SHIPBUILDING ORGANIZATION SIMULATION MODELLING

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ABSTRACT:

System Dynamic Continuous Computer Simulation sub model of the Business-production Shipbuilding Process – PSBP, which building started during 1991/92, in the frame work of the global science project with title "ORGANIZATION MODELING OF THE PRODUCTION PREPARING DEPARTMENT IN MARINE SHIPBUILDING" financed by Ministry of Science and Technology of the Republic of Croatia, No: 2-09-366, has been a result of the system dynamic simulation modeling of the dynamic shipbuilding process - "AMORELLA". Authors of the paper give a well laid out science report of the executed simulation modeling of the PBSP, and they suggest further application of the same methodology for other shipbuilding phases.

Keywords:
System Dynamic, Continuous Computer Simulation, Shipbuilding Sub Process and Business-production Shipbuilding Process.

1. INTRODUCTION

From 1990 to 1995 the authors have explored the existing organization structure of organization production construction model for ship «AMORELLA», especially sub process of «production preparing department». Result of their research was definition of the existing organization production model by using relatively new scientifically methodological technology of System Dynamics as a way of checking the validity of the model. System Dynamic Continuous Computer Simulation Model Of The Organization Production Shipbuilding Process– "Amorella"- **PPBP**, had a multilevel function of it's goal, from which the most important one's to mention are enabling business-production managing structure to continuously:
1. check the dynamics of shipbuilding process (costs and profit of the continuous shipbuilding process in whole, account view, payments of debits and credits, status of short terms and long terms bank credits, checking on the completing of working assignments of

all of the executes of the shipbuilding process (cooperate firms and all working units of the shipyard),
2. efficiently gives the forecast of the possible effect of "bottleneck" in shipbuilding process;
3. optimizes the particular process parameters; and
4. finding the most valuable scenario of the future realization of the shipbuilding process.

2. CHARACTERISTIC OF BUISNESS – PRODUCTION SHIPBUILDING PROCESS

System Dynamics Computer Simulation Model of The Shipbuilding Process is a continuous model, which comprise: 1. qualitative (mental, verbal and structural model), and 2. quantitative (mathematical and computer model, behaviour dynamics model) model presented using DYNAMO SYMOBOLICS (diagram of material and informational flows) and as well in DYNAMO higher programming language, which is very compatible for continuous use of business-production managing structure because of the:

1. Tracking and controlling of behaviour dynamics of **PPBP** (Abbreviation for term: Business-Production Shipbuilding Process (in Croatian: Poslovno proizvodnog Brodograđevnog Procesa-**PPBP**)) ,
2. Forecasting the future behaviour of **PPBP** and
3. Optimization of parameters of **PPBP**.

The authors are using three main principles, which are: approximation and aggregation; System thinking philosophy, in order to present the Organization Business-Production Shipbuilding Process (**PPBP**) in following dynamic phases (flow of SP process) and in discrete control events (discrete event DD):

1. SP: SUPPLY OF SHIPBUILDING CAPACITY – SSC (Abbreviation for Term Supply Of Shipbuilding Capacity (in Croatian Ponuda brodograđevnog kapaciteta –**PBK**)) is now a part of global world marine market which requires: fresh market information on supply/demand fluctuation, obligate supply documentation, as well as information on market competition and information on client's financial standing (debits or credits).

2. D.D.: EFFICIENT COMPETITION TERMINATION, i.e. signing the agreement with consignee – **SA** (Abbreviation. Signing the Agreement), what initiate the sub process of **PREPARING PROJECT DOCUMENTATION AND PREPARATION FOR OTHER PHASES**. Also, material specification and production materials are needed, concluding contract with clients and cooperates, finishing deadlines and concluding deliveries, payments for debits and credits, and determination dynamics of sub-contractor employment.

3. Concluding the preparation of project documentation, which includes finishing the complete technological project documentation, begins the process of preparing sections and part of equipment out of slipway which requires the adequate documentation for reception

warehouse that's completing is the basis for **DD**: setting (**PUTTING DOWN THE KEEL -PK.**)

4. Putting down the keel – **PK** is the basis for beginning of the shipbuilding on the slipway - **PGBNN**, beginning of the construction of the hull of the ship and continuously beginning of the other phases of ship constructor. In this phase it is very important to ensure the adequate documentation for worker's warehouses.

