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System Dynamics and Expert System Group

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SYSTEM DYNAMICS AS A SUPPORT
FOR CASH MANAGEMENT EXPERT SYSTEMS

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INTRODUCTION

The following is meant to be an example of the combination
of an Expert System (XPS) and a System Dynamics (SD)
model in which the farreaching effects of cash management
decisions in a complex system of feedback relationships in
a company are illustrated.

The great advantage in proceeding this way is to use the
results of an Expert System as constants and initials in a
System Dynamics model. That means, that the user is en-
abled to study the results of a static Expert System in a
dynamic model.

The mentioned System Dynamics model is created on the
background of an ancillary supplier for the car industry.
Rather to simulate the real system in a very detailed way
the model reduces this real system to the main areas of
the company. As in this paper the point of main emphasis
is to demonstrate a possible way of linkage of the two
systems a short problem definition is followed by the
description of the most important feedback-loops in
causal-loop diagrams of the System Dynamic model.
Subsequently the outcome of a model simulation with it's
graphic and tabular results is to be analysed under the
aspect of influence of constants and initials origi-
nating from the Expert System concerning cash management
decisions.

PROBLEM DEFINITION

Expert Systems and System Dynamics models are two seperate
and independent methods of structuring and supporting the
taking of decisions. Budgeting and financial planing are
two of the most important scopes of duty in a company
to maintain a needed minimum of liquid resources in
general and cash assets in particular. It is most obvious,
that cash management decisions contain a great potential
of influence on every area of the company. Differentiated
by the urgency of financial requirements the Expert System
gives a number of proposals for a possible solution to
unfavourable financial shortages. On the other hand
investment proposals are made to reduce excess liquidity.
In order to show the long-term influence of cash manage-
ment decisions on the feedback formation a special soft-
ware is necessary which stores the output information of
the Expert System.

