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Scenario Development Approach to Management Simulation Games

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***Abstract* – The paper introduces a scenario development approach to management simulation games. Nowadays the high efficiency of simulation games as a training method is obvious due to their ability to help students understand the complexity of decision making within a dynamic environment. Modern computer technologies allow creating complex games with an adaptable environment that requires development of appropriate game scenarios. It is not a trivial problem that requires elaborating of a formal approach, which will be described in the paper. As a result a general scheme for scenario development and modelling for a simulation game is proposed in the paper. Some sample scenarios for logistics and supply chain games are provided in the paper as well.**

***Keywords* – Game scenarios, logistics and supply chain game, management simulation game, scenario management.**

I. Introduction

Simulation games in education are widely used as they provide realistic, experiential learning environments, thus, provide a more comprehensive way to teach concepts and theories than traditional lecturing [1]. This paper focuses on management simulation games, a subset of simulation games that provide a dynamic, uncertain and competitive business environment to train learners for management decision making. The players of such games make management-type decisions in an offered situation, and their decision choices generally affect the environmental conditions under which the subsequent decisions must be made. In a very brief time, this gives the game participants a chance to study both long and short-term results of their decisions. This provides a possibility to react to these effects and make decisions in the light of altered circumstances as in the real business. As a result, the game participants are able to gain knowledge and practice skills in the game by repeating experiments with the simulated reality through the simulation game. In addition, such games help developing such skills as teambuilding, social networking, collaborating, etc.

Recent advances in technology allow identifying several research and development directions in management simulation gaming. As indicated in [2], in the past two decades the number of Internet-based management simulation games has grown as it allows running them through a central server with administrator-selected parameters and entering participants' decisions directly to the server. Thus, management simulation games use computers-servers to run the models and to process participants' decisions. This allows creating more realistic and complex game scenarios with respect to the number of decision variables included, the number of products and markets defined, and the amount of feedback available to the participants. Software agents embodied in management simulation games facilitate modelling and exploring possible scenarios in the game while controlling the game process, thus, affecting the environment and direction of the simulation [3].

Modern management simulation games should possess the following features: realism, accessibility, compatibility, flexibility and scale, simplicity of usage, decision support systems, and communication [2]. This paper focuses on enhancing realism, flexibility and scale of management simulation game by proposing a general scheme for the game scenario development.

The objectives of this paper are: (1) to introduce a scenario concept for management simulation games; (2) to propose a general procedure for management simulation game scenario development; (3) to provide examples of scenario development for ILMG and ECLIPS management simulation games.

II. Game Scenario Concept

Scenario approach is widely used in different fields, for instance, forecasting, optimisation etc. There are different views on the definition of scenario, depending on the context in which the term is used. This term appears in a wide variety of fields, ranging from state administration, information systems, requirement engineering to human computer interaction. Interpretation of scenarios seems to depend on their usage and how they are generated. In general, a scenario can be defined as a set of possible sequences of future events [4], [5]. There are different approaches to scenario development: formal, semiformal, and informal, based on experts' opinion [6]. The paper concentrates on a semiformal approach as it includes automatic procedure of scenario generation adjusted by an expert.

The game simulation could be performed according to a predefined scenario chosen (or specially elaborated) by the game manager (instructor). Scenario plays a very important role within the game structure and it has to be formalized for further implementation.

With a respect to management simulation games, a scenario can be conceived as a means of transforming the game initial state to a final state, following main development trends, which are influenced by both internal events and external activities. It could be presented by the 5-tuple [2] as it is shown in (1):

$$<SI, T, E, A, SF> \quad (1)$$

where:

SI – the initial state of the game;

T – predefined game business environment development trends;
E – predefined internal events;
A – performed external activities;
SF – game final state once the scenario has terminated.

The generic scenario structure is shown below (see Fig. 1).

