4th Research/Expert Conference with International Participation
"QUALITY" 2005, Fojnica, B&H, November 09-12, 2005

DYNAMIC MODELLING OF EMPLOYING PROCESS

M. sc. Marko Hell
University of Split, Faculty of Economics
Split, Croatia

Ph. D. Zlatan Kulenović
M.sc. Merica Slišković
University of Split, Maritime Faculty
Split, Croatia

Key words: dynamics model, workforce, system dynamics, modelling

SUMMARY
With this paper the dynamics model of supply and demand process and employment will be presented. Based on presented qualitative model it is possible to built qualitative model, and simulate desired scenarios. On that way planning and managing of the workforce become easier. The methodology of system dynamics is used during modelling.

1. INTRODUCTION

Information system (IS) of some technological and/or an organizational system is the part of the system which permanent give necessary information to all levels of management and decision in the system [5].
It is possible to classify information systems by its purpose:

1. Transaction data processing systems (eng. TPS);
2. Office automation systems (eng. OAS);
3. Management information systems (eng. MIS),
4. Management support systems (eng. MSS);
   a) Decision support systems (eng. DSS),
   b) Group decision support systems (eng. GDSS),
   c) Expert systems (eng. ES),
   d) Executive support systems (eng. ESS).

Executive support systems (ESS) are the highest level of information system (IS) class hierarchy. Although they are more oriented toward outside information they also use internal information of MIS.
Construction efficiency of adequate information system highly depends on defining of material and informational flows.
The use of system approach gives the opportunity to treat the employment in Republic of Croatia as unique system, which:

- realize some function,
- has his own structure,

- through it management, economic, technical-technological and other process are achieved,
- connection to surroundings are made,
- has time dimension (it is dynamic),
- operate, i.e. it is realize on certain space (has space dimension),
- has complex hierarchy structure (multilevel), etc.

Some other characteristics, which enable the more complete aspect of such system, can be listed. In this paper the qualitative simulation model of mariner employment dynamic will be presented, i.e. supply and demand of working labour. It is designed for permanent information supply in purpose of planning of investment in mariner staff and their employment. System dynamic methodology will show system flows of material and information.

2. DEFINITION OF THE SUPPLY AND DEMAND SYSTEM OF THE WORKING LABOUR OF THE MARINER

During system modelling, it is important to notice groups of elements which have joint structure and function. It is possible than to divide the system to systems of lower level in the purpose of simplification of the observation. Supply and demand system of the working labour is consisted of three sub-systems. The main continued supplier of the working labour is the mariner education system. The numerical state of employed depend on working place supply which is shown by the sub-system with the same name. Output results of these two sub systems are integrated in the sub-system of the mariner employment. Structure of the supply and demand system of the marine working labour is shown on Picture 1.

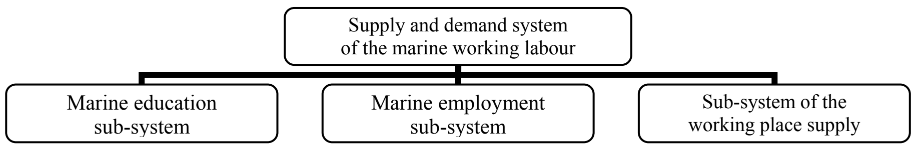

Figure 1. Structure of the supply and demand system of the marine working labour

After verbal description of the system the flow diagram of the mentioned system will be shown. Structural diagrams of the sub-system are shown separately in previous papers from the reference list.

2.1. Verbal Model

2.1.1. Sub-System Of The Job Position Supply

The state of the working place supply will be observed through state of open job ads. The speed of advertising has positive influence on the mentioned state, while the speed of closing the ads has a negative influence. Advertising speed is increasing with the average need of the employer. In our case the employer has no influence on his needs for the working labour so the needs of the employer are an independent variable which has seasonal and partial random character. It will be defined as follows[1]:

[1] The choice of coefficient used in function is experimentally obtained, after the MUSZ model has been studied. [6;175].

Employer_ needs =50*(1+0.5*SIN(2*3.14*TIME/12)*(2*(0.5-RANDOM(-0.5,+0.5)))).

During the calculation of the advertising speed it is necessary to pay attention on the constants of the planned reserves of the employer which have a positive influence and time of adjustment to desired state which slows down the observed speed. If the average deadline of the job ad is shorter, the speed of the closing the ads is increasing, which has a negative influence. The positive influence on ads closing speed is made by the state of open jobs ads.