Before that data can be used as constants and initials in
SD equations it has to be processed which means, that the
numeric results of XPS have to be indicated to guarantee a
correct attachment of proposed XPS decisions and the
designations of SD constants.
This function can only be fulfilled if the structure of
the SD model complies with the preconditions which were
set in XPS, i.e. that every area of the company addressed
by XPS decisions is assigned to a corresponding point of
attachment in the SD model. As mentioned above both XPS
and SD are independent methods for supporting decision
making processes. Derived from that fact the necessity
arises to verify both systems seperately. Nevertheless the
Expert System will only be mentioned graphically to
exemplify cash management decisions. The purpose of the
following main part of the discourse is to describe the
most important points of attachment within the outline
conditions of the SD model and to examine the results of
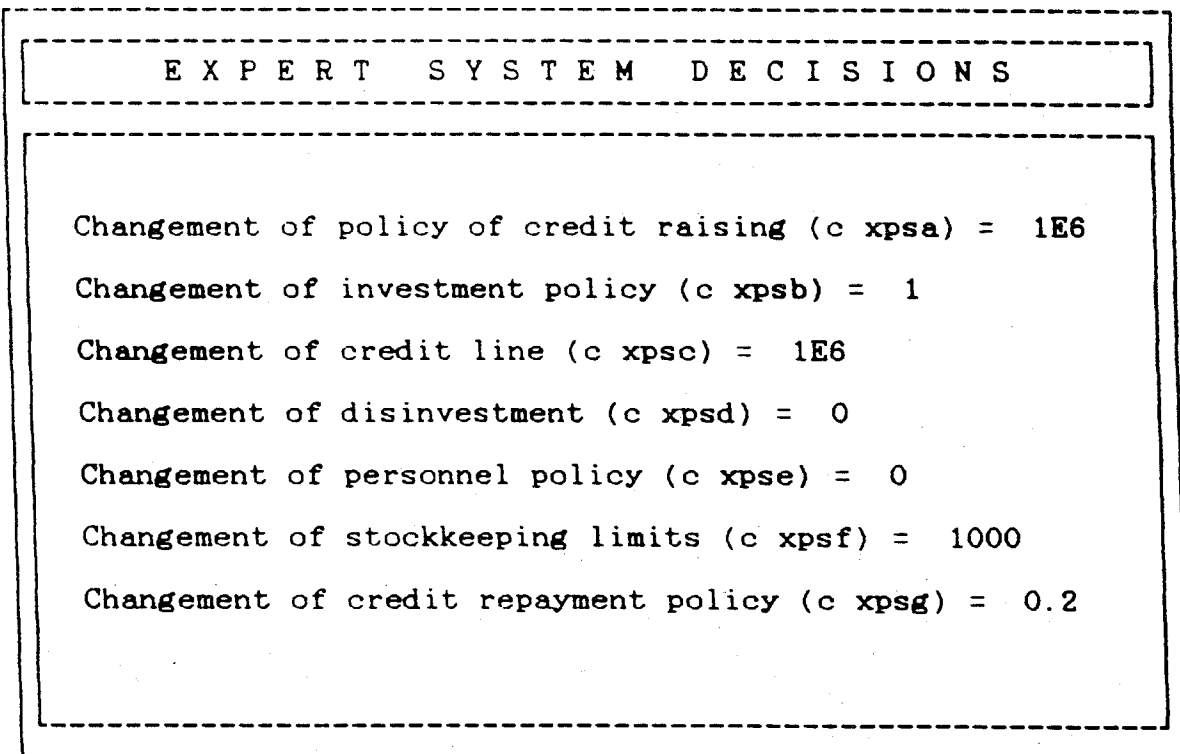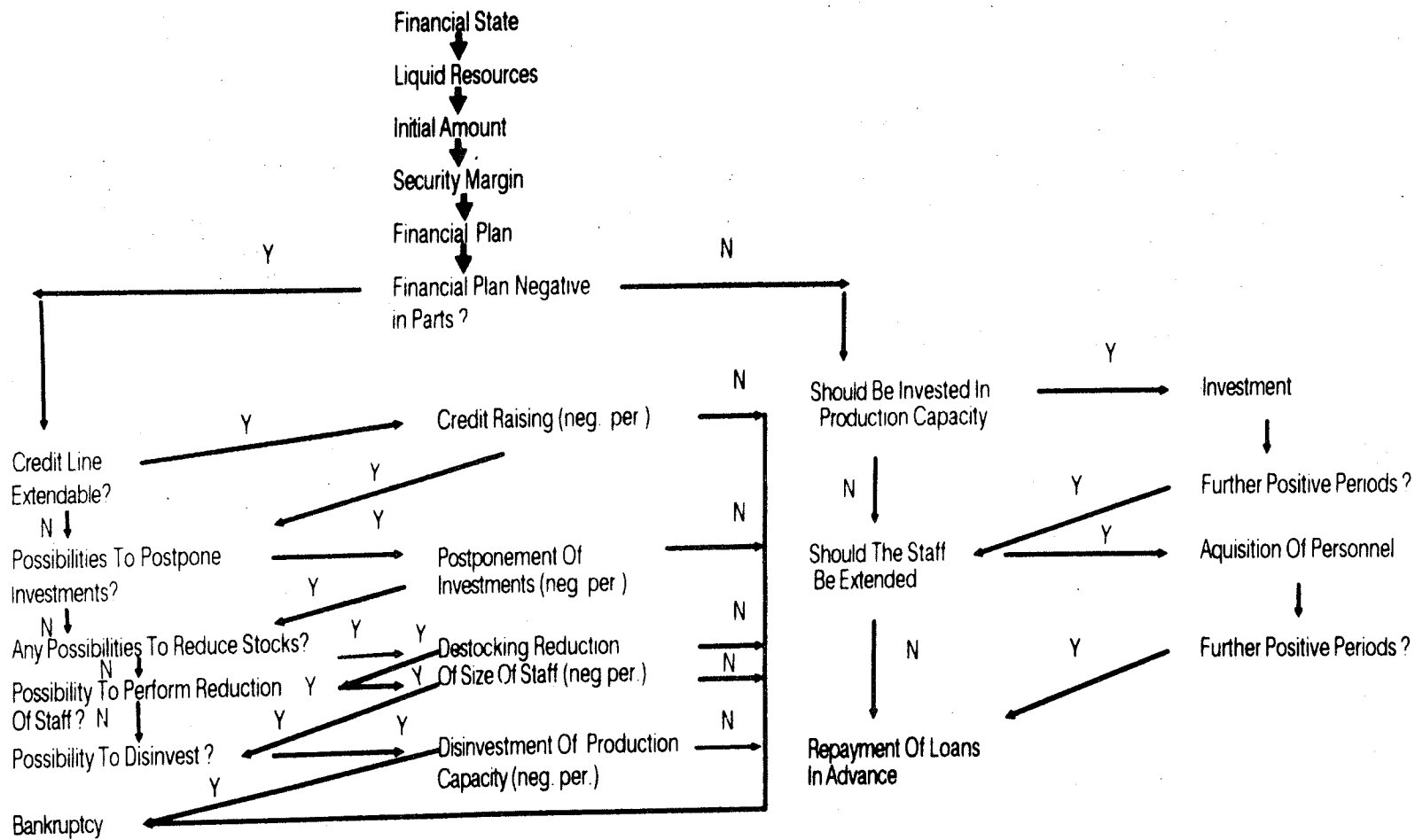the simulation of different starting points.

```
+------------------------------------------------------------+
| +--------------------------------------------------------+ |
| |    E X P E R T   S Y S T E M   D E C I S I O N S       | |
| +--------------------------------------------------------+ |
| +--------------------------------------------------------+ |
| |                                                        | |
| |   Changement of policy of credit raising (c xpsa) = 1E6| |
| |                                                        | |
| |   Changement of investment policy (c xpsb) = 1        | |
| |                                                        | |
| |   Changement of credit line (c xpsc) = 1E6            | |
| |                                                        | |
| |   Changement of disinvestment (c xpsd) = 0            | |
| |                                                        | |
| |   Changement of personnel policy (c xpse) = 0        | |
| |                                                        | |
| |   Changement of stockkeeping limits (c xpsf) = 1000   | |
| |                                                        | |
| |   Changement of credit repayment policy (c xpsg) = 0.2| |
| |                                                        | |
| +--------------------------------------------------------+ |
+------------------------------------------------------------+
```

Fig. 1: Points of attachment

Financial State

↓

Liquid Resources

↓

Initial Amount

↓

Security Margin

↓

Financial Plan

↓

Y ←————————————— Financial Plan Negative ————————————→ N
in Parts ?