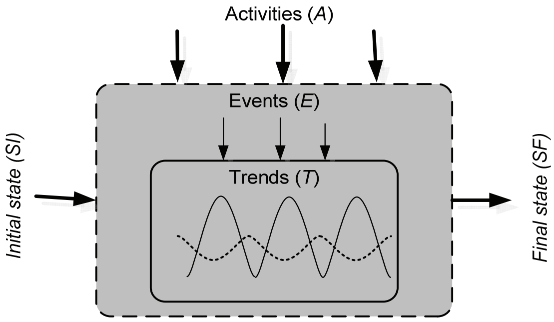

Fig.1. Generic scenario structure of management simulation game.

Trends T_i introduced to a game scenario dynamics over time *t* are defined by different functions, e.g. (2):

$$T_i = f_i(t), T_i \in T \quad (2)$$

Patterns of these trends depend on the type of function and its parameters which can be changed by the game manager.

All internal and external influences depend on the current game state and they are aimed at achieving a particular result of the game functioning or predefined learning objectives. Any internal and external influences lead to short-term or long-term changes in the pattern of trends, i.e., (3).

$$f_i^E : E \to T_i \text{ and } f_i^A : A \to T_i, \quad (3)$$

where:
$E = \{e_1, e_2, ..., e_n\}$ is a set of internal events;
$A = \{a_1, a_2, ..., a_n\}$ is a set of external activities.

Game initial state is defined by the proposed business environment characteristics and structure as well as by value of the trends' functions (4) at the moment when the game session starts:

$$SI = T_i(t_0), \quad (4)$$

where t_0 defines the initial time instant.

Thus, a scenario provides a flexibility of management simulation games as allows a game manager to define the initial state of game business environment, to determine the development of the game situation through time according to predefined trends, as well as preset the list of important events taking place during simulation. Events can affect trends. Participants make their decisions (or in other words, take actions) that can affect both trends and events. Trends may be configured according to the learning objectives by changing appropriate parameters available in the game.

Once all of the game scenario elements are defined, the scenario development procedure should be applied.

III. Scenario Development Approach

The scenario development for management simulation games becomes a complex process as the scenarios have to reflect real life situations [2], in other words, the number of a scenario parameters that define game initial state, game business environment development trends, internal and external events can be very large. In this situation, manual scenario development would be not so efficient. This makes it necessary to propose an advanced scenario development procedure (see Fig. 2).

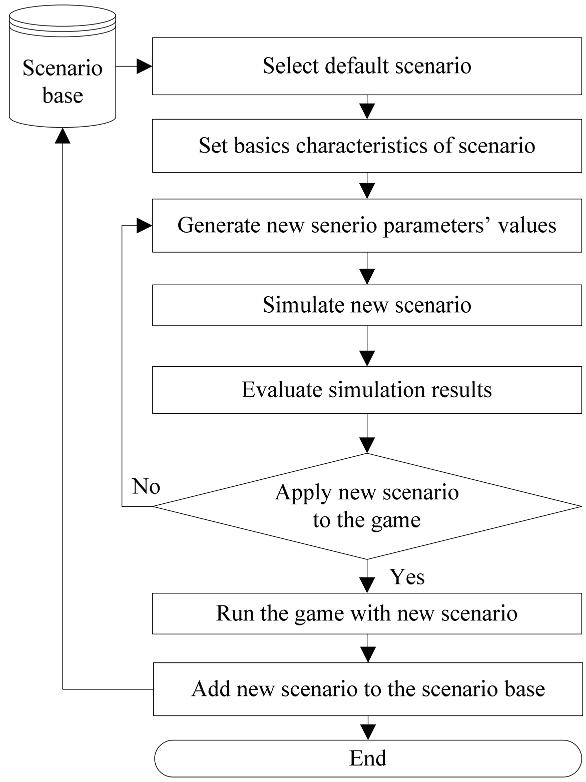

Fig. 2. Scenario development procedure for management simulation games.

Here, a scenario base represents a set of previously developed scenarios that can be used as a base for further scenario development. Game manager chooses a default scenario and sets basic scenario characteristics, thus defining initial state of the game. Then specially elaborated tools are applied to generate new values of scenario parameters that define game business environment development trends, internal and external events.