2.1.2. Mariner Employment Sub-System

The state of unemployed mariners positively depends on their graduating speed and the speed on the returning to the work of the older mariners. The increase of the employment speed decreases unemployment, which means a negative influence, while increases the state of employed ones, which means positive influence. The speed of closing contracts, i.e. the speed of closing ads has a positive influence on the speed of mariner employment. The speed of contracts expiring and speed of quitting the further navigation has a negative influence on state of employed once. The speed of quitting the further navigation depends on navigation average time, which is shown with the exponential delay of material flow of employment state. The speed of contracts expiring depends on contract time duration, and is also presented with the exponential delay of material flow of employment state. After the contract expire the speed of return of the mariners to work will negatively depend on speed of employment and the average resting time which is shown with the exponential delay of material flow of the speed of contracts expiring.

2.1.3. Education Sub-System

Through previous papers [3], [4] and [5], all phases of building the dynamic models of education are shown. On the following picture only the structure model of basic element of the educational system will be shown.

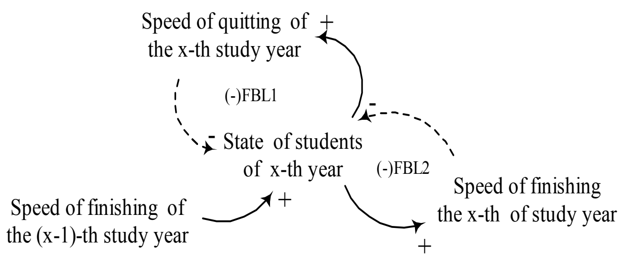

Figure 2. Structural diagram fbl of freshmen year.

In shown segment the following FBL applies: if the speed of finishing of the $(x-1)$ –th year is increasing, the state of students of the *x*-th year is also increasing, which means a positive (+)FBL sign; with the increase of the speed of finishing the *x*-th year of studying the state of students of the *x*-th year of studying decreases, which has a negative (−)FBL sign. The speed of quitting the *x*-th year of studying with its increasing, decrease the state of students on *x*-th year, which means a negative (−)FBL sign. It is possible to present its mathematical model with differential equation (1).

$$\frac{d(SxY - SxY_0)}{dt} = F(x-1)Y - FxG - QxG \qquad (1)$$

Which after integration the differential equation becomes a formula (2).

$$SxY = SxY_0 + \int_0^t \left(F(x-1)Y - FxG - QxG\right) \cdot dt\,, \tag{2}$$

Table 1. Meaning of variable of equations

Variable	*Meaning*
SxY	The state of x^{th} study year
SxY₀	The beginning state of x^{th} study year
F(x–1)Y	The speed of finishing of the previous study year
FxG	The speed of finishing of the actual study year
QxG	The speed of quitting of the actual study year
dt	The time step of simulation

The complete model of marine engineer education system contains 14 similar feedback loops (FBL).

2.2. Dijagram toka

The complete model of marine engineer education system contains 14 similar feedback loops (FBL).