N

Should Be Invested In ————————→ Investment
Production Capacity

Y ←———————— Credit Raising (neg. per)

Credit Line
Extendable?
N ↓

Possibilities To Postpone ————————→ Postponement Of
Investments? Investments (neg per)
N ↓

Any Possibilities To Reduce Stocks? ————→ Destocking Reduction
N Of Size Of Staff (neg per.)
Possibility To Perform Reduction Y
Of Staff ? N

Possibility To Disinvest ? ←————— Disinvestment Of Production
Capacity (neg. per.)

Bankruptcy

N ↓

Should The Staff ←————— Aquisition Of Personnel
Be Extended

N ↓ Y

Repayment Of Loans
In Advance

Y

Further Positive Periods ?

↓

Further Positive Periods ?

Fig. 2 : Decision Tree

THE MOST IMPORTANT FEEDBACK-LOOPS

The increasing monetary surplus of the period raises the
net cash flow and the liquid resources. This influences
the difference of liquid resources (dlm = lm - blm).
A positive difference leads to an increasing amount of
credit repayments. The total of loans and the total of
capital decrease and diminish the costs of capital.
In the event of a negative difference of liquid resources
contributions (Fig. 3) and credit raisings (Fig. 4) will
cover the lack. In both cases the capital in total will
be raised by increasing equity capital and loans. The
capital costs let the costs in total rise, the surplus of
the period will descend.
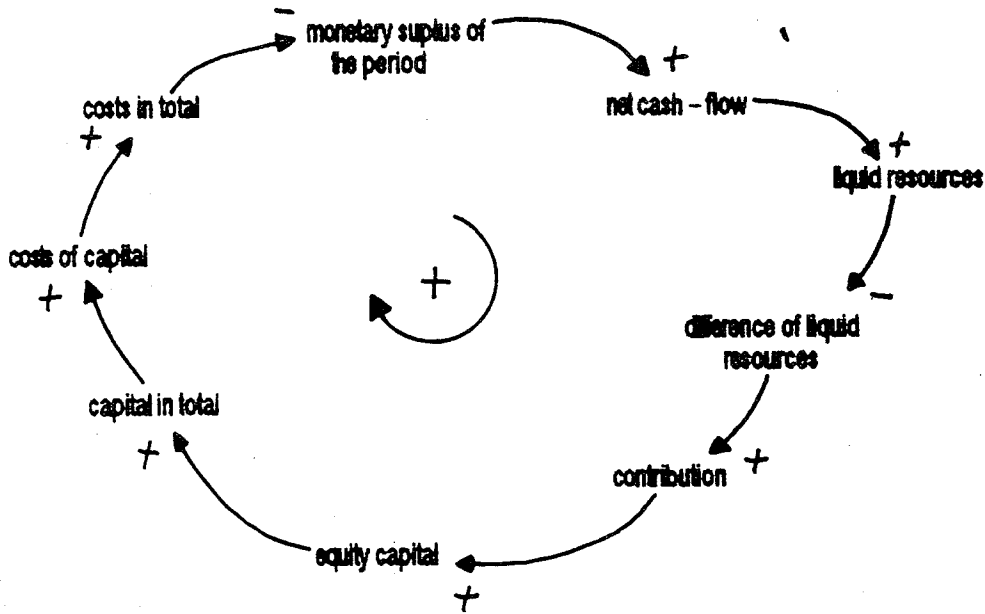
Fig. 3 : Liquid resource contribution loop
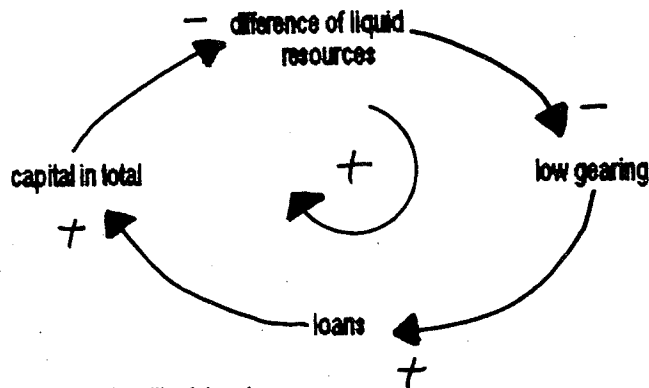
Fig. 4 : Credit raising loop

