A Conventional Versus a System Dynamics Approach to Planning

Ali N Mashayekhi
Institute for Research in Planning and Development
P.O.Box 19395/4647, Tehran, Iran
Fax: 21 2577216

Abstract

In the conventional view, planning is a process in which various goals for the future are set and action programs are formulated to achieve those goals. Future goals and appropriate plans are formulated based on analyses of environmental forces and audits of internal conditions or strengths and weaknesses. Then, plans are implemented to achieve the goals. But, In the System Dynamics view, planning is a decisive formulation of policies or decision making rules which will enable the system to evolve from it's present state to the desired one. The design of decision making rules is within a framework of feedback and based on consideration of the fact that new conditions will lead to new decisions and actions as the system moves towards it's desired states. The implication of these two views in planning is discussed with respect to management of a company within a growing market.

A Conventional versus a System Dynamics Approach to Planning

1. INTRODUCTION

Planning is a major function of management in all managerial levels from national to departmental levels in companies. System Dynamics as an approach to planning is used to help management to perform this function in some what different ways from the conventional approaches. This paper discusses the differences between System Dynamics and the conventional approaches to planning. Then, Forrester's market growth model is used to analyse the behaviorial implications of two approaches.

2. PLANNING APPROACHES

Two planning approaches are going to be discussed: The conventional approach and System Dynamics approach.

2.1 The conventional approach

The conventional planning approach, as presented in textbooks, is shown in Figure 1. In this approach, planning is a cyclical activity which occurs once in a while (every year, or once every two to three years). The goal of each planning cycle is to formulate a plan which should be implemented during the period that ends with the beginning of the next planning cycle. Planning, as shown in Figure 2, can be thought of as decision making in a short period of time, i.e, during the planning period, about what should be done during the implementation period. In each planning cycle, based on internal conditions as well as environmental factors, a set of objectives is set . Then, plans are formulated to achieve the objectives. Plans are executed and new conditions are then created. The results of plan implementation are measured, deviations from the plans are analysed, and the results are used in the new cycle of planning to design new set of objectives and plans.

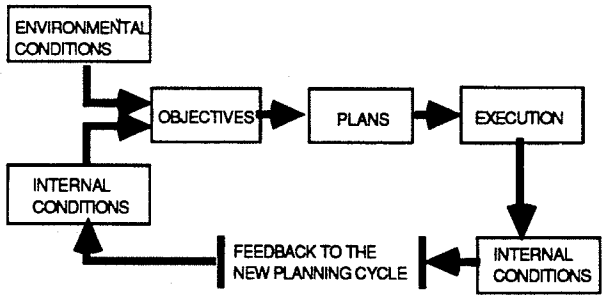


Figure 1: Conventional planning cycle

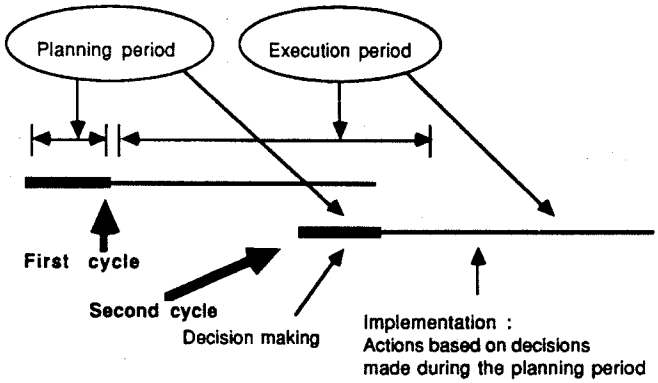
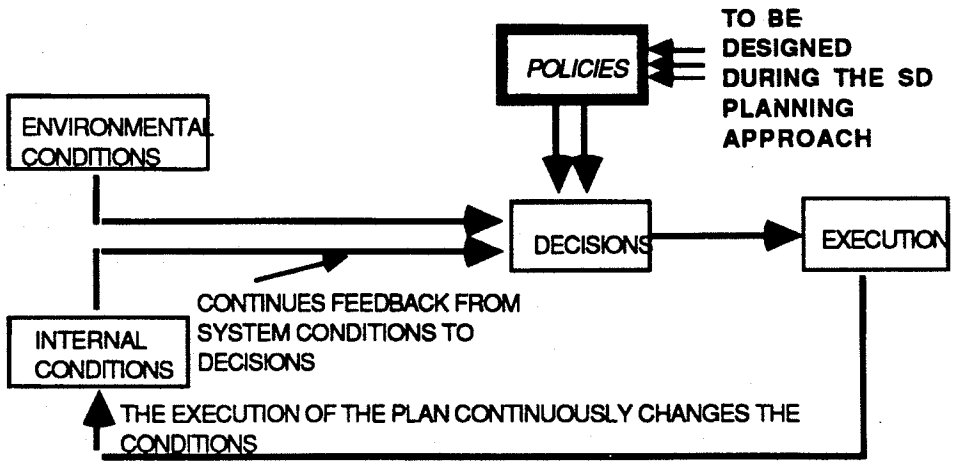


