Simulation modelling of marinas and heuristic optimisation of business in relation to investments in sports objects

Ph.D. Ante Munitić,
M.Sc. Eli Marušić,
M.Sc. Joško Dvornik,
M.Sc. Merica Slišković
University of Split
Maritime Faculty Split
Zrinsko-Frankopanska 38, 21000 Split, Croatia
phone: 385 21 380 762, fax 385 21 380 759
E-mail: amunitic@pfst.hr
emarusic@pfst.hr
josko@pfst.hr
merica@pfst.hr

Abstract

System dynamics simulation modelling of marinas in relation to investments in sports objects will enable rise of the quality of the total offer and competitive forces of the observed system, and at the end growing satisfaction of tourists. The system of marinas (LNT) has all the characteristics of a complex organisation and business system, for which dynamic modelling efficient methods of simulation techniques have to be used. One of the relatively recent, and particularly exposed and practically proved scientific methods is system dynamics simulation modelling which was developed by the Professor Forrester in the famous world scientific centre of the development of management science - The Sloan School of Management (MIT).

*This model is developed for the practical training of marine management students. In this paper, the business system of marinas (LNT) will be determined through a global model of integral nautical and tourist service (from berthing service as a basic service to all other additional services). The subsystem of investments in new capacities, like sports and additional capacities will be determined by exogenous variable **VINK** – value of investments in new capacities.*

Key words: *system dynamics, simulation modelling, business system of marinas, investments in sports objects, competitive advantages, nautical and tourist market, sports and recreation market.*

1. System dynamics quality simulation models of a business system (LNT)

The subsystem of investment in sports objects of a business system of a nautical and tourist port must have the characteristics of intelligent behaviour, which implies the following characteristics of managing behaviour: "If the capacity of LNT is full and if in the last several years the income per guest has not increased, it is necessary, in the next mid-term period, to invest in new facilities which will improve the quality of the total services of LNT. In this case it is planned to build at least 4 outdoor and two indoor tennis courts, one beach volleyball court and one swimming pool of $50m^2$, including facilities like dressing rooms, sauna, showers, massage and medical assistance, etc.). In case there is a decline of interest in the main LNT services, berthing, then it is necessary to stop the construction of new capacities. This implies that the started objects will be finished, while the others will be built after the demand increases again. Also, if the state of the transfer account of LNT is not positive or there are not sufficient means to cover the investment, it is necessary to ensure the mid-term and long term loans in order to complete the investment."

In order to determine the global system dynamics simulation model of LNT, it is necessary to determine the following relevant subsystems: subsystem of berthing capacity (the main nautical and tourist service); subsystem of servicing vessels; subsystem of capacities of additional services (trade and catering); information subsystem; subsystem of the state of finances in the transfer account; subsystem of credits for performed services; subsystem of debts; subsystem of income; subsystem of marketing and sales; subsystem of long term and short term loans; subsystem of engagement of total capacities; subsystem of the new sport capacities and their facilities.

Simulation of LNT begins on the first day of April of the observed business year (TIME=120 days). The first season finishes at the beginning of October of the same year (TIME=300 days). The next period of off-season business begins in October of the same year (TIME=300 days) and lasts to the beginning of the new season (TIME=485 days). The new tourist season begins on the 485^{th} day (TIME=485 day) and lasts to October of the next business year (TIME=665 days). New off-season business begins on the 665^{th} day and ends on the 850^{th} day (TIME=850 days).
Investing into new capacities begins on the 380^{th} day (TIME=380) and lasts on average 180 days, which means that it ends on the 560^{th} day of business, and the first positive effects of the investment (variable KPNI), or increase of the total income (UP), total operating costs (UTP), generator of the vessel arrivals (GDP) and average realised revenues per vessel per day (POPPD) stars in time TIME=406 days.

1.1. Mental and verbal simulation model of LNT business system

In accordance with system dynamics simulation quality methodology, it is possible to present the mental and verbal model of LNT in the following way:

"If the variable *generator of the vessel arrival* GDP increases, *the number of vessel registration a day* BPPD will also increase, which shows a positive (+) cause-consequence link CCL", i.e., as abbreviated:

GDP(+)→(+)BPPD

«If the *number of vessel registration a day* BPPD *increases, the total number of registered vessels* UBPP will also increase, which shows a positive (+)cause-consequence link CCL», i.e., as abbreviated:

BPPD(+)→ (+)UBPP

"If the *total number of registered vessels* UBPP increases, *the number of vessel checkouts a day* BOPD will also increase, which shows a positive (+) CCL.", i.e., as abbreviated:
UBPP(+)→ (+)BOPD

"If the *number of vessel checkouts a day* BOPD increases, *the total number of registered vessels* UBPP will decrease, which shows a negative (-) CCL", i.e., as abbreviated:

BOPD(+)→ (-)UBPP

"If the *average staying time of vessels* PVZP increases, then *the number of vessel checkouts a day* BOPD decreases, which shows a negative (-) CCL", i.e., as abbreviated:

PVZP(+)→(-)BOPD

(-) FBL1: The variables UBPP and BOPD create the so called negative (-) feedback loop or self-governing (-) KPD1", i.e., as abbreviated:

UBPP(+)→(+)BOPD(+)→(-)UBPP

"If the *number of vessel checkouts a day* BOPD increases, *the total value of the issued invoices* UVIR will also increase, which shows a positive (+) cause-consequence link CCL", i.e., as abbreviated:

BOPD(+)→(+)UVIR

"If the *average time of stay of vessels* PVZP increases, *the number of vessel checkouts a day* BOPD will be decreased, which shows a negative (-) CCL, i.e., as abbreviated:

PVZP(+)→(-)BOPD

"If the *average realised revenue per vessel per day* POPPD increases, *the value of the issued invoices a day* VIRD will also increase, which shows a positive (+) FBL, i.e., as abbreviated:

POPPD(+)→(+)VIRD

"If the *value of the issued invoices a day* VIRD increases, *the total value of the issued invoices* UVIR will also increase, which shows a positive (+) cause-consequence link CCL", i.e., as abbreviated:

VIRD(+)→(+)UVIR

"If the *total value of the issued invoices* UVIR increases, *the value of the collected debts a day* VNPD will also increase, which shows a positive (+) cause-consequence link CCL".

UVIR(+)→(+)VNPD

"If the *average time of collecting debts* PVNP increases, *the value of collected debts a day* VNPD will decrease, which shows a negative (-) cause-consequence link CCL".

PVNP(+)→(-)VNPD

"If the *value of collected debts a day* VNPD increases, the *total value of issued invoices* UVIR will decrease, which shows the negative (-) CCL."

VNPD(+)→(-)UVIR

(-) FBL2: The variables VNPD and UVIR create the so called negative (-) feedback loop, or self-governing (-) FBL2",

UVIR(+)→VNPD(+)→(-)UVIR

"If the *value of collected debts a day* VNPD increases, then the *total realised revenues a day* UOPD will also increase, which shows a positive (+) cause-consequence link CCL".

VNPD(+)→(+)UOPD

"If the *total realised revenues a day* UOPD increase, the INCOME will also increase, which shows a positive (+) cause-consequence link CCL".

UOPD(+)→(+)INCOME

"If the *value of collected debts a day* VNPD increases, the *value of paid assets to the transfer account a day* VUSZRD will also increase which shows a positive (+) cause-consequence link CCL".

VNPD(+)→(+)VUSZDR

"If the *value of paid assets to transfer account a day* VUSZRD increases, the *state of the total assets in the transfer account* SUSZR, will also increase, which shows a positive (+)cause-consequence link CCL".

VUSZRD(+)→(+)SUSZR

"If the *state of the total assets in the transfer account* SUSZR, increases, then the *value of the disbursements from the transfer account a day* VISZRD will also increase, which shows a positive (+) cause-consequence link CCL".

SUSZR(+)→(+)VISZRD

"If the *value of disbursements from the transfer account a day* VISZRD increases, then the *state of the total assets in the transfer account* SUSZR will decrease, which shows a negative (-)cause-consequence link CCL".

VISZRD(+)→(-)SUSZRD

(-) KPD3: The variables SUSZR and VISZRD create the so called negative (-) feedback loop, or self-governing (-) FBL3".

SUSZRD(+)→VISZRD(+)→(-)SUSZRD

"If the number of *registered vessels a day* BPPD increases, then the *total operating costs* UTP will also increase, which shows a positive (+)cause-consequence link CCL".

BPPD(+)→(+)UTP

"If the variable *average costs per vessel per day* PTPD increases, then the *total operating costs* UTP will also increase, which shows a positive (+)cause-consequence link CCL".

BPPD(+)→(+)UTP

"If the *total operating costs* UTP increase, then the *value of the liabilities a day* VDOPD will also increase, which shows a positive (+) cause-consequence link CCL".