Investment increases the production capacities and here-
with the needed staff. After a certain delay the number
of employees will rise as well as the expenditures on
personnel. The higher costs diminish the surplus of the
period. As explained above this event has a diminishing
influence on the capital in total and investment will be
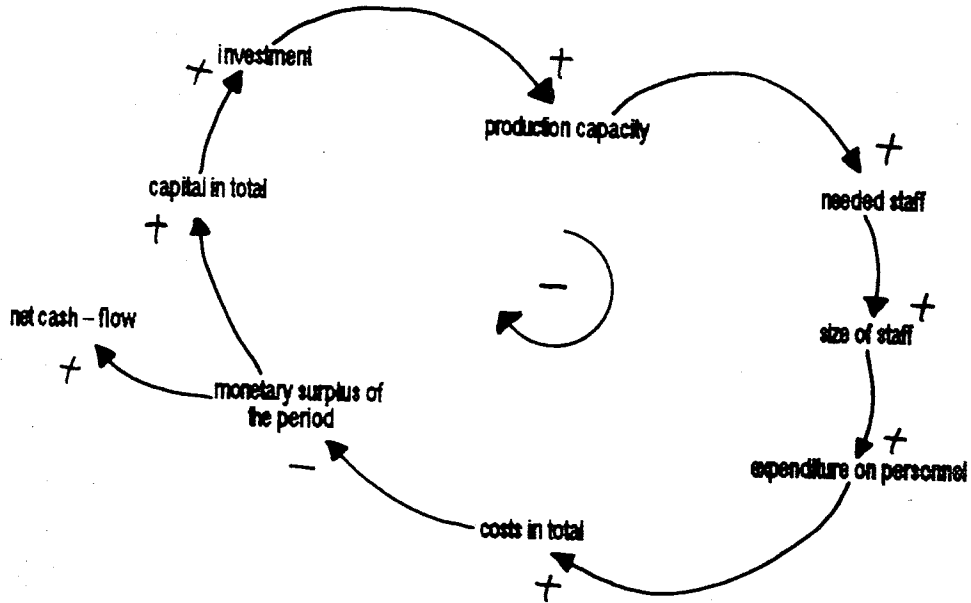reduced. (Fig. 5)

Fig. 5 : Investment effect loop

A second negative feedback loop can be built up starting with
higher investment which extends the production capacity. The
management is enabled to extend the production. In the same time
the costs of production in total will increase and this implies
higher costs in total. The monetary surplus decreases and
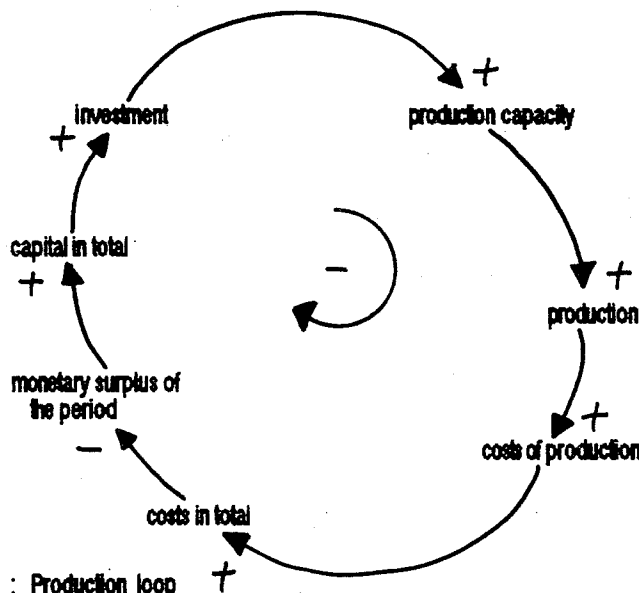initiates a growth of capital in total. (Fig. 6)
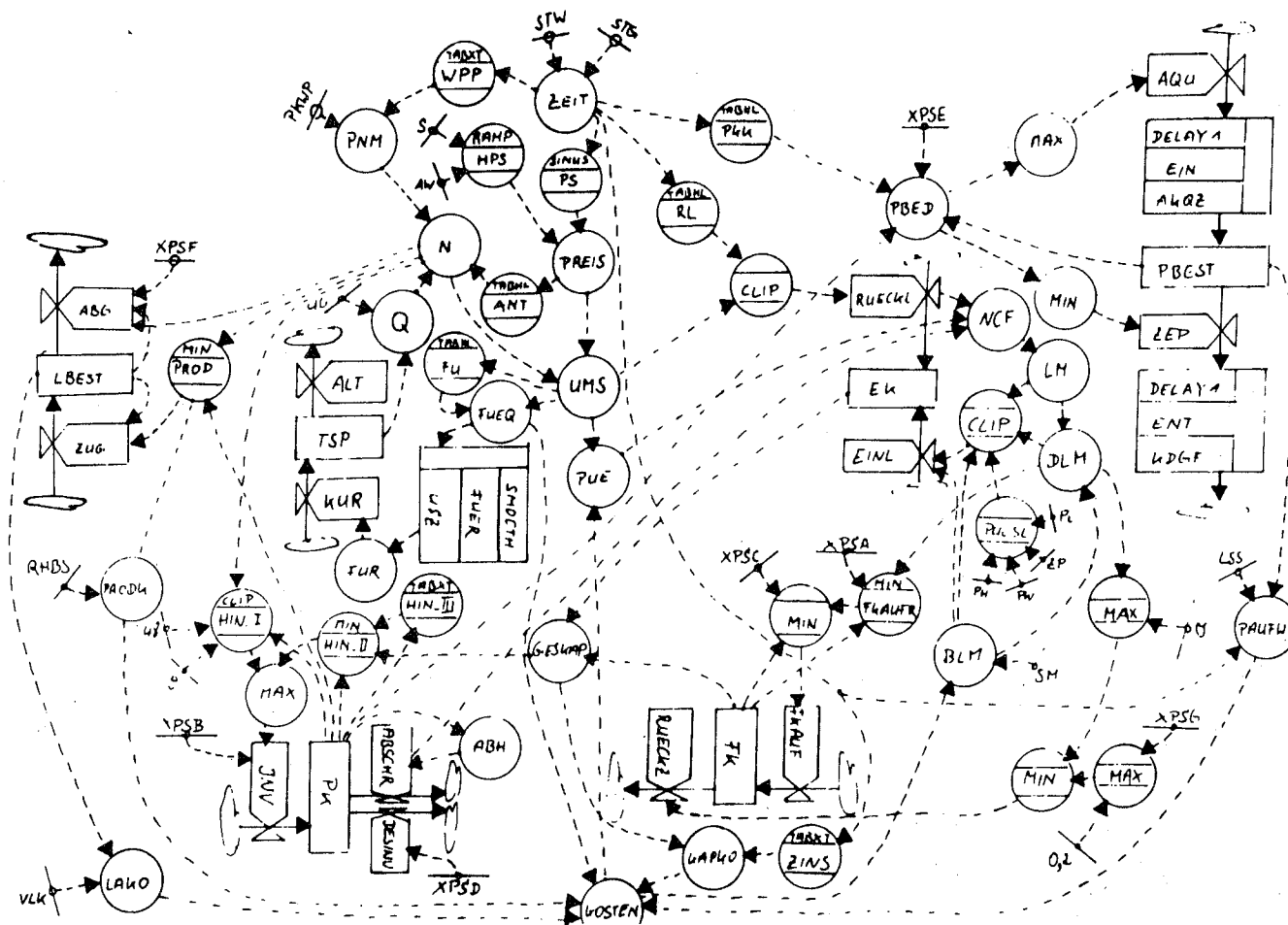