5. Finishing the shipbuilding on the slipway begins the process of **DD**: launching of the ship - **PB**, and then begins the process of **SP: FINAL EQUIPPING OF THE SHIP - ZOB** which requires the adequate equipment, and preparation for the controlling and documentation for transfer.

6. After phase of the equipping of the ship - **ZOB** follow **DD: TRANSFER OF THE SHIP – PPB**, which required collaudation documentation in case of possible finishing due to complaint of ship owner.

7. After transfer of the ship – **PPB** start **SP: COMERCIAL USE OF THE SHIP IN THE GUARANTEE PERIOD – KKBUGR**, which end in **DD**: when guarantee period run out – **IGR.**
8. At the end of guarantee period – **IGR** start **SP: COMERCIAL USE OF THE SHIP – KKB**. This phase comprise agreed time period (from 8 to 10 years), in which ship owner is obliged to fulfil all financial obligation (sum due) i.e. full cost price of ship toward shipyard. « Merchandise credit» shipyard => ship owner determine agreed time period.

9. DD: Speed (rate) in which shipyard collection debts - **BNPB** influence on decrease of **SP**: state of unpaid debts of shipyards – **SNPOTB**, whit final sum i.e. state equal zero.

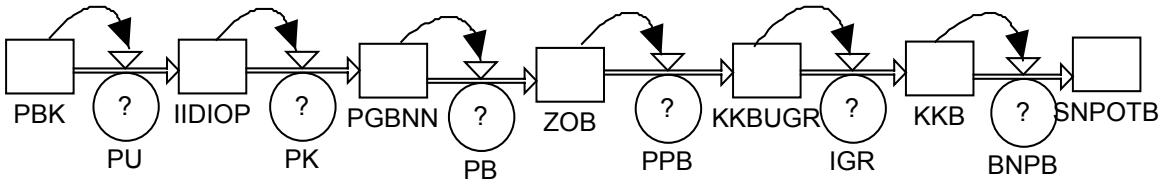

Figure 1. The Rudimentarily diagram of shipbuilding process

3. INVESTIGATION OF BUSINESS – PRODUCTION PROCESS (PPBP) WITH SYSTEM DYNAMICS APPROACH

System Dynamics Methodology of system modelling is very suitable for computer simulation of behaviour dynamics of the most complex organisational system. Business-production process (PPBP), without doubt, belongs to that group of system. Furthermore, we will observed PPBP as a whole, in accordance with System Dynamics Methodology, i.e. system is consist of nine relevant sub systems (Figure 2.):

1. Planned process of shipbuilding as a whole (**CPPIB**)
2. Co-operation, i.e. external flexible labour capacities (**KEKRK**)
3. Internal performer of labour duty, i.e. labour unit (**IIRZ**)
4. Supplying of materials, production materials, machinery and equipment which will be build in to the ship (**NM**)
5. State of outstanding debts and debt (**SDP**)
6. State of transfer account, i.e. incoming and outgoing money (**SNZR**)
7. Total income, income, profit, expenses, penalty, stimulations (**UPDT**)
8. Investment in basic and permanent working capital (**IOTOS**)
9. Short terms and long terms loans, i.e. sub system of financing shipbuilding!

Between these sub systems mentioned before exist numerous materials, energetically and information flows. As a fact, these are intercommunication flows: basic materials, additional material, machinery, equipment which will be build in to the ship, proper staff, co-operative flexible labour capacities, money, documentations, information about the state and change of state of elements of sub system, and organisational system of PPBP and its relevant "surroundings" (world maritime market, national and foreign market: staff, money, energy, information, material resources)