Figure 2: Conventional planning is decision making during the planning period for implimentation during the execution period.

2.2 The System Dynamics approach

Planning in System Dynamics consists of designing appropriate policies which govern a stream of decisions on a continuous basis, as shown in Figure 3. In System Dynamics, the major task is to design policies and not specific decisions which should be made according to those policies, given the prevailing conditions. Decisions that should be made during the planning stage are about policies, i.e, about how to make specific decisions during the implementation stage. According to the System Dynamics point of view, the behavior of the system and the objectives that the system can achieve, or the states that the system goes through, are dictated by the policies that are designed during the planning process.



2.3 Major differences between the two approaches

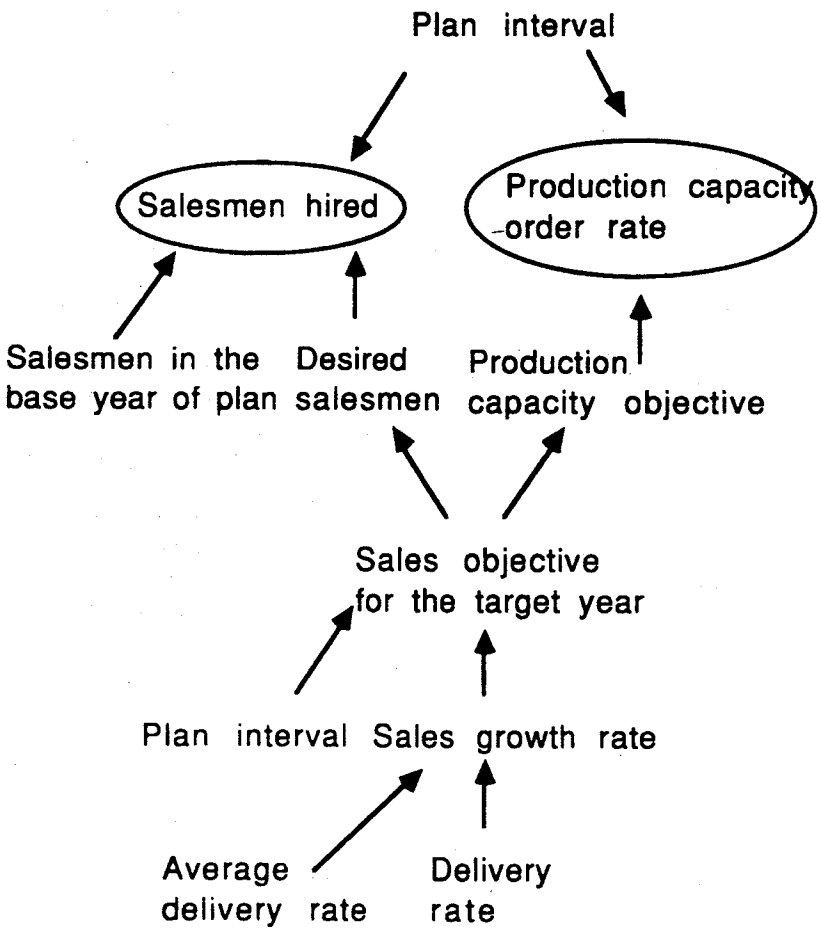
The major interrelated differences between the two approaches can be summerized as follows:

A- Feedback exists in both approaches. In the conventional approach, feedback includes considerable lags and has an impact only during the planning periods, while in System Dynamics approach feedback influences the decisions as soon as information about the new conditions becomes available.