Fig. 6 : Production loop

Fig. 7 : Flow chart

```
--------------------------------------      -----------------------------------------
   area of turnover and demand                    product area
--------------------------------------      -----------------------------------------
pnm   =potential demand bec. of            fueq =research & development
       changement of market conditions          quotient
wop   =increase of production              fu   =aux. ref. fueq
tw    =table ref. pnm                      fuer =r & d rate
piwp  =production in thsd                   fur  =aux. ref. fuer
zeit  =period multiplifier                 usz  =time for transposition
stw   =start of ramp-fkt. zeit             kur  =rate of know-how transp
stg   =slope of ramp-fkt. zeit             uv   =1 - (loss in transp.)
n     =direct demand                       tsp  =technical state of prod
ant   =price influence on n.k              alt  =product obsolescence
tant  =table ref. tant                     q    =quality of products
ums   =turnover in thsd                    ug   =const. for conversion
preis=price per piece                      -----------------------------------------
ps    =inflation                              area of prduction capacity
hps   =aux. ref. ps                        -----------------------------------------
s     =slope of ramp-fkt. hps              pk    =production capacity
aw    =start of ramp-fkt. hps              desinv=disinvestion rate
------------------------------------       inv   =rate of investions
     area of finances                      hin_I=investment rule I
------------------------------------       hin_II=investment rule II
pue   =monetary surplus of the             hin_III=investment rule III
       period                              p     =period
kosten=costs in total                      abschr=rate of depreciation
kapko=costs of capital                     abh   =aux. ref. abschr.
zins  =interest-rate credits               zk    =time constant
geskap=capital in total                    -----------------------------------------
paufw=expenditure on personnel                   area of personnel
lss   =Rate of wage increase               -----------------------------------------
ek    =equity capital                      pbed =needed staff
einl  =contribution                        pkk  =prod. cap. per employee
ph    =pulshight                           aqu  =rate of aquisitions
pw    =pulswidth                           ak   =aux. ref. aqu
zp    =period of first pulse               ein  =rate of employment
pi    =pulsinterval                        pbest=size of staff
ruecil=reserve funds                       akqz =time for aquisition
ri    =amounts for res. funds              zep  =pers. to be discharged
rcf   =net cash-flow                       ent  =dischargements
lm    =liquid resources                    ldgf =period od notice
blm   =needed minimum of li.re             -----------------------------------------
sm    =security margin                           area of stocks
dlm   =difference of liqu.res.             -----------------------------------------
fk    =loans                               lbest=stock of finished goods
fkauf=high gearing                         prod =production
fkaufr=rule for high gearing               prodk=costs of production
rueckz=low gearing                         rhbs =costs of material/piece
------------------------------------       zug  =stockpiling
   points of attachment of XFS and SD      abg  =destocking
------------------------------------       lako =costs of stockkeeping
xpsa =ch. of policy of credit raising           in total
xpsb =changement of investment policy      vlk  =costs of stockkeeping
xpsc =changement of credit line                 per unit
xpsd =changement of disinvestment
xpse =changement of personnel policy
xpsf =changement of stockkeeping limit
xpsg =changement of credit repayment p.
```