After the scenario is generated, it is necessary to simulate it with the game. It can be done manually or automatically. As the manual simulation supposes real players to test the game scenario, it would take more time and efforts. Automatic scenario simulation has several advantages: (1) the scenario can be simulated in a very short time period; (2) several replications can be made for more efficient scenario evaluation. To simulate the developed game scenario, special software agents are proposed [7], [8]. They act as the game participants by performing activities related to the company development under the proposed scenario conditions [4].

Depending on the type of the game, several agents can be running simultaneously.

When the game results are obtained, a game manager has to evaluate a new scenario. If it matches learning objectives, and it is proved that certain game results can be achieved, then the scenario could be applied to the regular game session and added to a scenario base. Scenario from the scenario base can also be applied to the game without any changes.

The proposed procedure can be applied to scenario generation of different management simulation game types.

IV. Illustrative Examples

To provide the examples of scenario development, two management simulation games were selected, namely, International Logistics Management Game and ECLIPS game.

A. International Logistics Management Game

As an example of a management simulation game for introducing scenario development and modelling approach, the International Logistics Management Game (ILMG) was selected [9], [10]. The game is aimed at providing a virtual business environment for training decision-making skills in the area of international logistics, production management, finances etc. The game can be classified as a total enterprise (or general management), interacting, computer-aided and internet-based, real-time processed business simulation. ILMG software functioning according to the structure presented in Fig. 3.

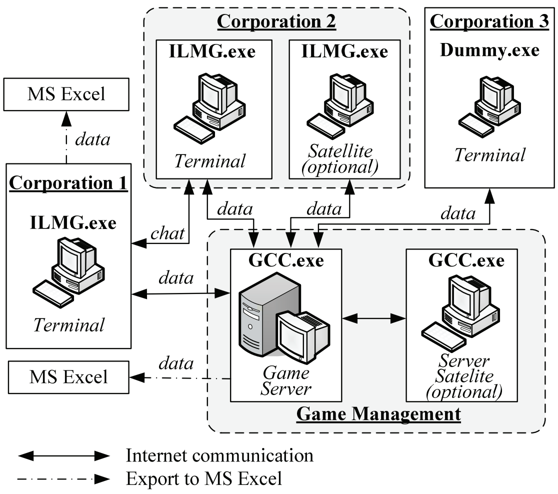

Fig. 3. ILMG software structure.

Different scenarios in the game are introduced to simulate real world situations and force trainees to acquire skills and experience in managing different functions of the company in various situations. During the game, participants operate as different corporations within an international market, producing goods or services (i. e., making strategic and operational decisions) and competing with each other in order to improve their corporation performance and to achieve the following goals: to earn profit, to capture substantial market share and to achieve high customer satisfaction.

The ILMG scenario is generated by the game manager according to specific learning objectives. Initial conditions of the game and corporations' state are set up by changing different parameters that can be divided into several groups (see Fig. 4): regional parameters (e. g., unit projecting cost, basic wage level), regional-related production parameters (e. g., productivity parameters, overhead parameters), technical coefficients of products (e. g., material per unit, setup cost), market related parameters (e. g., price effect parameters), financial parameters (e. g., prime rate, tax rate) etc.

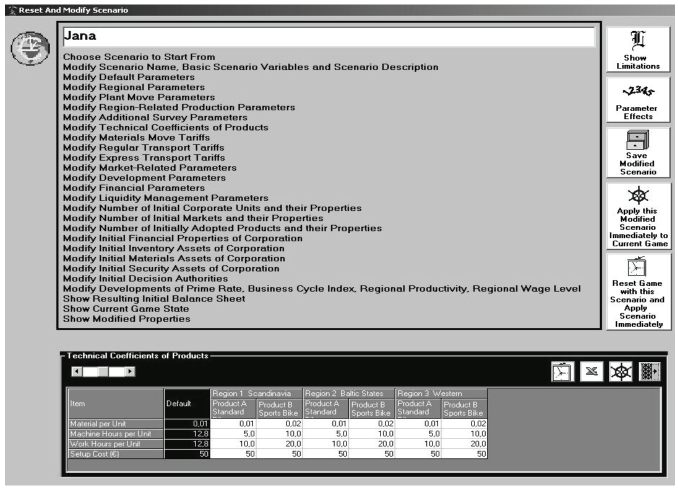

Fig. 4. ILMG scenario development screen.

