change) and TP (Table, Permanent change) equations in DYNAMO are not used in STELLA. Symbols for a diagram are not the same (Forrester 1961, Richardson and Pugh 1985, Richmond, Peterson and Vescuso 1987).

Second, when we look at an equation in detail, we find three differences between DYNAMO and STELLA. First, while an N equation (initial value) is defined for all the level variables and sometimes for a rate or auxiliary variable in DYNAMO, an initial value is defined only for a stock in STELLA and this is defined in a dialog box of a stock. Although an N equation for a rate in DYNAMO can be used as one method in order to break the simultaneous equations (Pugh 1983, 154-159), another method, that is to say, changing a logic of a model a
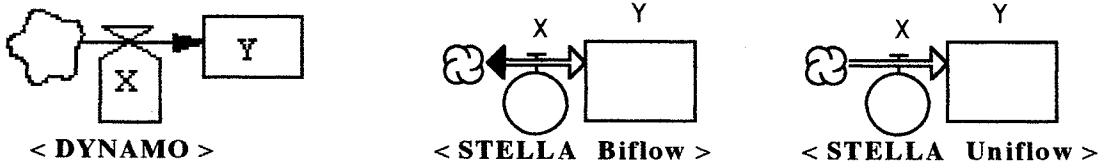
DYNAMO	STELLA
Level ☐	☐ Stock
Rate ⊠► ⊠►	⇨ Flow
Auxiliary ◯ , Exogenous variable ◎ Constant —O— , Supplementary	◯ Converter
Table function ⊖	◯ Graphical function
Information link ◦----➤	◦⌒▲ Connector
Source or Sink of material ⬡	⬡ Cloud

Table 2 The Basic Equivalents of DYNAMO to those of STELLA

little, is often necessary in order to break the simultaneous equations in the case of STELLA. Second, continuation statements in an equation, are identified by " X " or " . " at the first column or by an optional space or two and " ^ " at a convenient breaking point in DYNAMO, continuation statements are not used in an equation of STELLA. Finally, the arithmetic operators are the same except exponentiation: " ** " is for DYNAMO, " ^ " is for STELLA. Finally, while variable name of DYNAMO is restricted within six characters (seven characters in the case of PD Plus), STELLA allows a variable name to be sixty-five characters.

Third, DYNAMO requires a time script for a quantity name, such as X.K or Y.KL in an equation, on the other hand STELLA does not require a time script for a variable name in an equation when it is defined in a dialog box. A time script of DYNAMO is the traditional form which has been convenient to everyone, but in the case of PD Plus "rates on the right side of auxiliary, rate, and supplementary equations are subscripted KL rather than JK (Pugh Robert Associates, Inc. 1986a, p.55)" which is due to application of the Runge-Kutta variable step-size integration method. This form is basically different from the form of DYNAMO. According to PD Plus, the user familiar with DYNAMO is forced to write a rate equation in such as R X.KL = DELAY3(Y.KL, DEL), which makes everyone confused a little.

Fourth,   as a time-related character,   the number of the actions taken by DYNAMO is different from that taken by STELLA, on the condition that the interval between event times of an event such as a PULSE or a SAMPLE is 1.6 and DT is 1.0. DYNAMO and PD Plus are supposed to have 10 actions at TIME=2,3,5,6,8,10,11,13,14,16 (Pugh 1983, 53-54. Pugh Robert Associates, Inc. 1986b, 64-65), but actually it takes only 6 actions at TIME=2, 5,8,10,13,16, on the other hand STELLA takes 10 actions at TIME=2,3,5,6,8,10,11,13,14,16.

< DYNAMO >   < STELLA Biflow >   < STELLA Uniflow >

Finally, the relationship between Level and Rate in DYNAMO is different a little from the relationship between Stock and Flow in STELLA. The former on the right above is the same as the latter on the center above, which is called "Biflow" in STELLA. But, actually, STELLA offers options of two kinds of flows: Biflow and Uniflow. In the case of Uniflow shown on the left above, if X is less than 0, X is set to be equal to 0, which prevents, e.g., an order or inventory from being negative.