B- The coventional approch is a cyclical, discontinued, one-shot decision making activity, where by during the planning period, decisions are made about actions that should be undertaken during the execution period. In System Dynamics approach, however, planning consists of decision making on how decisions should be made during the execution phase. In other words, in the System Dynamics planning approach, policies are designed which govern a countinous stream of decisions (during the operation of the system) about actions that should be implemented.

C- As soon as plans are implemented, conditions of the system which is one of the bases of decision changes. The conventional approach lacks a timely feedback mechanisim to consider changing conditions in the daily decisions as they occur. Conversely, in System Dynamics approach, changing conditions are countinusly considered and fed back into decision making process to shape the new decisions.

Planning practices in a centrally planned economy follow the conventional approach. Some policy formulation in management of a market economy, such as setting reserve ratio in the banking system, is in line with the System Dynamics approach.



In the next section, the managerial consequences of these differences are illustrated in a company model.

3. MANAGERIAL IMPLICATIONS OF DIFFERENT APPROACHES

To show and analyse the managerial concequences of two planning approaches, Forrester's market growth model has been modified to incoperate the possibilities of simulating the conventional planning approach. It is assumed that the model is a valid presentation of a company in the real world. Then, the performance of the company is examined under two planning approaches.

In order to modify the model, some equations have been added to make possible the application of a conventional planning approach to the salesman hiring and production capacity expansion. Figure 4 shows a causal flow diagram for the formulation of salesman hiring and capacity ordering. The STELLA equations of the modified model are presented in the Appendix. Two switches, SW_SALES_PLAN, and SW_CAP_PLAN have been put into the model to switch from a SD policy formulation approach to a conventional planning approach.

In the conventional approach a planning interval is choosen. Then, at the beginning of each interval, objectives of the number of salesmen and production capacity are set for the end of plan the interval based on sales objective. The sales objective is set based on the current sales and a growth rate during the plan period equivalent to the recent growth rate of the delivery rate. During the plan period, the company sticks to the plan and moves towards its objectives of salemen linearly. During planning, it is assumed that by acheiving to the salemen objective, the sales objective will be acheived too. For the production capacity ordering, the difference between objective and production capacity is ordered with a puls function at the beginning of the plan interval in order to have the prodcution capacity ready by the end of the plan period. Plan period, PINT_Plan_interval, is a constant and here is set equal to 12 months. The salesmen objective, or DS_DES_SALESMAN, for the end of the plan period

is set based on the sales ojective, SO_Sales_objective, and average sales effectiveness at the time of objective setting, SEUP_SE_used_in_pl. The production capacity objective, PCO_Prod_cap_obj, is also set based on the sales objective and normal capacity utilization, NCU_Normal_cap_util. Objectives for the end plan period are held constant during the plan period.
In the current formulation, the effect of the availability of resources on the hiring and capacity ordering rate has not been considered. Therefore, the impact of planning approach on the performance through resource availability has not been included.

3.1 Performance based on a System Dynamics planning approach

Figures 5 and 6 show the performance of the system as presented in Forrester's paper using system dynamics approach to planning and policy design . Figure 5 shows the result of a better policy when capacity expansion is based on a fixed delivery delay goal which does not detoriate as delivery delay performance worsens (Figure 13 of Forrester's paper). Figure 6 shows performance when production capacity expansion is based on delivery delay goal which adjusts itself to traditional delivery delay, or delivery delay that company gets used to, Figure 14 of Forrester's paper. In System Dynamics approach to planning, for a better growth performance, the capacity expansion policy which generates Figure 5 is recomended. In both Figures, objective setting for sales and production capacity in conventional planning approach are disregarded. In other words, in Figures 5 and 6, it is assumed that the company does not stick to the plans prepared in conventional ways. Decisions are made based on some rules and procedures, identified by policies, considering internal and external conditions. When the company is managed based on predetermined policies, the nature of those policies determine the performance rather than the objectives and plans which might be formulated during the conventional planning periods.