Fig. 8 : Explanation

SELECTED RESULTS OF SIMULATIONS

For understanding the results of the SD model it is ne-
cessary to explain the different kinds of possible de-
cisions given by the Expert System and acting as con-
stants in the SD model. In case of a negative amount of
liquid resources five proposals are made to solve this
problem. These are further loans (xpsa and xpsc), cancel-
lation of proposed investments (xpsb), reduction of
stockkeeping (xpsf), measures to decrease expenditures on
personnel (xpse), and disinvestments (xpsd). On the other
hand a number of proposals are given for the utilization
of excess liquidity. Those are investments (xpsb), expan-
ding the number of employees (xpse), repayment of loans
(xpsg), and depositing money in time deposit accounts,
which has been neglected in this model.

In the initial position the following values were set:
xpsa= 1000000
xpsb= 1
xpsc= 1000000
xpsd= 0
xpse= 0
xpsf= 1000
xpsg= 0.2

The results of the simulation can be drawn from the
attached plots and verbal explanations.

Fig. 9: Plot No.1

-23-
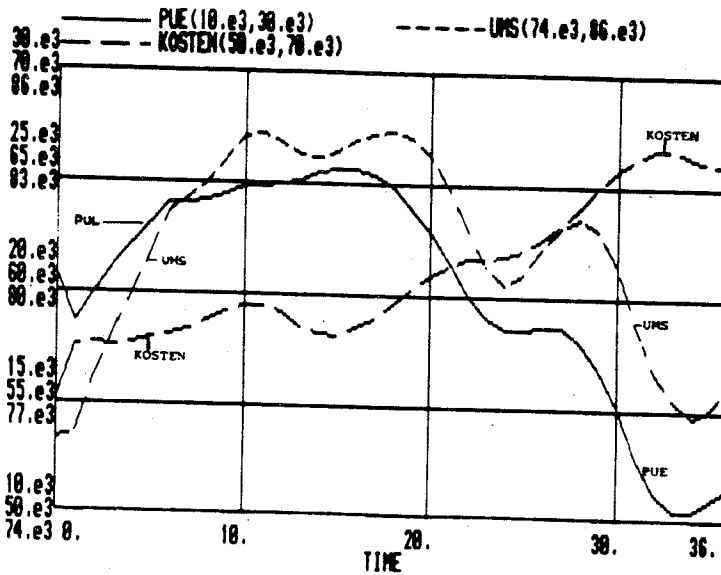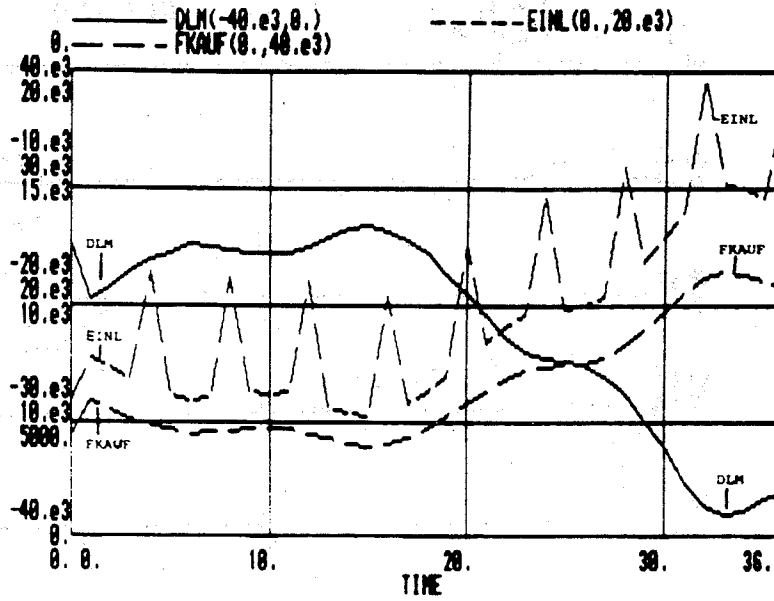
Fig. 10: Plot No.2

