

# Review on Research and Educational Activities

*by*

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## Main Directions:

- Simulation methodology (e.g., simulation-based optimisation, integrated visualization)
- Application of simulation in various areas (e.g., logistics, risk management)

## In particular:

- Methodology of discrete-event simulation
- Optimisation of simulation models
- Design of simulation experiments
- Simulation-based business games
- Practical applications of discrete-event simulation
- Supply chain simulation and management (*e.g., Bullwhip effect*)
- Simulation-based sustainable management of complex systems (*e.g., SC resilience*)

## Main Results (*by 2012*):

- Overview in the paper:  
Yuri Merkuryev. The  
Modelling and Simulation of  
Complex Systems:  
Methodology and Practice.  
An Overview. *Information  
Technology and  
Management Science*.  
2012, Vol. 15, p. 32-44.

### The Modelling and Simulation of Complex Systems: Methodology and Practice. An Overview

Yuri Merkuryev, Riga Technical University

**Abstract** – This paper summarizes the research in the field of modelling and simulation of complex systems conducted in recent years at the Department of Modelling and Simulation of Riga Technical University under the supervision of the corresponding member of the Latvian Academy of Sciences, Prof., Dr.habil.sc.ing. Yuri Merkuryev (Juris Merkuryevs). The main attention is devoted to developments within integrated simulation methodologies that incorporate simulation with other scientific approaches for the analysis, optimisation and management of complex systems, with a special focus on logistics systems. Practical application of the developed methods is considered by referencing to implemented research projects. Future research directions are also discussed.

**Keywords** – discrete-event system simulation, logistics, modelling and simulation, optimization, supply chain management, sustainable development

#### I. INTRODUCTION

The overview provides a summary of the main results of the research in the field of modelling and simulation (M&S) of complex systems conducted at RTU, the Department of Modelling and Simulation (RTU DMS) under the supervision of the corresponding member of the Latvian Academy of Sciences, prof., Dr.habil.sc.ing. Yuri Merkuryev (Juris Merkuryevs).

M&S research activities at RTU DMS are mainly related to discrete-event systems that change their state instantaneously, at discrete time moments. In particular, such systems are often considered in queuing and reliability studies, as well as in inventory management. At the same time, continuous systems and combined systems (that include both discrete-event and continuous ones) are discussed as well.

The M&S process generally incorporates the following main phases:

- development of a conceptual model of the considered system;
- transferring the conceptual model into a computer programme, i.e. development of a simulation model;
- experimenting with the simulation model.

For instance, a flow chart of the M&S process in case of discrete-event system simulation is presented in Fig. 1 [1].

In the subsequent sections, research results will be considered that are related to the main steps of the M&S process (e.g., design of simulation experiments), as well as to the application of simulation to solving different problems, inherent to operation of complex systems (e.g., analysis, optimization and management). The main attention will be devoted to developments within integrated simulation methodologies that incorporate simulation with other scientific

approaches for the analysis, optimisation and management of complex systems, with a special focus on logistics systems.