3.2 Performance based on a conventional planning approach

Figures 7.1 and 7.2 show the behavior of the model when salemen hiring and capacity expansion are based on decisions made in conventional planning approach. In this experiment the company sticks to the plans although management's delivery delay goals, which is set constant as it was for Figure 5, might not be satisfied. In terms of growth, the performance of the system in Figures 7 is not as good as the performance in Figure 5 where proper policy is designed and implemented using System Dynamics approach. However, the performance shown in Figures 7, is better than the performance shown in Figure 6 where not a proper policy is implemented using a System Dynamics approach. Therefore, when a company operates based on policies that govern its day to day decisions, rather than based on decions that are made during planning period, then its performance could be better or worse depending on the governing policies. In both cases there is a feedback from results to the decision stream. In the conventional planning approach the feedback is discountinued with considerable lags, in System Dynamics approach the feedback is continues and with no or shorter lags. In the conventional planning, the system might limit itself because of not feeding back quickly enough the new conditions, resulted from previous decisions, into new decisions.

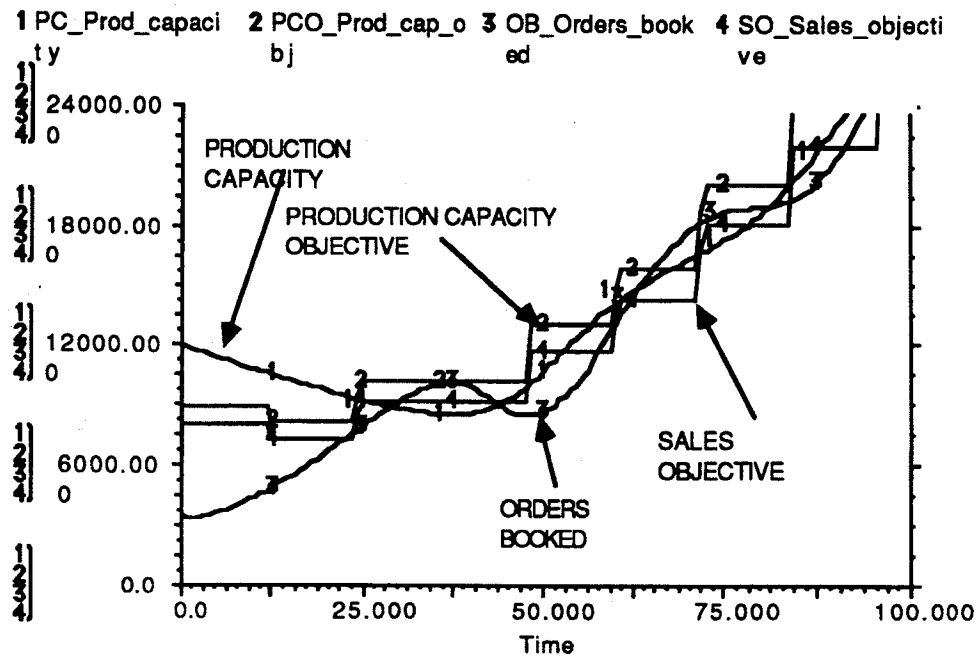


Figure 5: The System Dynamics approach: Model performance with capacity expansion policy based on a constant delivery delay goal.