System Dynamics Computer Simulation model does not use "large –scale base or banks of the information, because they are based on higher processing of information, i.e. on the usage of knowledge about dynamical processes. The meaning of this is "minimal processing of the information", which also mean "maximal processing of information", i.e. "expert knowledge about investigated dynamical process". Model constructor uses initial and starting information about states and changes of state relevant variables of dynamical process, with knowledge about causal-consequence relationship among individual variables. Using this possibility simulation model is capable to independently and automatically generate results from simulation in running time area, whether analyse of past or future time period is done.
System Dynamics highly aggregated structural sub system of **PPBP** is worked out (Figure 1.) and presented in series of separated scientific papers (phases: **PBK, IIDIOP** and **PGBNN**) and globally in final report of realization of Republic scientific project number 2-09-366 in 1991 year (Modelling of organization of preparing the production in maritime shipbuilding). In these papers, numerous causal-consequence relationships (**UPV**) are presented, together with feedbacks loops (**KPD**) which dominate on dynamical character of behaviour of **PPB**. In this paper so called "module system dynamics computer simulation technique", which implement analogue system dynamics models for the most of sub system, is used for determination of all relevant sub systems of **PPBP**. Further, we will present module i.e. "**SUB SYSTEM OF 5TH PHASE OF SHIPBUILDING PROCESS –LAUNCHING OF THE SHIP**" (Figure 3.) or in short terms discrete event of launching the ship **PB**.
For realization of the phase of launching the ship **PB**, all preliminary phases must be conditionally fulfilled in integrity: **PBK**- offer of shipyard capacities, which end with successfully signed contract for building the ship – **PU**, which previously state was **PU=0**,

and with signed contract it changes state in **PU=1**. This initiates starting the phase of production documentation for realization and other equipment **IIDIOP**, and also specifications of materials and production materials, with signing the contract with suppliers and co-operations. Subsequently, starts making the sections and parts of equipments, supplying of entrance warehouse with corresponding documentation, which completeness is necessary for next phase **PBPP** i.e. putting down the keel – **PK**. If the phase **IIDIOP** is completed than it is possible to putt down the keel, and discrete variable **PK** is 1 (**PK=0** is changed in **PK=1**), this starts next phase **PPBP** i.e. **PGBNN** beginning of the shipbuilding on the slipway. For fulfilling launching of the ship previous phase **PGBNN** has to be fulfilled completely. If this condition is satisfied variable **PB** change its value **PB=0** in new **PB=1** and initialize next phase of **PPBP** i.e. final equipping of the ship **ZOB**.
In complete model all discrete variables: **PU, PK, PB, PPB, IGR** and **BNPB** have initial value "zero" and active quantity "one", which indicate that this is binary intelligent control switch, i.e. in state "zero" they block next phases of process of **PPB**, while in state "one" initialize fulfilment of next phase of **PPBP**.
In other words, special complex expert logical switch which enable initial and control-logical management **PPBP**, i.e. module-expert computer simulation of management of the shipbuilding process under code name "**IKLUPPBP**", is used in model. It is necessary to point out that all initial states of **SP** (**IIDIOP, PGBNN, ZOB, KKBUGR, KK** and **SNPOTB**) i.e. of the phases of the process are zero!

Structural informative intersectional model of construction of **Skiff No.356 (Amorella)** shown on Figure 2.