Most of the parameters have to be defined before the game starts and they cannot be changed afterwards. However, some parameters (i. e., prime rate, business cycle index of the region, regional productivity index, and regional wage level) can be easily edited during the game that allows changing a business environment to simulate different situations.

In ILMG, the game manager has to set over than a hundred different parameters for the simplest scenario (one region, one product, two bank accounts). To support this task, special stand-alone application GameEditorPro was developed (see Fig. 5). It generates a full set of the game scenario parameters according to guidelines provided by the game manager.

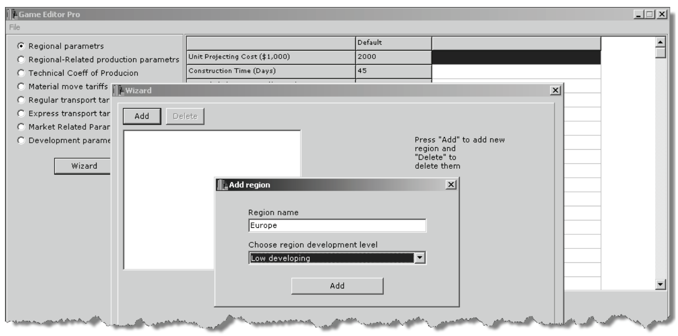

Fig. 5. GameEditorPro for ILMG interface example.

The game manager decides only on a number of regions (R) and products (P) and their characteristics; then the software automatically generates all other scenario parameters. Regions are defined with qualitative characteristics as regions with "advanced", "less advanced" or "developing" economy. Products are classified as "hi-tech", "medium-tech" and "low-tech" products. For example, the game manager sets up a new scenario with three regions R1="advanced", R2="developing" and R3="advanced", and three different products such as P1="low-tech", P2="hi-tech'" and P3="hi-tech".

Then an automatic generation of scenario parameters is performed by the following algorithm:

- the total number of parameters is calculated;
- the full range of parameters values is defined;
- each defined range is divided into three equal subsets;
- each subset of parameters characterizes either one region type or one product type;
- within each subset, values of parameters are generated randomly to exclude the possibility obtaining identical regions or products.

The parameters of the scenario received from the GameEditPro module can be exported to the ILMG software. It is used to simulate and test a specific scenario. In this case, a player agent is involved and it makes strategic, marketing, production, purchasing, transport, investment and financial decisions. Finally, the game manager manually evaluates the key indicators received by the player agent and decides if they meet learning objectives such as "a positive Net profit, a customer's fill rate is more than 50 %, and a liquidity ratio is greater than 1". If the evaluation is negative, the procedure of scenario generation is repeated and new values of game parameters are generated. Otherwise, the generated scenario is approved and introduced in the game regular session.

For the testing purpose, the game with 3 player agents was run for 8 periods (or 2 years). These agents substituted real players of the game. The key indicators received by the agents' players are given in Table I and presented in Fig. 6. As far as the obtained results meet the above-mentioned requirements, the tested scenario can be introduced in the game regular session.

TABLE I

KEY INDICATORS OBTAINED FROM SCENARIO MODELLING

	Agent 1	*Agent 2*	*Agent 3*
Net Profit (EUR)	80,749,580	81,865,660	90,920,780
Service Level	64%	60%	63%

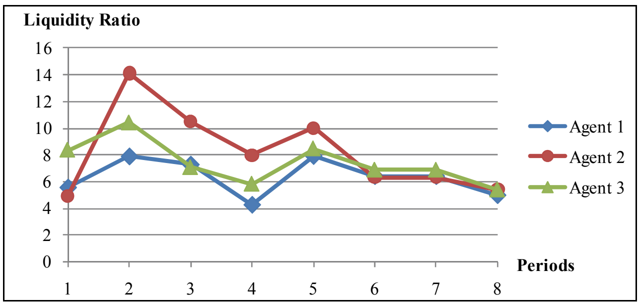

Fig. 6. Liquidity ratio of tested scenario.