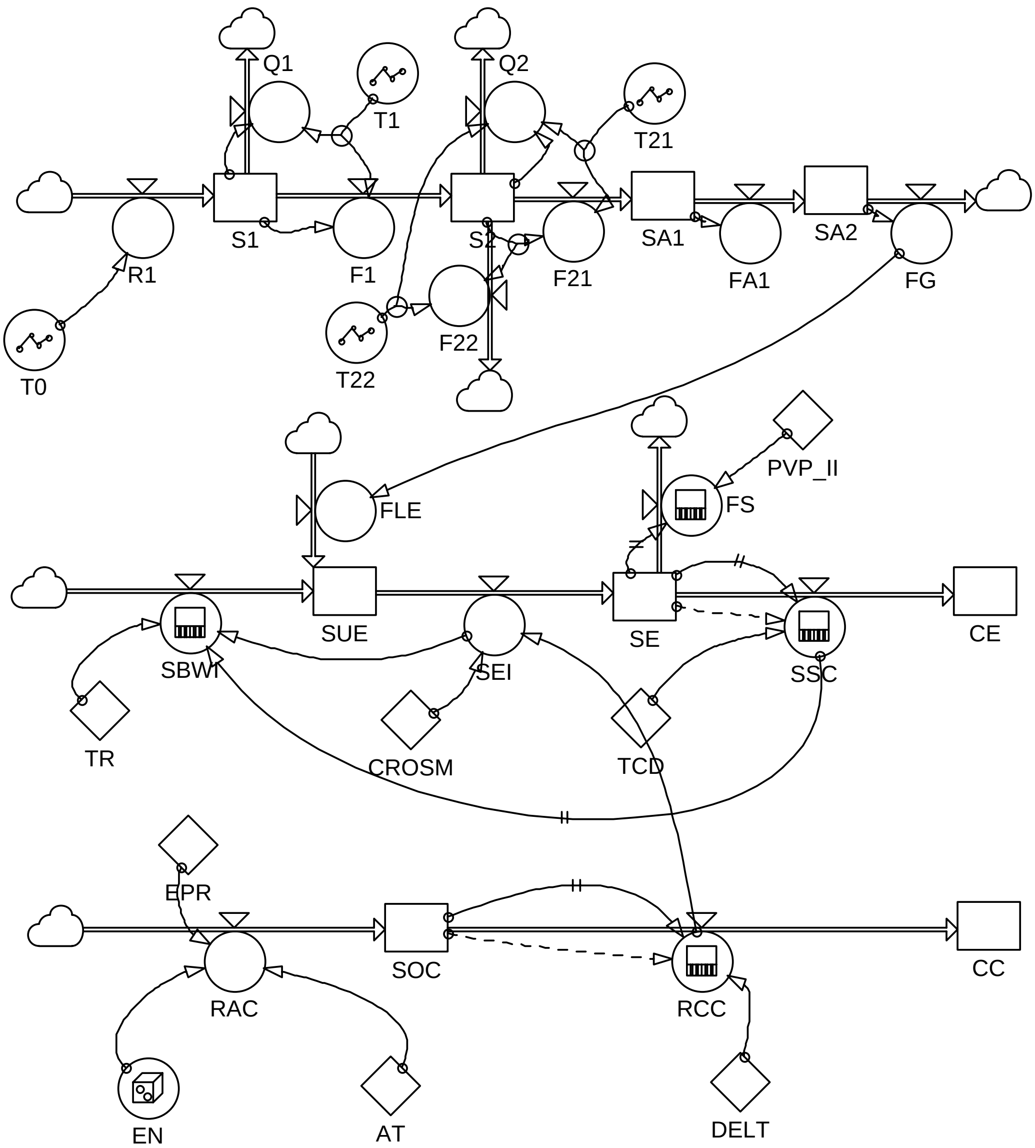

Figure 3. Flow diagram of supply and demand system of the marine working labour

3. MATHEMATICAL-COMPUTER MODEL

Base on the previous flow diagram in the next text mathematical-computer model is presented.

```
init    CC = 0
flow    CC = +dt*RCC
init    CE = 0
flow    CE = +dt*SSC
init    S1 = 183
flow    S1 = +dt*R1
-dt*Q1
-dt*F1
init    S2 = 76
flow    S2 = -dt*F21
-dt*Q2
-dt*F22
+dt*F1
init    SA1 = 20
flow    SA1 = +dt*F21
-dt*FA1
init    SA2 = 17
flow    SA2 = +dt*FA1
-dt*FG
init    SE = 0
flow    SE = -dt*FS
-dt*SSC
+dt*SEI
init    SOC = 10000
flow    SOC = +dt*RAC
-dt*RCC
init    SUE = 1000
flow    SUE = +dt*FLE
+dt*SBWI
-dt*SEI
aux     F1 = S1*T1
aux     F21 = S2*T21
aux     FA1 = SA1
aux     FG = SA2
aux     FLE = FG
aux     FS = DELAYMTR(SE, PVP_II,3,0)
aux     Q1 = S1*(1-T1)
aux     Q2 = S2*(1-T22-T21)
aux     R1 = T0
aux     RAC = (1/AT)*(EPR+EN)
aux     RCC = DELAYMTR(SOC, DELT,1)
aux     SBWI = (1/SEI)*DELAYMTR(SSC, TR ,1,0)
aux     SEI = 0.98*RCC*CROSM
aux     SSC = DELAYMTR(SE, TCD,3)
aux     EN = 50* (1+ 0.5*SIN(2*3.14*TIME/12)*(2*(0.5-RANDOM(-0.5,+0.5) ) ) )
aux     F22 = S2*T22
aux     T0 = GRAPH(TIME,1995,1,[147,108,86,95,115,122"Min:0;Max:250"])
aux     T1                                                                 =
GRAPH(TIME,1995,1,[0.43715847,0.476190476,0.638888889,0.337209302,0.589473684,0.208695652"Min:0;Max:250"])
aux     T21 = GRAPH(TIME,1995,1,[0.276315789,0.125,0.257142857,0.202898551])
aux     T22 = GRAPH(TIME,1995,1,[0.486842105,0.15,0.285714286,0.376811594,0.310344828,0.285714286
"Min:0;Max:250"])

const   AT = 5
const   CROSM = 0.002
const   DELT = 3
const   EPR = 6000
const   PVP_II = 240
const   TCD = 6
const   TR = 2
```