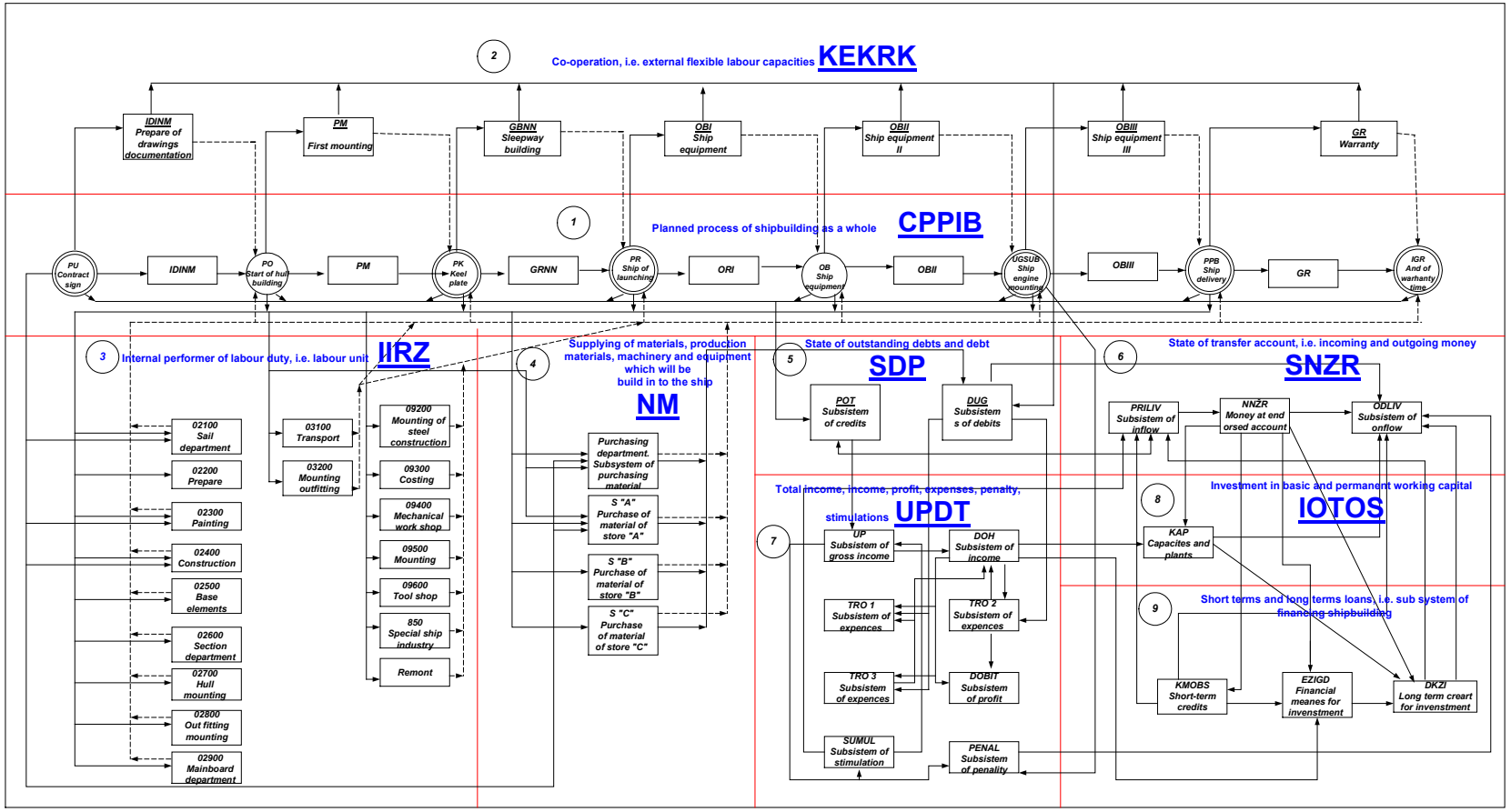

Figure 2. Structural informative intersectional model of construction of Skiff No.356 (Amorella)

4. EXAMPLE OF SYSTEM DYNAMICS MODEL OF 5th PHASE PPBP-a PB-LAUNCHING OF THE SHIP

It is evident that **PPBP** has characteristic of very complex management – intelligent system, and therefore software – module procedure is used for its realization. Global Simulation model of **PPBP** is presented with more than 250 analogical sub models, i.e. software modules with base structural model for every phase in **PPBP**, mutually analogues, shown in Figure 3.