Then the scenario is implemented and the game manager continuously reviews the key performance indicators of corporations represented by the human players. If they are out of range as defined by the teaching objectives, the game simulation time is fixed and a new scenario model is generated, e. g., such parameters as prime rate, business cycle index of the region, regional productivity index, or regional wage level could be adjusted. A two-year period is simulated during the regular session of a game.

B. ECLIPS Game

ECLIPS game is a board game that considers an inventory management problem in a multi-echelon supply chain, in particular, detailed workings of different inventory replenishment policies. It provides an insight into organization and functioning of multi-echelon supply chain based on continuous or periodic inventory review planning as well as demonstrates benefits and shortcomings of their implementation under different conditions [11], [12]. ECLIPS game provides flexible supply chain network modelling capability.

To support activities of the game manager and players, a special computer-aided tool was developed. It is aimed at providing environment that allows simulating different scenarios of the ECLIPS game [12]. The example of the simulated supply chain is represented in Fig. 7.

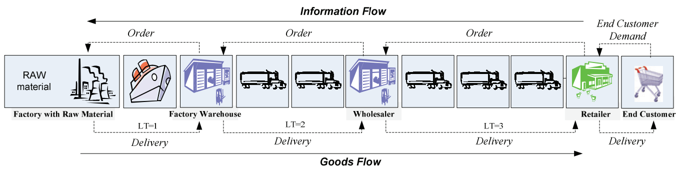

Fig. 7. Three echelon supply chain of the ECLIPS game.

The current version of the software allows testing scenarios by changing different parameters of the supply chain (see Fig. 8), e. g., end customer demand, inventory holding cost, order cost, new production cost, lead times between stock points and service level coefficient. Here, the number of stock points or supply chain echelons is limited by three as well as the end customer demand can be modelled either by one or two dice with sides defined by the game manager.

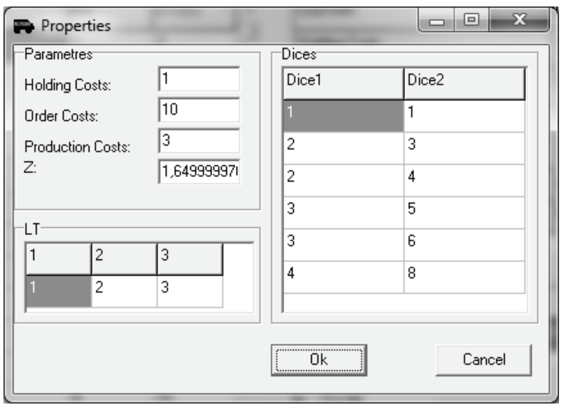

Fig. 8. Scenario parameters of the ECLIPS game.

After setting all parameters, the scenario is simulated to obtain game results. To evaluate reproducibility of the achieved results, the confidence interval method is proposed. Scenario is evaluated by three key indicators: service level (cumulative), average cost and average inventory.

The simulation results from 10 replications of 52 game periods for average inventory under a continuous replenishment policy are aggregated and represented in Table II. The cumulative mean and 95 % confidence intervals of the simulation results are given in Table II, as well. Similar calculations were performed for service level and average cost.

TABLE II

CONFIDENCE INTERVAL CALCULATION FOR AVERAGE INVENTORY

Repli-cation	Average inventory	Cumulative mean	Standard deviation	Confidence Level	Lower interval	Upper interval	% deviation
1	100.92	100.92	n/a	n/a	n/a	n/a	n/a
2	99.08	100.00	0.881	7.914	92.09	107.91	7.9%
3	104.33	101.44	1.784	4.430	97.01	105.87	4.4%
4	99.94	101.07	1.563	2.487	98.58	103.55	2.5%
5	101.63	101.18	1.395	1.732	99.45	102.91	1.7%
6	101.83	101.29	1.283	1.346	99.94	102.63	1.3%
7	100.26	101.14	1.203	1.112	100.03	102.25	1.1%
8	102.40	101.30	1.168	0.977	100.32	102.28	1.0%
9	101.12	101.28	1.098	0.844	100.44	102.12	0.8%
10	100.74	101.23	1.043	0.746	100.48	101.97	0.7%

The cumulative mean and confidence intervals for average cost, average inventory and service level are graphically represented in Fig. 9 to Fig. 11. Here, the cumulative mean in all the graphs is reasonably flat and the confidence intervals narrow fairly rapidly.