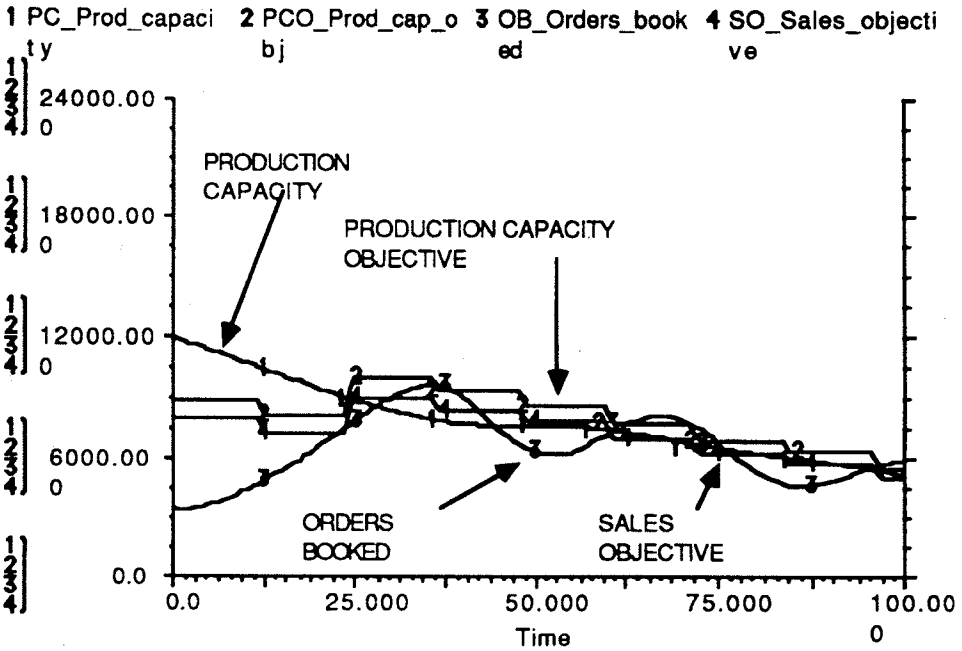


Figure 6: The System Dynamics approach: Model performance with a capacity expansion policy based on a traditional delivery delay goal.

4.

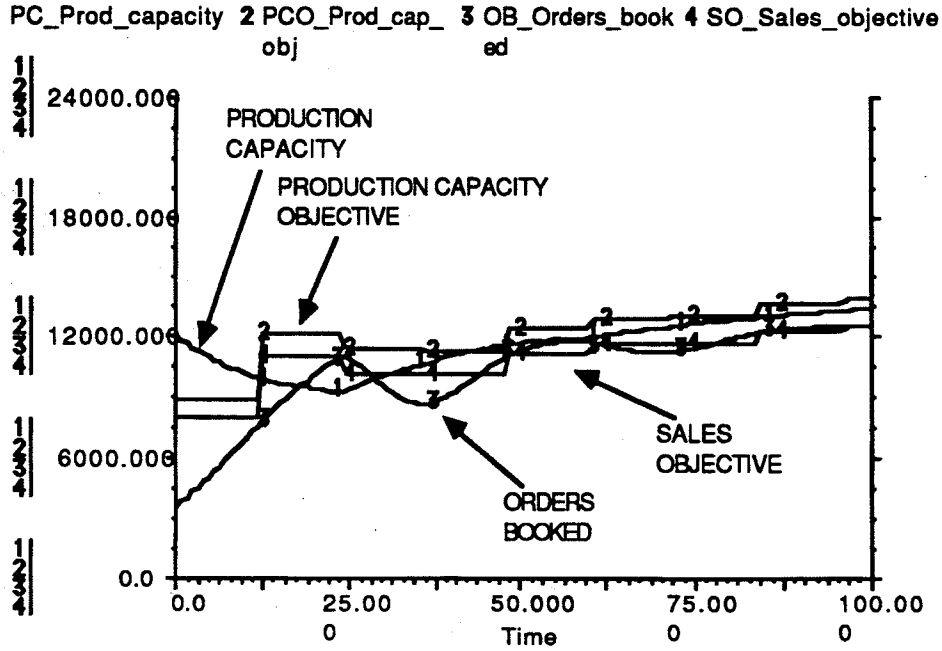


Figure 7.1: The conventional approach: The model behavior with capacity expansion and the hiring of salesmen based on a conventional approach.