As a similarity between DYNAMO and STELLA, it is interesting to know how the value changes in a diagram. The following diagrams of DYNAMO on the left side and STELLA on the right side show that X1 is connected to X2, and X2 is connected to X3 and then X3 is connected to X4 by information link (or connector). These values change at TIME=K in the order of information link (or connector) from X1 to X4. That is to say, all the values of the

variables connected change simultaneously as well as interrelatedly in the both cases of DYNAMO and STELLA.
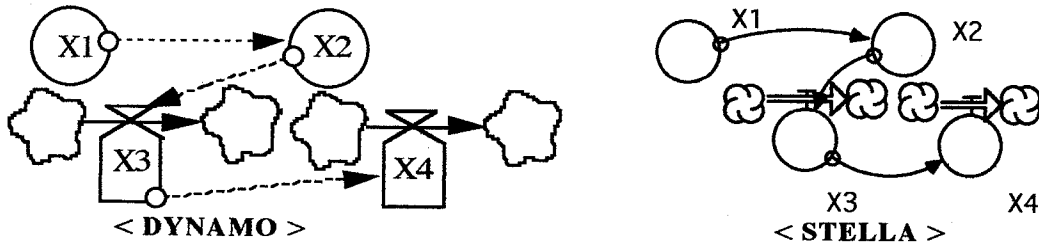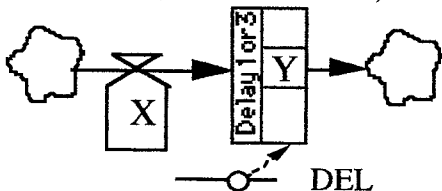

< DYNAMO >   < STELLA >

A Conversion Table of DYNAMO into STELLA II

DYNAMO has basically twenty-six built-in functions and a user can also define additional functions as macros. STELLA II has sixty-nine built-in functions and user can define Sub-models and Space Compression Objects (SCO) in the place of macros of DYNAMO. Table 3 shows a comparison of DYNAMO twenty-six functions with STELLA II functions. Except trigonometric functions of DYNAMO, most of the names of DYNAMO functions are different from those of STELLA II functions. Although STELLA II has SWITCH function also, this function is not equivalent to SWITCH function of DYNAMO. Moreover, the number and the character of arguments of a function are not always the same. While many of the sixty-nine built-in functions of STELLA II do not appear in Table 3, they are convenient. Especially "INIT" function is very convenient when an initial value of a stock in DYNAMO has to be used in an equation in STELLA II. "DELAY" function is also for expressing the delayed value of input.

In the order of Table 3, the following is a conversion table of DYNAMO functions (*shown on the left side*) into STELLA II functions (*shown on the right side*) using simple examples. At the end of this section, we will show applications of a Sub-model and a Space Compression Object (SCO) of STELLA II function using STELLA II (Mac v3.0.4, 1993). With this new technology, a user uses any STELLA model like a macro of DYNAMO, or a part of a larger model of STELLA II in the process of model building.
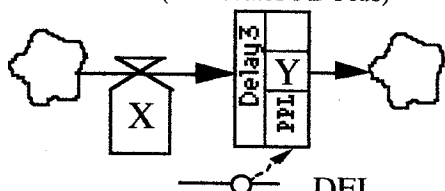
Delay and Smooth Functions
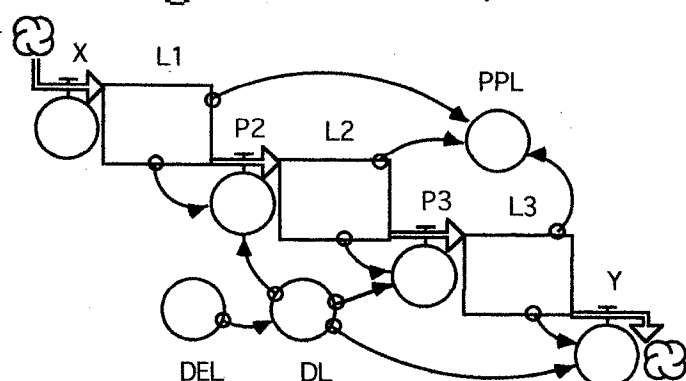
DELAY1 or 3 (* indicates PD Plus)


```
R  Y.KL=DELAY1(X.JK,DEL)
*R  Y.KL=DELAY1(X.KL,DEL)
 or  R  Y.KL=DELAY3(X.JK,DEL)
    *R  Y.KL=DELAY3(X.KL,DEL)
R  X.KL=100+STEP(10,2)
C  DEL=2
```