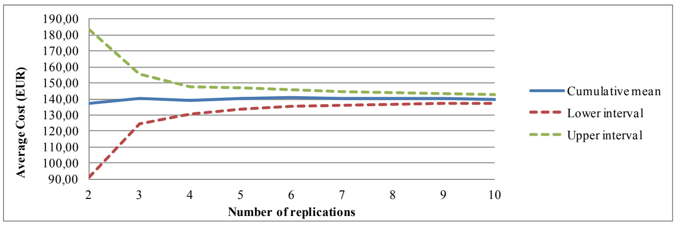

Fig. 9. Cumulative mean and 95 % confidence interval for average cost.

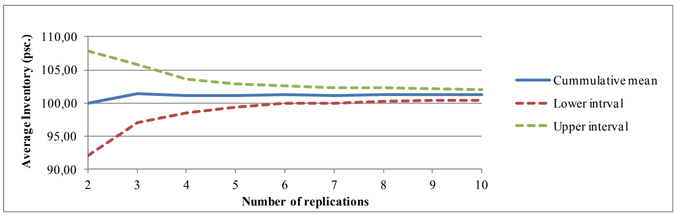

Fig. 10. Cumulative mean and 95 % confidence interval for average inventory.

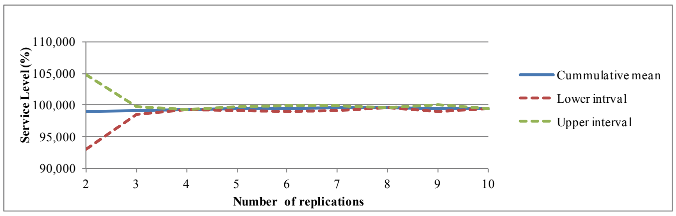

Fig. 11. Cumulative mean and 95 % confidence interval for service level.

The calculations and their graphical interpretation allow concluding that for average inventory and service level the deviation is less than 5 % at three replications. The interval narrows a bit slower for the average cost and the deviation is less than 5 % after the 5th replication. Thus, it is possible to confirm the convergence of the scenario modelling results. Similar calculations are performed for a periodic replenishment policy. Therefore, the scenario can be proposed for the implementation of the regular play of the ECLIPS game.

V. CONCLUSION

Recent advances in information technology have had a great impact on the process of the development and application of management simulation games. The research results provided in this paper show that the complexity of such games can be overcome by introducing a formal game scenario concept.

The proposed scenario development approach allows generating and simulating scenarios of games in order to evaluate their relevance to learning objectives defined by the game manager. Despite the fact that some of the described procedure steps are not yet automated, the provided examples of scenario development for ILMG and ECLIPS games show the procedure advantages for game managers.

Currently, it is not possible to completely avoid the interference of an expert (game manager or instructor) in the process of scenario development; however, further research direction may be related to the elaboration of method for generating values of various scenario parameters, as well as to the use of more sophisticated agents for scenario simulation.