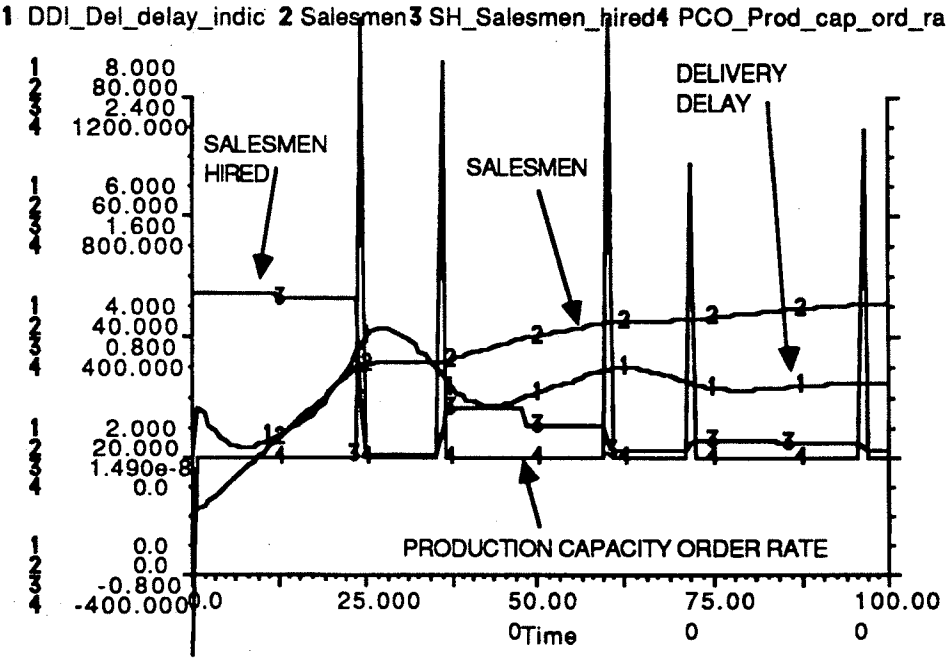


Figure 7.2: The conventional approach: The model behavior with capacity expansion and the hiring of salesmen based on a conventional approach.

C

CONCLUSION

As can be seen from Figures 5, 6, and 7, when a plan is formulated and implemented based on the System Dynamics planning approach, the performance of the system can be either better or worse than when plans are formulated based on a conventional approach. When a good system dynamics policy is planned and implemented, because the result of decisions is fed back to the decision making process imediately and continusly, the compounding effect of feedback mechanism causes the positive results of decisions accumulate and raise more rapidly. For the same reason, when the policy is not designed properly, then the compounding effect of feedback mechanisim causes the poor policy to create a worse behavior. In the conventional planning, if the environment is favorable and during the planning a set of coordinated decisions are made, as usually are, then the performance of the system will be better than when a poor policy is implemented with a compounding effect. The System Dynamics approach could lead into a superior results only if the modeling is done properly and good policies are designed and implemented.

REFERENCES:

Forrester, 1968, Jay W., Market Growth as Influenced by Capital Investment, Industrial Management Review, 9, No. 2 pp. 83-105.

APPENDIX - STELLA EQUATION

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ADRA = ADRA + dt * ( CADRA )
INIT(ADRA) = DRA_Delivery_rate_a
ASE_Ave_sale_eff = ASE_Ave_sale_eff + dt * ( CASE )
INIT(ASE_Ave_sale_eff) = SE_Sales_eff
Base_Salesman = Base_Salesman + dt * ( CBS_man )
INIT(Base_Salesman) = Salesmen
B_Backlog = B_Backlog + dt * ( OB_Orders_booked - DR_Delivery_rate )
INIT(B_Backlog) = 2000
DDRC = DDRC + dt * ( CDDRC )
INIT(DDRC) = B_Backlog/DR_Delivery_rate
DDRM = DDRM + dt * ( CDDRM )
INIT(DDRM) = DDI_Del_delay_indic
DDT = DDT + dt * ( CDDT )
INIT(DDT) = DDRC
DRA_Delivery_rate_a = DRA_Delivery_rate_a + dt * ( CAR )
INIT(DRA_Delivery_rate_a) = DR_Delivery_rate
PCDO = PCDO + dt * ( -PCR + PCO_Prod_cap_ord_ra )
INIT(PCDO) =PCO_SD_PLANNING*12
PC_Prod_capacity = PC_Prod_capacity + dt * ( PCR )
INIT(PC_Prod_capacity) = 12000
Salesmen = Salesmen + dt * ( SH_Salesmen_hired )
INIT(Salesmen) = 10
SEUP_SE_used_in_pl = SEUP_SE_used_in_pl + dt * ( CSEUP )
INIT(SEUP_SE_used_in_pl) = ASE_Ave_sale_eff
SO_Sales_objective = SO_Sales_objective + dt * ( CSO )
INIT(SO_Sales_objective) =8*DRA_Delivery_rate_a
B_Budget = RS_Revenue_to_sales*DRA_Delivery_rate_a
CADRA = (DRA_Delivery_rate_a-ADRA)/DRAT
CAR = (DR_Delivery_rate-DRA_Delivery_rate_a)/DRAT
CASE = (SE_Sales_eff-ASE_Ave_sale_eff)/1
CBS_man = IF (INT(TIME/PINT_Plan_interval)- (TIME/PINT_Plan_interval)=0) THEN (Salesmen-
Base_Salesman)/DT ELSE 0
CDDRC = (DDI_Del_delay_indic-DDRC)/TDDRC
CDDRM = (DDRC-DDRM)/TDDRM
CDDT = (DDRC-DDT)/TDDT
CSEUP = IF (INT(TIME/PINT_Plan_interval)-(TIME/PINT_Plan_interval)=0) THEN(ASE_Ave_sale_eff-
SEUP_SE_used_in_pl)/DT ELSE 0
CSO = IF INT(TIME/PINT_Plan_interval)-(TIME/PINT_Plan_interval)=0 THEN
MIN(TIME,1)*(SOI_Sales_obj_ind-SO_Sales_objective)/DT ELSE 0
DDB = .3
DDC = (DDRC/DDOG_Del_delay_op_G)-DDB
```