UTP(+)→(+)VDOPD

"If the *value of liabilities a day* VDOPD increases, then the INCOME will decrease, which shows a negative (-) cause-consequence link CCL".

VDOPD(+)→(-)INCOME

"If the *value of liabilities a day* VDOPD increases, then the *value of the total debts* VUD will also increase, which shows a positive (+) cause-consequence link CCL".

VDOPD(+)→(+)VUD

"If the *value of the total debts* VUD increases, then the *value of debt settlement a day* VIOPD will also increase, which shows a positive (+) cause-consequence link CCL".

VUD(+)→(+)VIOPD

"If the *average time of debt settlement* PVIOP increases, then the *value of debt settlement a day* VIOPD will decrease, which shows a negative (-) cause-consequence link CCL".

PVIOP(+)→(-)VIOPD

"If the *value of debt settlement a day* VIOPD increases, the *value of total debts* VUD will decrease, which shows a negative (-) cause-consequence link CCL".

VIOPD(+)→(-)VUD

(-) KPD4: The variables VUD and VIOPD create the so called negative (-) feedback loop, or self-governing FBL4".

VUD(+)→VIOPD(+)→(-)VUD

"If the *value of debt settlement a day* VIOPD increases, the *value of paid assets from the transfer account a day* VISZRD will also increase, which shows a positive (+) cause-consequence link CCL".

VIOPD(+)→(+)VISZRD

"If the *value of the investment in new capacities* VINK increases, then the *value of paid assets from the transfer account a day* VISZRD will also increase:

R VISZRD.KL=VIOPD.KL+VINK.KL

where:
VISZDR – the value of paid assets from the transfer account a day;
VIOPD – the value of debt settlement a day BIOP – the rate of debt settlement
VINK – the value of investment into new capacities

The value of investment into new capacities – VINK will be determined:

R VINK.KL=DELAY3(PULSE(500000,1,366,1000)+PULSE(100,1,380,1000)+^
PULSE(1000000,1,390,1000),180)

where

DELAY3 is the name of MACRO function DYNAMO programme package and it is the exponential delay of III class of investment (investment into new capacities) which average construction period is 180 days.

Remark: The first item of the equation VINK.KL (500,000 EUR) denotes the total investment of the marina during the construction period of 180 days (its own financial means and bank loan as the outer finances); the other item of the equation denotes the possible investment in total of 2 million US$ of the foreign partner investors, and it will not have a negative effect (increase of costs) to financial state of the transfer account, but the new investor will ensure the return on investment by an agreed share in the profit. The investment effect will reflect for the first time in the realisation of the increased revenues in the following season.

Positive effects of the investment will reflect in the variable KPNI coefficient of the increase of new investments:

A KPNI.K=TABHL(KPNIT,VINK.KL,500,2500,500)

T KPNIT=1,1.2,1.5,1.8,1.9

The variable KPNI denotes an increase of revenues in the future period (after completing the investment and the beginning of work of the completed new capacities). The symbol KPNIT denotes the tabular amplitudes of a relative factor of increase of new investments to the growth of total revenues, costs, average costs per vessel and the generator of vessel arriving.

The state of the total assets in the transfer account – SUSZR, will be determined:

L SUSZR.K=SUSZR.J+DT(VUSZRD.JK-VISZRD.JK),

where
VUSZRD – the value of the paid assets to the transfer account a day
VISZRD – the value of the paid assets from the transfer account a day

Remark: If the state of the total assets in the transfer account is higher than zero, then the marina is solvent, and if it is zero or less than zero, then it is financially insolvent and in order to be capable to pay its liabilities it has to ensure cash assets on the basis of loans (mid-term or short term loans).

1.2. Structural model of the LNT business system

In accordance to the completed mental and verbal simulation model of investing into sports and other objects in the LNT business system, it is possible to determine the system dynamics simulation model of LNT:

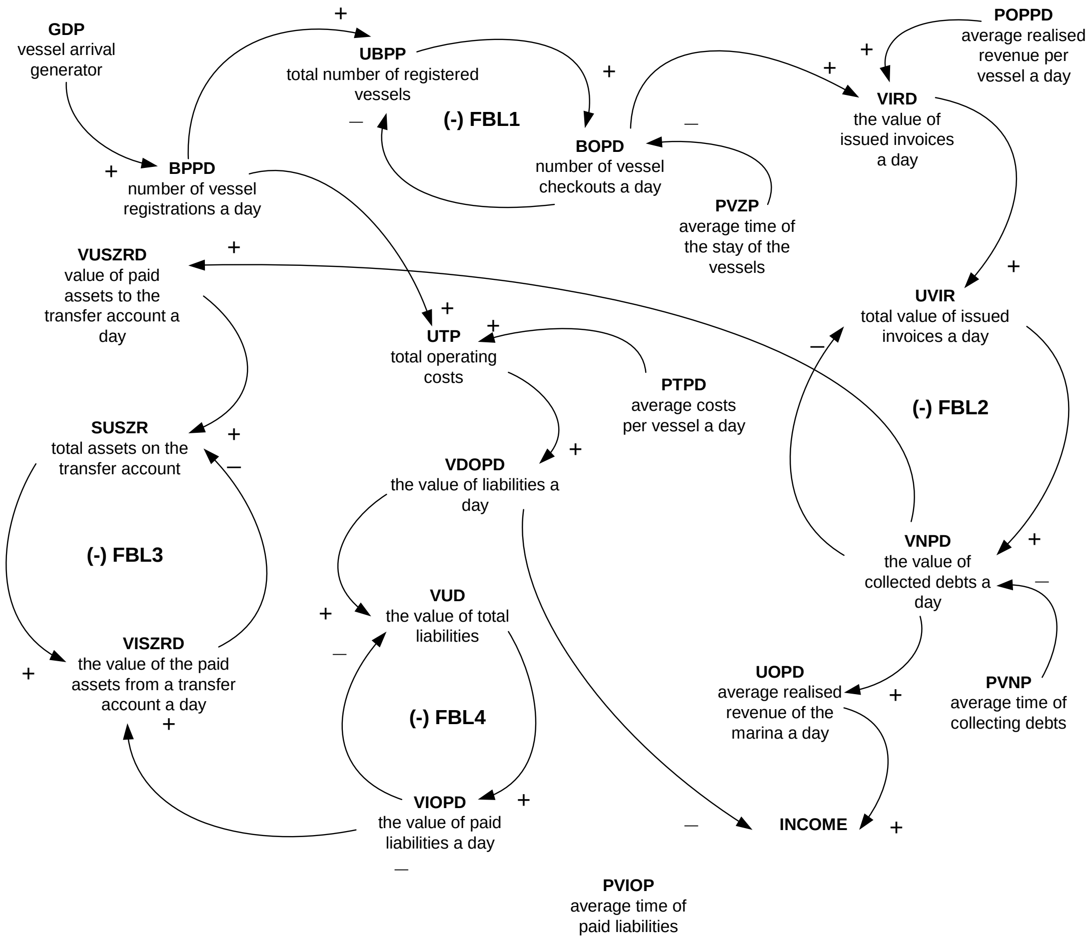

Figure 1. Structural model of the LNT business system

2. Conclusions

On the basis of the system dynamics research of the performance of the complex business system LNT, with the aid of a fast digital computer on which the performance simulation was done, it is possible to bring forward a number of relevant conclusions:

1. A direct application of system dynamics simulation complex models in the field of scientific research of performance of nonlinear management systems has full rationalization, because it ensures to the model constructor an extremely suitable software medium which may be determined as intelligent models of the second generation, if the first generation refers to present expert systems.
2. System dynamics and its efficiency of intelligent modelling of a business system may be considered as a logic order of development of intelligent systems in the field of applying research of dynamics of cybernetic business systems.
3. System dynamics uses special methodology and special software packages, the most outstanding being: DYNAMO; Powersim, Stella, Vensim, and Think.

4. System dynamics is especially convenient for the study of performance dynamics of business systems in which a great number of non-linear retroactive circles operate, or for systems where at operating the system the use of manager's intuition alone fails.
5. A special importance and quality of applying system dynamics in education, training, designing and exploitation of complex business management systems may be considered in acquiring new knowledge which classic management methods cannot offer.

On the basis of the above presentation, the authors of this paper recommend the implementation of system dynamics methodology tool into all fields of human activities with the aim of understanding various complex systems, in which the experiment cannot be performed in real life without jeopardizing their existence, growth and development.

The possible scientific contribution of this paper is primarily in authorised determining of general multiple simulation models which allow for acquiring new knowledge about dynamic performance of real nautical and tourist business systems, but also sports organisation systems. Also, in order to follow successfully the development of modern sports industry, the students of kinesiology need knowledge and skills in various areas, especially economy, management and marketing. By using the proposed tools and system dynamics simulation methodology, the students will acquire knew knowledge about performance dynamics of complex organisation systems in the field of tourism, sports and recreation.

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