In the first scenario the value for investment policy
(xpsb) has been changed to 1.1. This causes an additional
amount of needed liquidy. There are no impacts on the
turnover because only the direct demand and the price in-
fluence this variable. As well as investments raising the
production capacity they do have an increasing impact on
the number of needed employees. As can be seen on the
plotted results of scenario No.1 the costs in total rise
in the long run (from 55,23e3; 66,09e3 to 55,23e3;
76,3e3). Stocks stabilize at 5648 (former 5304). Number
of staff rises from 4768 to 5495 all in period 36.
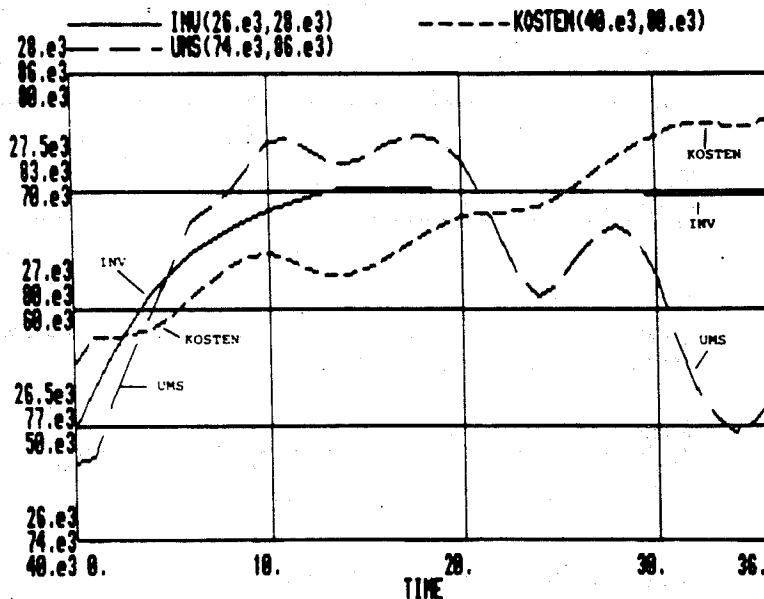
Fig. 11: Plot 1, Scenario 1
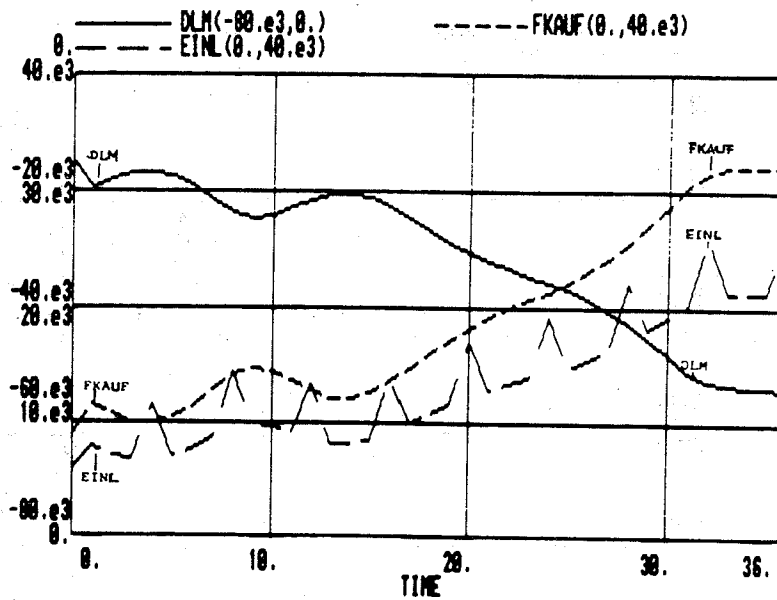
Fig. 12: Plot 2, Scenario 1

In the second scenario xpse (change of personnel policy) has been reduced (-200). This artificial reduction of staff leads to a decreasing amount of costs in the short run but gets almost compensated after bigger wavings until period 36. The production equals the one in the initial simulation from period 19 onwards, in the first 18 periods it is also characterized by greater wavings. The total amount of needed 'liquid resources as well as the surplus of the period exceed the ones from the original simulation.
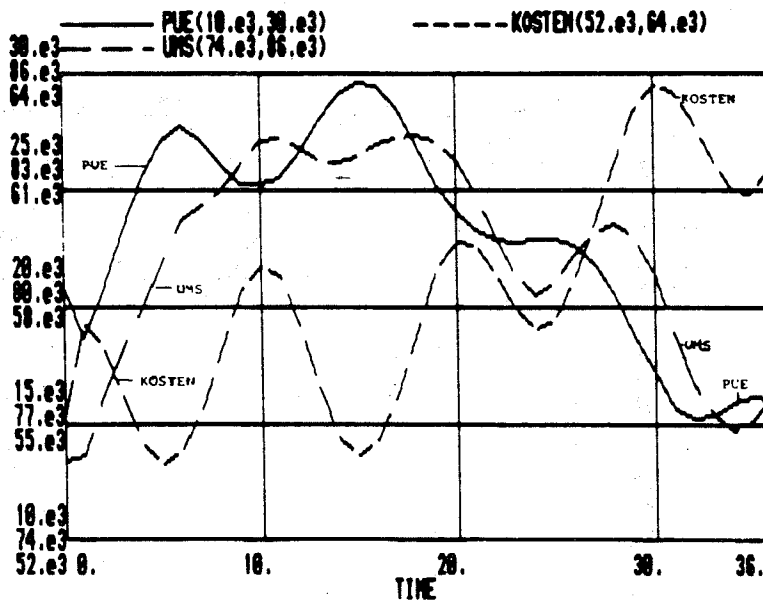
Fig. 13: Plot 1, Scenario 2
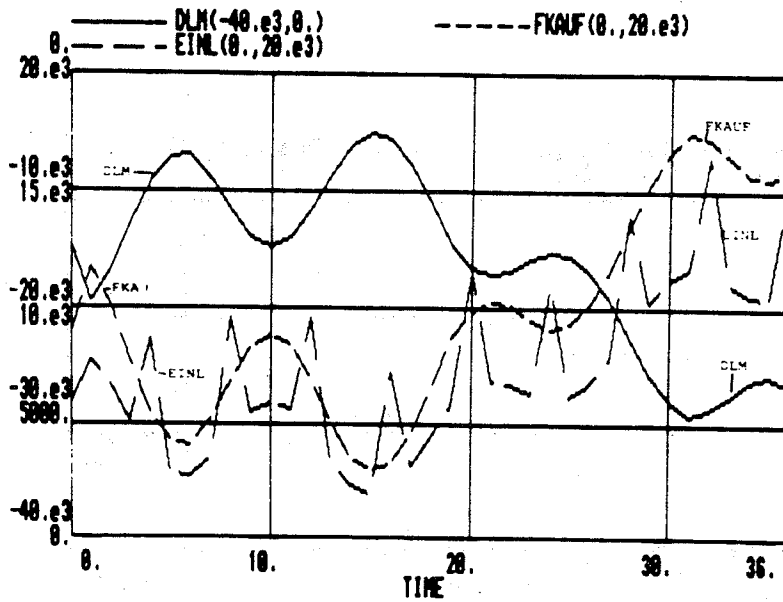
Fig. 14: Plot 2, Scenario 2