UNATTACHED:

```
Y = SMTH1(X,DEL)
 or  Y = SMTH3(X,DEL)
DEL = 2
X = 100+STEP(10,2)
```
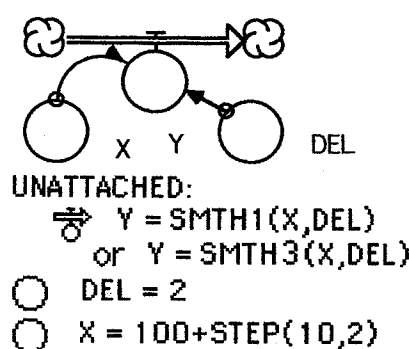
DELAYP (* indicates PD Plus)


```
R  Y.KL=DELAYP(X.JK,DEL,PPL.K)
*R  Y.KL=DELAYP(X.KL,DEL,PPL.K)
R  X.KL=100+STEP(10,2)
C  DEL=2
```

DYNAMO Functions	STELLA II Functions
Delay and Smooth Functions	***Special Functions***
[Material delay]	**[SMTH1]**
DELAY1(IN,DEL) ---------------------------------->	SMTH1(<input>,<averaging time>[,<initial>])
	[SMTH3]
DELAY3(IN,DEL) ---------------------------------->	SMTH3(<input>,<averaging time>[,<initial>])
DELAYP(IN,DEL,PPL) ---------------------------->	*none*
[Information Delay]	**[SMTH1]**
SMOOTH(IN,DEL) ------------------------------>	SMTH1(<input>,<averaging time>[,<initial>])
	[SMTH3]
DLINF3(IN,DEL) ---------------------------------->	SMTH3(<input>,<averaging time>[,<initial>])
Logical Functions	
[Clipping or Limiting Function]	
CLIP(P,Q,R,S), FIFGE(P,Q,R,S) ---------------->	*none*
	Mathematical Functions
[Maximum Function]	**[MAX]** (better to use Euler's method)
MAX(P,Q) --->	MAX(<expression>,<expression>,...)
[Minimum Function]	**[MIN]** (better to use Euler's method)
MIN(P,Q) -->	MIN(<expression>,<expression>,...)
	Special Functions
[SWITCH or FIFZE Function]	**[SWITCH]**
SWITCH(P,Q,R) ----------------------------------->	*the name is the same, but not equivalent.*
FIFZE(P,Q,R) -------------------------------------->	*none*
Table Functions	***Graphical Function*** (*not a built-in function*)
TABLE(TAB,X,XLOW,XHIGH,XINCR) ------>	*none*
TABHL(TAB,X,XLOW,XHIGH,XINCR) ------>	*defined in a Graphical Funcion Dialog*
TABXT(TAB,X,XLOW,XHIGH,XINCR) ------>	*none*
TABPL(TAB,X,XLOW,XHIGH,XINCR) ------>	*none*
Test Input Functions	***Test Inputs***
[Pulse Source Function] (*: PD Plus)	**[PULSE]** : First pulse and interval should be constants.
PULSE(HGHT,FRST,INTVL) --------------------->	PULSE(<volume>[,<first pulse>,<interval>])
*PULSE(HGHT,WDTH,FRST,INTVL) ------------->	PULSE(<volume>[,<first pulse>,<interval>])
[RAMP Function]	**[RAMP]**
RAMP(SLOPE,START) ------------------------->	RAMP(<slope>[,<time>])
Random-Number Functions	***Statistical Functions***
NOISE() -->	RANDOM(-0.5,0.5[,<Seed>])
NORMRN(MEAN,STDV) ------------------------->	NORMAL(<mu>,<sigma>[,<Seed>])
[SAMPLE Function]	
SAMPLE(X,INTVL,ISAM) ---------------------->	*none*
	Test Inputs
[STEP Function]	**[STEP]**
STEP(HEIGHT,STEPTM) ------------------------>	STEP(<height>,<time>)
Trigonometric Functions	***Mathematical Functions***
[e to the Ath power]	**[EXP]**
EXP(A) , -174≤A≤174 ------------------------>	EXP(<expression>)
[natural logarithm of A]	**[LOGN]**
LOGN(A) , A>0 ---------------------------------->	LOGN(<expression>) , expression>0
[square root of A]	**[SQRT]**
SQRT(A) , A≥0 ---------------------------------->	SQRT(<expression>) , expression≥0
	Trigonometric Functions
[sine of A (A in radians)]	**[SIN]**
SIN(A) , -823,000<A<823,000 ---------------->	SIN(<radians>)
[cosine of A (A in radians)	**[COS]**
COS(A) , -823,000<A<823,000 ---------------->	COS(<radians>)