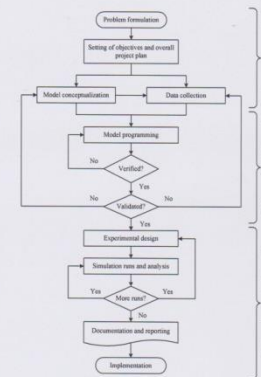


Fig. 1. Flow chart of the simulation study

#### II. SIMULATION OF LOGISTICS SYSTEMS

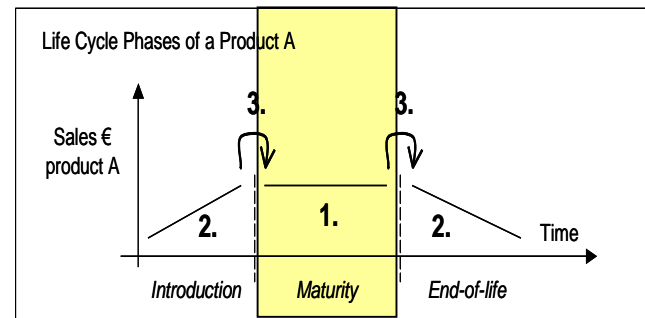
##### A. Simulation in Logistics

Simulation is considered to be one of the most effective technologies for the analysis and planning of logistics systems (in particular, for supply chains) [2]. Not always the power of the mathematical analysis proves to be sufficient for finding a complete analytical solution to complicated business tasks. In this case, the experimental study serves as an alternative solution. In particular, the use of simulation in logistics has become very popular. A survey of simulation applications in logistics is presented in [3], where the main logistics activities are analysed (see Fig. 2), and logistics tasks, which can be effectively solved with the help of simulation, are specified for each activity. Practical applications of simulation that demonstrate provided improvements of the operation of real logistics systems are described in the survey as well.

The performed survey of simulation practice in logistics confirms the effectiveness of the simulation technology in

## ECLIPS: "Extended collaborative integrated life cycle supply chain management system" (6th FWP, 2006-2009)

- **Aim:** Increasing supply chain performance while decreasing costs by defining appropriate inventory management algorithms at each phase of product life cycle



- **Partners:** 3 companies (B – co-ordinator, B, F), 1 university (LV – RTU), 2 industrial (D, CZ)

## Role of Simulation:

### A. To back up decision making and optimization processes:

1. Simulation-based analysis of the optimality gap between planning policies (*switching to the cyclic planning*)
2. Simulation-based optimization of supply chain management parameters during the maturity phase (*realization of the cyclic planning*)

### B. To validate developed algorithms:

3. Concept validation through simulation (*testing of the cyclic planning*)

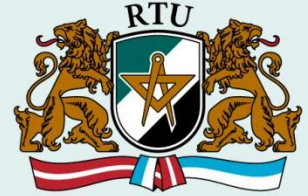
### C. To convince potential users (*simulation as buy-in*):

4. Helping companies (in particular, at the levels of investors, managers and planners) in getting inside the possibilities provided

### D. To educate (*e.g., by business gaming*)

5. Simulation-based business game "Eclips"

# Research: Sample Projects - Eclips



## Main Results Published:

- Yuri Merkuryev, Galina Merkuryeva, Jana Bikovska, Jonas Hatem and Bram Desmet. Business simulation game for teaching multi-echelon supply chain management. *International Journal of Simulation and Process Modelling*. 2009, Vol.5, No 4, p. 289-299.
- Galina Merkuryeva, Yuri Merkuryev, Hendrik Vanmaele. Simulation-Based Planning and Optimization in Multi-Echelon Supply Chains. *Simulation: Transactions of The Society for Modeling and Simulation International*. Vol. 87, No.8, August 2011, pp. 698-713.