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Jana Bikovska. Vadību imitējošo spēļu scenāriju veidošanas pieeja
Rakstā ir apskatīta vadību imitējošo spēļu veidošanas pieeja. Vadīšanas imitējošās spēles gūst aizvien lielāku popularitāti, tā ir kā alternatīva pieeja mācībām, kas nodrošina virtuālo biznesa vidi vadības lēmumu pieņemšanas iemaņu trenēšanai. Mūsdienās, pateicoties informācijas un komunikācijas tehnoloģiju attīstībai, paplašinās arī imitējošo spēļu funkcionālās iespējas, kas paaugstina to efektivitāti un maksimāli pietuvina reālās dzīves situācijām. Līdz ar to rodas nepieciešamība izstrādāt tādas metodes, pieejas un rīkus, kas nodrošina spēles kompleksās biznesa vides pārvaldību. Šim nolūkam tiek ieviesta vadību imitējošo spēļu scenāriju koncepcija, kura kalpo par pamatu rakstā piedāvātajai spēļu scenāriju veidošanas procedūrai. Šī procedūra paredz vairāku soļu izpildi, lai izveidotu tādu vadību imitējošas spēles scenāriju, kas atbilst apmācības mērķiem. Dažus no šīs procedūras soļiem izpilda spēles vadītājs (instruktors), bet daži ir automatizēti. Piemēram, scenāriju parametru vērtības tiek ģenerētas automātiski, kā arī izveidoto scenāriju modelēšana notiek automātiski, piemēram, pielietojot aģentus, kas aizstāj reālus spēles dalībniekus. ILMG un ECLIPS spēles tika izvēlētas, lai parādītu, kā izstrādātā pieeja tiek praktiski realizēta. ILMG ir universāla, internetā bāzēta, tiešsaistes vadību imitējoša datorspēle, kas nodrošina virtuālo biznesa vidi lēmumu pieņemšanas iemaņu pilnveidošanai tādās sfērās kā starptautiskā loģistika, ražošanas vadība, tirgzinība un finanses. ILMG spēles scenāriju parametru skaits ir diezgan liels, un scenārija manuāla veidošana un modelēšana ir pārāk laikietilpīga. Līdz ar to, pielietojot izstrādāto scenāriju veidošanas procedūru, izdevās krietni samazināt darba apjomu un patērēto laiku. Savukārt ECLIPS ir funkcionāla galda spēle, kuras mērķis ir sniegt priekšstatu par piegādes ķēdes darbības pamatprincipiem un dažādu krājumu vadības stratēģiju ieviešanas priekšrocībām un trūkumiem. ECLIPS spēlei tika izstrādāts elektronisks analogs, kas ļauj ģenerēt, modelēt un novērtēt dažādus spēles scenārijus, kas arī būtiski atvieglo spēles vadītāja (instruktora) darbu.

Яна Биковска. Подход для разработки сценариев в деловых имитационых играх
В статье рассмотрен подход для разработки сценариев в деловых имитационных играх. Использование деловых имитационных игр становится все более популярным, так как обеспечивает альтернативный подход к обучению, предоставляя виртуальную бизнес-среду для освоения навыков принятия управленческих решений. Благодаря современному уровню развития информационных и коммуникационных технологий, расширяются и функциональные возможности деловых имитационных игр, что значительно повышает их эффективность и максимально приближает к ситуациям реальной жизни. В этой связи появляется необходимость в разработке таких методов, подходов и средств, которые обеспечивают управление комплексной бизнес-средой этих игр. Для этого вводится концепция сценария имитационной игры, которая служит основой для предлагаемой в статье процедуры разработки сценариев деловых имитационных игр. Эта процедура предполагает выполнение нескольких этапов с целью разработки такого сценария деловой имитационной игры, который соответствует конкретной цели обучения. Некоторые этапы этой процедуры исполняет инструктор, другие - автоматизированы. Например, значения параметров сценария генерируются автоматически, а также моделирование сценария происходит автоматически, например, с использованием агентов, которые замещают реальных участников игры. Для демонстрации практической реализации разработанного подхода используются две игры: ILMG и ECLIPS. ILMG представляет собой универсальную онлайн деловую имитационную игру, которая обеспечивает виртуальную бизнес-среду для освоения навыков принятия решений в таких сферах, как международная логистика, управление производством, маркетинг и финансы. Количество различных параметров сценария в ILMG игре достаточно большое, следовательно, разработка и моделирование сценария в ручном режиме занимает много времени. Применив разработанную процедуру разработки сценария, удалось значительно сократить объем работы и потраченное время. В свою очередь, игра ECLIPS представляет собой функциональную настольную деловую мимтационную игру, цель которой дать представление об основных принципах работы цепи поставок, а также об основных преимуществах и недостатках различных стратегий управления запасами. Для ECLIPS игры бал разработан электронный аналог, который позволяет генерировать, моделировать и оценивать различные сценарии игры, что значительно облегчает работу инструктора.