Table 3 A Comparison of Functions of DYNAMO with those of STELLA

▢ L1(t) = L1(t – dt) + (X – P2) * dt
INIT L1 = DL*X
   INFLOWS:
      ⇶ X = 100+STEP(10,2)
   OUTFLOWS:
      ⇶ P2 = L1/DL

▢ L2(t) = L2(t – dt) + (P2 – P3) * dt
INIT L2 = L1
   INFLOWS:
      ⇶ P2 = L1/DL
   OUTFLOWS:
      ⇶ P3 = L2/DL

▢ L3(t) = L3(t – dt) + (P3 – Y) * dt
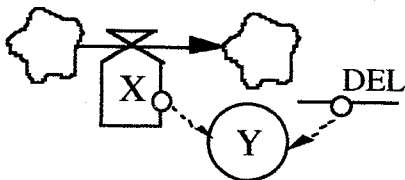INIT L3 = L2
   INFLOWS:
      ⇶ P3 = L2/DL
   OUTFLOWS:
      ⇶ Y = L3/DL
◯ DEL = 2
◯ DL = DEL/3
◯ PPL = L1+L2+L3

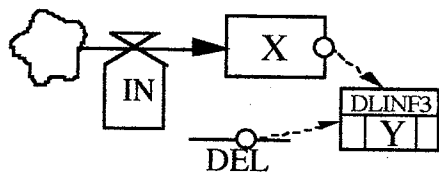## SMOOTH (* indicates PD Plus)
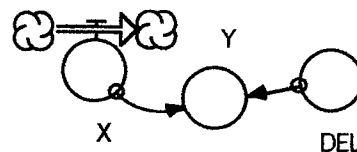

A Y.K=SMOOTH(X.JK,DEL)
*A Y.K=SMOOTH(X.KL,DEL)
R X.KL=100+STEP(10,2)
C DEL=2

UNATTACHED:
   ⇶ X = 100+STEP(10,2)
◯ DEL = 2
◯ Y = SMTH1(X,DEL)

DLINF3

A Y.K=DLINF3(X.K,DEL)
L X.K=X.J+DT*IN.JK
N X=IN
R IN.KL=100+STEP(10,2)
C DEL=2
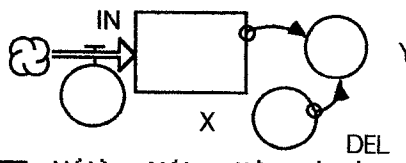
▢ X(t) = X(t – dt) + (IN) * dt
INIT X = IN
   INFLOWS:
      ⇶ IN = 100+STEP(10,2)
◯ DEL = 2
◯ Y = SMTH3(X,DEL)

Logical Functions
CLIP & FIFGE
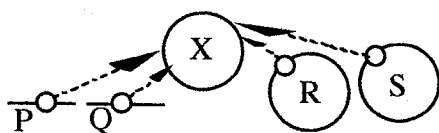
A X.K=CLIP(P.K,Q.K,R.K,S.K)
or A.K=FIFGE(P.K,Q.K,R.K,S.K)
C P=10
C Q=0
A R.K=-2+TIME.K*2
A S.K=8

MAX A X.K=MAX(MAX(X1.K,X2.K),X3.K)

MIN A X.K=MIN(MIN(X1.K,X2.K),X3.K)
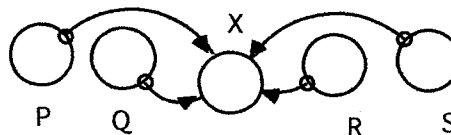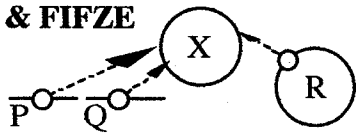

◯ P = 10
◯ Q = 0
◯ R = -2+TIME*2
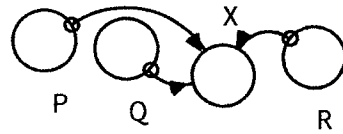◯ S = 8
◯ X = IF R≥S THEN P ELSE Q
◯ X = MAX(X1,X2,X3)
◯ X = MIN(X1,X2,X3)