a) Structural diagram of flows of 5th phase of **PPBP**

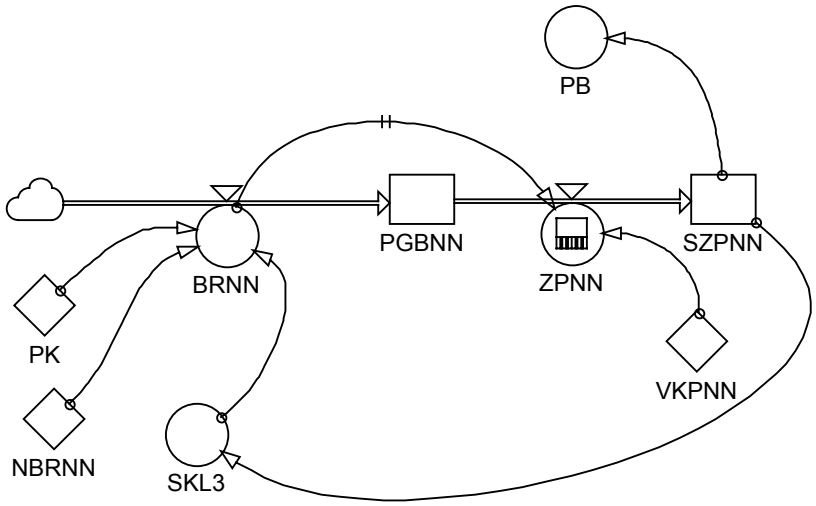

*Figure 3. Structural diagram of flows of 5th phase of **PPBP***

b) Mathematical – computer model of 5th phase of **PPBP**

A PK.K=1
R BRNN.KL=PK.K*NBRNN*SKL3.K
C NBRNN=31712
L PGBNN.K=PGBNN.J+DT*(BRNN.JK- ZPNN.JK)
N PGBNN=0
R ZPNN.KL=DELAY3(BRNN.KL,VKPNN)
C VKPNN=30
L SZPNN.K=SZPNN.J+DT*(ZPNN.JK)
N SZPNN=0
A PB.K=CLIP(1,0,S302100.K+S302200.K+
S102300.K+S302400.K+S202500.K+S103200.K +
S109200.K+S109400+S1BSO.K+S1IRUS.K,SZPNN.K)*
CLIP(1,0,S3S"A".K,PS3"A")*CLIP(1,0,S1S"B".K,
PS1"B")*CLIP(1,0,SZPGBNN.K,NSZPGBNN)

C PS3"A"=24421000
C PS3"B"=3291000
A SKL3.K=CLIP(0,1,SZPNN.K,PSPNN)

Where are:

PK= placing down the keel (b.d.),
BRNN= speed of growth on the slipway ($/day),
NBRNN= planed (standardize) labour on the slipway ($/day),
PGBNN= beginning of building of the ship on the slipway ($),
ZPNN= speed of finishing building of the ship on the slipway ($/day),
VKPNN= time of completing production on the slipway (day),
SZPNN= cumulative state of finished labour on the slipway ($),
PB= launching of the ship (b.d.),
PS3"A"= planed state of the warehouse "A" ($),
PS3"B"= planed state of the warehouse "B" ($),
SKL3= logical (expert) switch which control fulfilment of planed shipbuilding process, and from time to time stop it.

All others phases in shipbuilding process as active participation of all participant in shipbuilding production –business process are presented with analogue software module. This module function as "organization whole", with superadded sectors and sub sectors: outstanding debts, debts, transfer account, penalty, stimulations, total income, expenses, cost price, profit, basic funds, short terms and long terms loans. **PPBP** – model is programmed in DYNAMO and SYSDYNS higher programming languages.

5. CONCLUSION

System Dynamics Simulating Modelling is one of the most appropriate and successful scientific dynamics modelling methods of the complex, non-linear, natural, technical and organizational systems.
Implementation of System Dynamics Continuous Computer Simulation sub model of the business-production shipbuilding process – **PPBP**, which is a part of discrete digital computer simulated models of continuous nonlinear realities, in BrodoSplit, has allowed it's managing structure the continuous application of «active simulation process» in archiving following effects:
1. Quantitative grading of historical equals of **PPBP**,
2. Narrowing the future uncertainty,
3. Completing the list of the costs of shipbuilding process of the actual process,
4. Heuristic optimization of **PPBP** and enlarging the financial stability,
5. Improvement of organization of the process and complete automation of **PSBP**.

6. REFERENCES

1. Forrester, Jay W. 1973/1971. *Principles of Systems,* MIT Press, Cambridge Massachusetts, USA,
2. Richardson, George P. and Pugh III Aleksander L. 1981, *Introduction to System Dynamics Modelling with Dynamo* MIT Press, Cambridge, Massachusetts, USA,
3. Munitic, A. 1989. *Computer Simulation with Help of System Dynamics*, BIS, Croatia,
4. Ante Munitic, 1989., Computer simulation of shipbuilding production process management,, *INTERNATIONAL CONFERENCE OF THE SYSTEM DYNAMICS SOCIETY*,, JULY, 11-14, Germany,
5. Ante Munitic, Slavko Simundic, 1995., System dynamics continuous computer simulation model of ship construction documentation elaboration sub-process, *IMAM'95*, 23-27 April, Croatia,
6. Slavko Simundic, Ante Munitic, 1995., The knowledge basis model in the expert system structure for the technological preparation phase in shipbuilding, *IMAM'95*', 23-27 April, Croatia
7. Ante Munitic, Slavko Simundic, 2002.,(in Croatian), Sistemski dinamicki kontinuirani simulacijski model V faze brodogradevnog procesa "Porinuce broda", *SORTA*, Croatia.

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