Scenario No. 3 illustrates the reduction of xpsf (stock-keeping) from the initial 1000 to a minimum of 10. This decision has no influence on the number of employees nor on the production capacity. The costs in total decline by the amount of stockkeeping costs. The needed liquid resources can be reduced by approximately 20 percent. The analyst should be aware of the fact, that this decision can only be pursued if a direct delivery of finished goods to the buyer can be guaranteed.
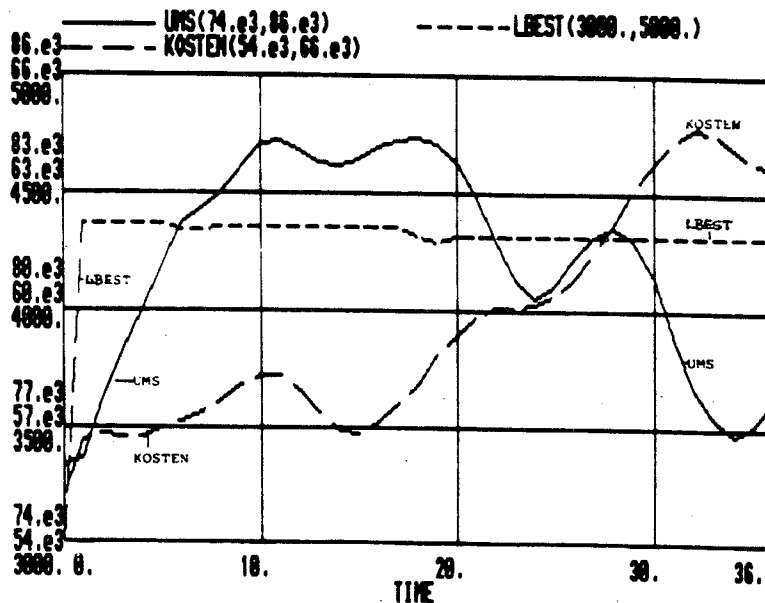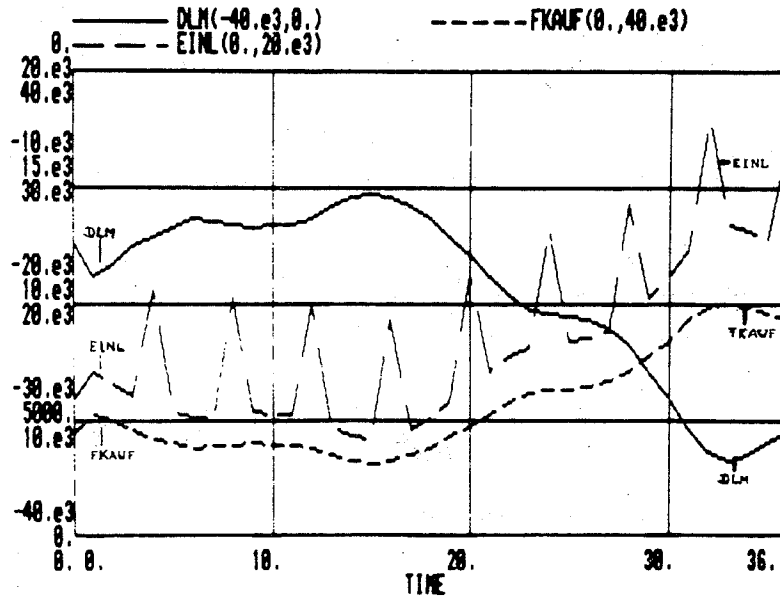

Fig. 15: Plot 1, Scenario 3

Fig. 16: Plot 2, Scenario 3