SWITCH & FIFZE

A X.K=SWITCH(P.K,Q.K,R.K)
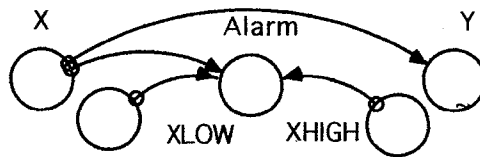 or A.K=FIFZE(P.K,Q.K,R.K)
C P=10
C Q=0
A R.K=-2+TIME.K*2

$\bigcirc$ P = 10
$\bigcirc$ Q = 0
$\bigcirc$ R = -2+TIME*2
$\bigcirc$ X = IF R=0 THEN P ELSE Q

Table Funcions
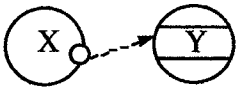## TABLE

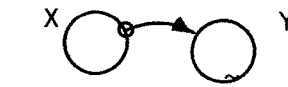A Y.K=TABLE(TAB,X.K,0,6,1)
T TAB=-20/0/20/20/40/40/50
A X.K=TIME.K-1

$\bigcirc$ Alarm = IF X<XLOW OR X>XHIGH
THEN SOUND(1) ELSE SOUND(0)
$\bigcirc$ X = TIME-1
$\bigcirc$ XHIGH = 6
$\bigcirc$ XLOW = 0
$\oslash$ Y = GRAPH(X)
(0.00, -20.0), (1.00, 0.00), (2.00, 20.0),
(3.00. 20.0),(4.00, 40.0), (5.00, 40.0),
(6.00, 50.0)

TABHL

A Y.K=TABHL(TAB,X.K,0,6,1)
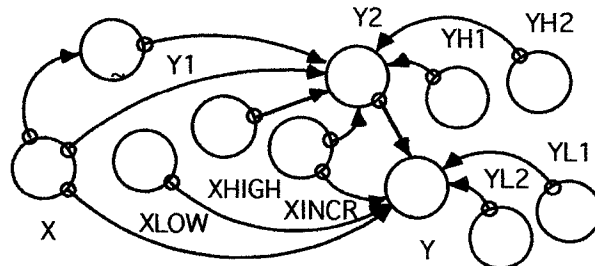T TAB=-20/0/20/20/40/40/50
A X.K=TIME.K-1

$\bigcirc$ X = TIME-1
$\oslash$ Y = GRAPH(X)
(0.00, -20.0), (1.00, 0.00), (2.00, 20.0),
(3.00. 20.0),(4.00, 40.0), (5.00, 40.0),
(6.00, 50.0)

TABXT

A Y.K=TABXT(TAB,X.K,0,6,1)
T TAB=-20/0/20/20/40/40/50
A X.K=TIME.K-5

The variables of this function correspond to the followings in DYNAMO:
  A   **Y.K=TABXT(TAB, X.K, XLOW, XHIGH, XINCR)**
  T   **TAB=YL1/YL2/... /YH1/YH2**

$\bigcirc$ X = TIME-5
$\bigcirc$ XHIGH = 6
$\bigcirc$ XINCR = 1
$\bigcirc$ XLOW = 0
$\bigcirc$ Y = IF X<XLOW THEN ((YL1-YL2)/-XINCR)*X+
    (YL1*(XLOW+XINCR)-Y2*XLOW)/XINCR ELSE Y2
$\bigcirc$ Y2 = IF X>XHIGH THEN ((YH1-YH2)/-XINCR)*X+
    (YH1*XHIGH-YH2*(XHIGH-XINCR))/XINCR ELSE Y1

○ YH1 = 40
○ YH2 = 50
○ YL1 = -20
○ YL2 = 0
⊘ Y1 = GRAPH(X)
(0.00,-20.0),(1.00,0.00),(2.00,20.0),(3.00,20.0),
(4.00,40.0),(5.00,40.0),(6.00,50.0)

TABPL This function uses a cubic spline, one of polynominal approximation, which is so complicated that the conversion of this function is excluded here.