```
DDI_Del_delay_indic = B_Backlog/DRA_Delivery_rate_a
DDM = B_Backlog/PC_Prod_capacity
DDMG = 2
DDOG_Del_delay_op_G = DDW*DDT+DDWC*DDMG
DDW = 1
DDWC = 1-DDW
DRAT = 1
DR_Delivery_rate = PCF_Prod_cap_frac*PC_Prod_capacity
DS_DES_SALESMAN = SO_Sales_objective/SEUP_SE_used_in_pl
GRDR_Growth_rate =(DRA_Delivery_rate_a-ADRA)/DRAT/DRA_Delivery_rate_a
IS_Indicated_saleme = B_Budget/SS_Salesman_Salary
NCU_Normal_cap_util = .9
OB_Orders_booked = SE_Sales_eff*SSW
PCO_CON_PLANNING = IF (INT(TIME/PINT_Plan_interval)-(TIME/PINT_Plan_interval)=0) THEN
(PCO_Prod_cap_obj-PC_Prod_capacity)/DT ELSE 0
PCO_Prod_cap_obj = SO_Sales_objective/NCU_Normal_cap_util
PCO_Prod_cap_ord_ra = (SW_CAP_PLAN*PCO_CON_PLANNING+(1-
SW_CAP_PLAN)*PCO_SD_PLANNING)*SW3
PCO_SD_PLANNING = IF SW3=1 THEN CEF*PC_Prod_capacity ELSE 0
PCR = PCDO/12
PINT_Plan_interval = 12
RS_Revenue_to_sales = 12
SCT_Salesmen_contac = 60
SEDC = IF TIME>SEDCT THEN SEDF ELSE  SEDI
SEDCT = 36
SEDF = 1
SEDI = 1
SEDS = IF SW2=1 THEN SEDM_Sales_eff_f_de ELSE SEDC
SEM_Sales_eff_max = 400
SE_Sales_eff = SEDS*SEM_Sales_eff_max
SH_CON = (DS_DES_SALESMAN-Base_Salesman)/PINT_Plan_interval

SH_Salesmen_hired = SH_CON*SW_SALES_PLAN+(1-SW_SALES_PLAN)*SH_SD
SH_SD = (IS_Indicated_saleme-Salesmen)/20
SOI_Sales_obj_ind = DR_Delivery_rate*(1+GRDR_Growth_rate)^PINT_Plan_interval
SSW = IF SW1=1 THEN Salesmen ELSE SCT_Salesmen_contac
SS_Salesman_Salary = 2000
SW1 = 1
SW2 = 1
SW3 = 1
SW_CAP_PLAN = 1
SW_SALES_PLAN = 1
TDDRC = 4
TDDRM = 6
TDDT = 12
CEF = graph(DDC)
(0.0,-0.0700),(0.250,-0.0440),(0.500,-0.0200),(0.750,-
0.0100),(1.000,0.0),(1.250,0.0100),(1.500,0.0200),(1.750,0.0440),(2.000,0.0700),(2.250,0.110),(2.500,0.150)
PCF_Prod_cap_frac = graph(DDM)
( 0.0,
0.0),(0.500,0.250),(1.000,0.500),(1.500,0.670),(2.000,0.800),(2.500,0.870),(3.000,0.930),(3.500,0.950),(4.000,0.
980),(4.500,0.990),(5.000,1.000)
SEDM_Sales_eff_f_de = graph(DDRM)
(0.0,1.000),(1.000,0.970),(2.000,0.870),(3.000,0.730),(4.000,0.530),(5.000,0.380),(6.000,0.250),(7.000,0.150),(
8.000,0.0800),(9.000,0.0300),(10.000,0.0200)
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