4. CONCLUSION

The development of human community is becoming more and more dependent on a successful application of modern computer technology and on possibilities of quick adjustment to very frequent changes that turned from exception to a way of life. Certainly one of basic preconditions for successful resisting challenges of time is quality education of people working in different fields. Dynamic and quick development of science and the changes its application causes bring to a constant and increasing need for application of system approach during the observation of the problems in case.
A relatively young methodology of system dynamics, starting with the presentation during the observation of the behaviour of the industrial systems[1], l has reached a wide application in technical and in social science. Day by day the science reveals that the dynamics of many systems, due to their complexity, cannot be described with classic mathematical conceptions. Therefore the system dynamics can be considered an efficient supplement to a mathematical analysis.
With this approach paper a simulation model of supply and demand dynamics of mariner working labour is built. Implementation of such model into the system of top management support (ESS) would provide, based on collected data from several sources, a great speed during the making of the graph and the information for the top manager. This actually enables the information search for necessary business activities in different fields, and simulation of possible events based on that.
Model that is build in this way can be, with small finishing, applied on another system which has similar structure. From all mentioned the importance of building the supply and demand model of working labour is visible. In this way, contribute to solving the problem of unemployment as also the Croatian company competition on world market will be made.

5. REFERENCES

[1]. Čerić V.: Simulacijsko modeliranje, Školska knjiga, Zagreb, 1993.;
[2]. Forrester J. W.: Principles of Systems, Massachusetts Institute of Tehnology Press Cambridge, Massachusetts and London, England, Second Preliminary Edition, Ninght Printing, 1980, Copyright 1968.;
[3]. Hell M., Kulenović Z., Garača Ž.: Dynamics Modeling Of Croatian System Of Maritime Education, Proceeding of 14th International Conference on Infromation and Intelligent Systems / Boris Aurer and Dragutin Kermek (ur.). - Varaždin : Faculty of Organization and Informatics Varaždin , 2003. 395-405
[4]. Hell M., Kulenović Z., Munitić A.: Qualitatively Modelling Of Maritime Educational Process Of Croatia, Proceedings of 4th International Carpahtian Control Conference ICCC', 2003 / Igor Podlubny, Karol Kostur (ur.). - Košice : TU Košice, Berg Faculty , 2003. 80-84.
[5]. Kulenović Z., Munitić A., Hell M.: Dynamical Model Of Management Of Ships Engineer Educative Syste", Pomorski znanstveni časopis NAŠE MORE (2003) (0469-6255) **I** (50/2003), 1-2; 40-43
[6]. Munitić A.: Kompjuterska simulacija uz pomoć sistemske dinamike, Ivo Lola Ribar, RO Računari Lola omladinska tvornica, Split, 1989.;
[7]. Radošević D.: Osnove Teorije sustava, Nakladni zavod Matice hrvatske, Zagreb, 2001.;
[8]. Richardson G. P., Pugh A. L. III: Intoduction To System Dynamics Modeling with Dynamo, The MIT Press, Cambridge, Massachusetts, and London, England, 1981;
[9]. Sikavica P., Bebek B., Skoko H., Tipurić H.: Poslovno odlučivanje, Informator, Zagreb, 1999.;
[10]. Srića V.: Uvod u sistemski inženjering, Informator, Zagreb, 1988.;

[1] Jay Forrester presented it in its work Industrial Dynamics, in 1961