Test Input Functions

PULSE While DYNAMO uses three arguments, PD Plus uses four arguments due to the Runge-Kutta option. The first arguments of DYNAMO and PD Plus are the pulse height. STELLA, which has the Runge-Kutta option also, uses three arguments. The first argument is volume, and its first pulse and interval should be specified as constants. (* indicates PD Plus)

R X.KL=100+PULSE(10,2,5)
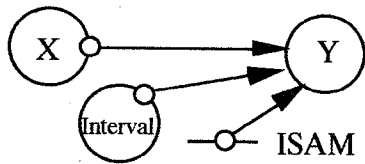* R X.KL=100+PULSE(10,DT,2,5) } ⟶ X = 100+PULSE(10*DT,2,5)

RAMP   A X.K=100+RAMP(10,2)   ⟶   ○ X = 100+RAMP(10,2)

Random-Number Functions
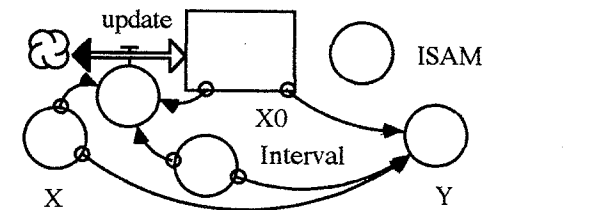
NOISE   A X.K=NOISE()   ⟶   ○ X = RANDOM(-0.5,0.5,SEED)

NORMRN   A X.K=NORMRN(2,1)   ⟶   ○ X = NORMAL(2,1,SEED)

SAMPLE   ⟶

A Y.K=SAMPLE(X.K,
X   INTERVAL.K,ISAM)
A X.K=TIME.K
A INTERVAL.K=2
C ISAM=10

□ XO(t) = XO(t - dt) + (update) * dt
INIT XO = ISAM
INFLOWS:
    update = PULSE(X-XO,
        STARTTIME+Interval,Interval)
○ Interval = 2
○ ISAM = 10
○ X = TIME+100
○ Y = IF (PULSE(1,STARTTIME+Interval,
   Interval)=0) THEN XO ELSE X

STEP   A X.K=100+STEP(10, 2)   ⟶   ○ X = 100+STEP(10,2)

Trigonometric Functions

EXP   A X.K=EXP(A.K), where -174≤A≤174   ⟶   ○ X = EXP(A)

LOGN   A X.K=LOGN(A.K), where A>0   ⟶   ○ X = LOGN(A)   , where A>0

SQRT   A X.K=SQRT(A.K), where A≥0   ⟶   ○ X = SQRT(A)   , where A≥0

SIN   A X.K=SIN(A.K), where -823,000<A<823,000   ⟶   ○ X = SIN(A)

COS   A X.K=COS(A.K), where -823,000<A<823,000   ⟶   ○ X = COS(A)

Applications of a Sub-model and an SCO of STELLA II (Mac v3.0.4)

A Sub-model and a Space Compression Object (SCO) are mechanisms for managing complexity. They also enable us to compress the space for a diagram. An SCO cannot have a flow diagram across its boundary. The most part of DELAYP function of STELLA II is a Sub-model (*on the left below*), and SAMPLE function of STELLA II is inside an SCO (*on the right below*) which gets three values outside of it by the converters for the arguments.

A Sub-model of DELAYP of STELLA   **An SCO of SAMPLE function of STELLA**
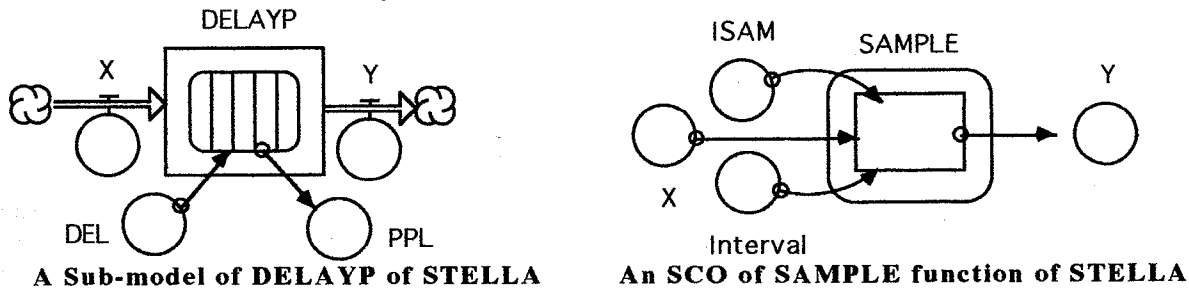
Conclusion

We've shown our findings: general features of DYNAMO and STELLA, and a conversion table of DYNAMO functions into STELLA II functions. In conclusion, we apply these findings to converting the model of Saturday Evening Post written in DYNAMO (Hall 1973) into a model in STELLA II (V3.0.4.) for the aim of estimating these findings. Figure 1 shows our successful conversion of this model in terms of the following points.

1. Each sector of the original model is mapped completely.

2. As Macro PIPEOUT in the original model uses PULSE function whose first pulse is specified as a variable, it is unable to convert this function into STELLA II because the first pulse and interval of PULSE function in STELLA II should be constant. So Macro PIPEOUT, which computes a one-year pipeline delay, is converted completely into a converter RSE in this model using DELAY function in STELLA II. DELAY function returns a delayed value of input, using a fixed lag time of delay duration and an optional value initial for the delay. (Take care that tthis function in STELLA II is entirely different from the term "delay" in DYNAMO!)

3. SAMPLE function in DYNAMO is converted simply as well as completely into SAMPLE1~3 using Space Compression Object (SCO) of STELLA II v3.0.4.

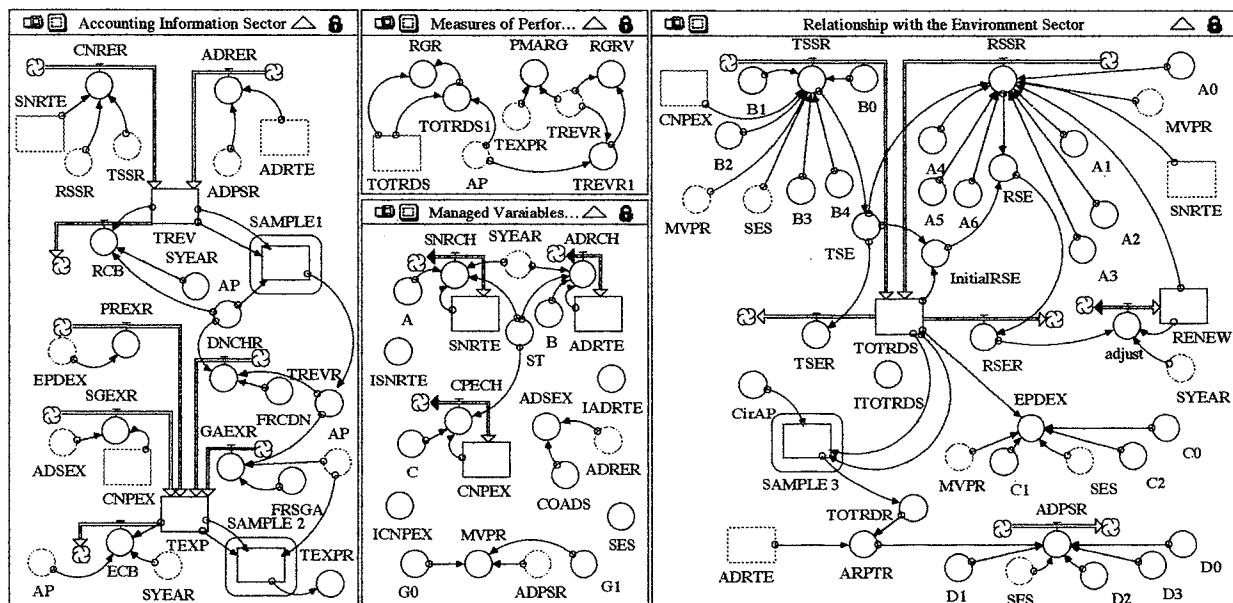4. In order to break simultaneous computation in this model, a new stock RENEW is inserted

Figure 1 The Old Saturday Evening Post Model written in STELLA II (Mac v3.0.4)

into this model. This revise does not changes the important logic of the original model.

5. Although the initial value of the stock TREV is based on the initial value of the rate RSSR in the original model, an N equation for a rate in DYNAMO is not allowed in STELLA II. So a new logic is devised in order to compute the initial value of TREV without using RSSR. This new logic in STELLA II does not change the important logic of the original model.

6. All the results of computation of this model are the same as those of the original model.

        Figure 2 is a high-level mapping of this model, which supports Figure 1 with a simple and clear picture of the interrelationships among the sectors of the model. After this successful conversion, we changed all the names of the variables into the long labels expressing the actual circumstances for the more convenience of understanding the model.
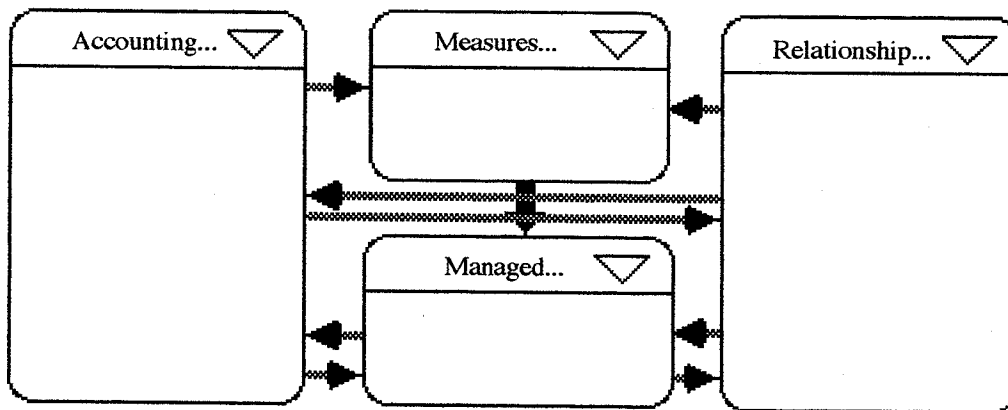

Figure 2 A High-Level Mapping of Figure 1

References

Clark, Thomas D., JR., Victoria L. Mitchell, and Karen L. Williams 1990. End User Computing Growth and Management in Organization. *Proceedings of 1990 International System Dynamics Conference* (July 10-13): 201-215.

Forrester, J. W. 1961. *Industrial Dynamics*. Cambridge, Mass.: MIT Press.

Hall, Roger I. 1973. *A System Model of a Magazine Publishing Firm*, Seattle: Unpublished doctoral dissertation. University of Washington.

Hall, Roger I. 1976. A System Pathology of an Organization: The Rise and Fall of the Old Saturday Evening Post. *Administrative Science Quarterly* 21(2): 185-211.

Hall, Roger I., Peter Aitchison, and William L. Kocay 1994. Causal policy maps of managers: formal methods for elicitation and analysis. *System Dynamics Review* 10(4): 337-360.

Long, G. Gale 1990. Review: A Business User's Guide to STELLA. *System Dynamics Review* 6(1): 112-113.

Mandinach, Ellen B, Hugh F. Cline 1994. Systems, science, and schools. *System Dynamics Review* 9(2): 195-206.

Morecroft, J. D. W., Lane, D. C., and Vitta, P. S. 1991. Modelling Growth Strategy in a Biotechnology Startup Firm. *System Dynamics Review* 6(2): 93-116.

Pugh, Alexander L., III. 1983. *DYNAMO USER'S MANUAL*(Sixth edition). MIT press

Richardson, George P., and Alexander L. Pugh III. 1985. *Introduction to System Dynamics Modeling with DYNAMO*. Cambridge, Mass.: MIT Press.

Richardson, George P. 1985. Introduction to the System Dynamics Review. *System Dynamics Review* 1(1): 1-3.

Richardson, George P. 1991. NOTES AND INSIGHTS: What are We Publishing? A view from the Editor's Desk. *System Dynamics Review* 7(1): 61-67.

Richmond, Barry, Steve Peterson, and Peter Vescuso 1987. *An Academic User's Guide to STELLA*. High Performance Systems.

Saeed, Khalid 1989. Review: An Academic User's Guide to STELLA. *System Dynamics Review* 5(2): 217-220.

Shimada, Toshiro, edit. 1994. *System Dynamics Nyumon(Japanese)*. Nikkagiren.

Wholstenholme, Eric. F. 1990. *System Enquiry*. John Wiley & Sons.

High Performance Systems, Inc. 1993. *STELLA II: Technical Documentation*.

Pugh Robert Associates, Inc. 1986a. *Professional DYNAMO Plus : Introductory Guide and Tutorial*.

Pugh Robert Associates, Inc. 1986b. *Professional DYNAMO Plus : Reference Manual*.