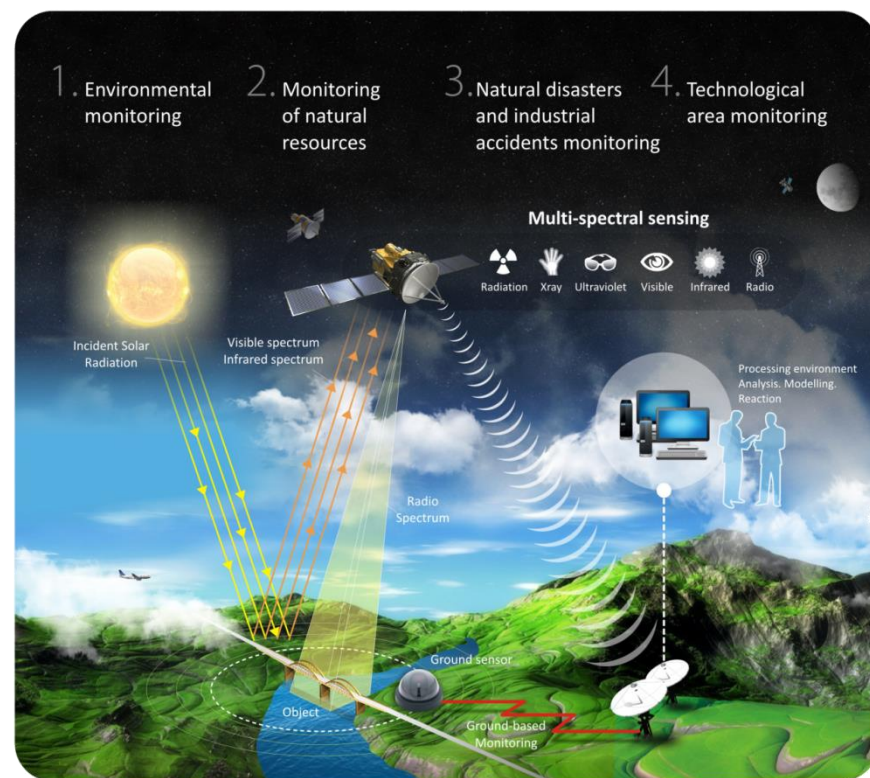


# Research: Sample Projects



## INFROM: "Integrated Intelligent Platform for Monitoring the Cross-Border Natural-Technological Systems" (EC EstLatRus Programme, 2012-2014)

- **Aim:** Technology development for monitoring and control of cross-border natural-technological systems in normal and emergency situations by using data from space and ground-based facilities
- **Partners:** RTU (LV; leading partner) and Sankt-Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (Russia)



## Main Results:

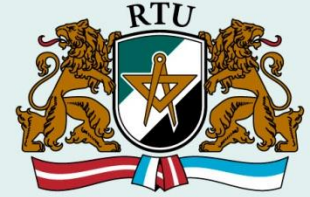
- **The developed technology** supports monitoring of complex natural and technological systems in both normal and emergency situations, including modelling and forecasting of environmental and technological processes, as well as integrated processing of ground-based, aerospace and social sensor data. Its main elements:
  - remote sensing image processing tools
  - geographic information system
  - simulation block
  - web-based solutions
- **Demonstration cases:**
  - forecasting Daugava river floods
  - monitoring forest development
  - monitoring Lubana lake overgrowing



## Case Study: Forecasting Daugava River Flooding

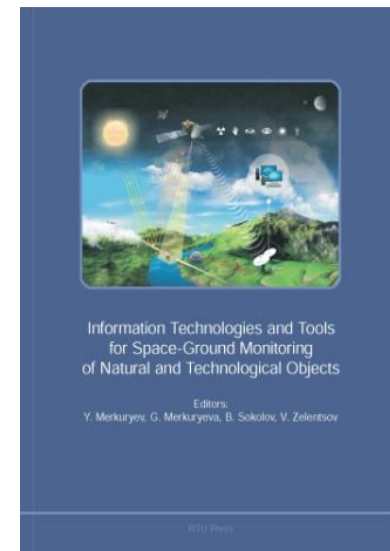


# Research: Sample Projects - Infrom



## Main Results Published:

- Y.Merkuryev, G.Merkuryeva, B.Sokolov, V.Zelentsov (Eds.). *Information Technologies and Support Tools for Space-Ground Monitoring of Natural and Technological Systems*. RTU, Riga, 2014. 110 p.
- Galina Merkuryeva, Yuri Merkuryev, Boris V. Sokolov, Semen Potrjasaev, Vyacheslav A. Zelentsov, Arnis Lektauers. Advanced river flood monitoring, modelling and forecasting. *Journal of Computational Science*. Volume 10, 2015, P. 77-85.



# Research: Sample Projects



## NexIT: "The next generation of information and communication technologies" (Latvian State Programme, 2014-2017)

- **Aim:** Development and practical application of advanced information and communication technologies towards implementation of the smart city concept
- **Topic:** The role of simulation in developing Intelligent Transport Systems
- **Current development:** Research paper for the HMS 2015 conference *The 17<sup>th</sup> International Conference "Harbour, Maritime, & Multimodal Logistics Modelling and Simulation"* (Bergeggi, Italy, September 21-23, 2015)

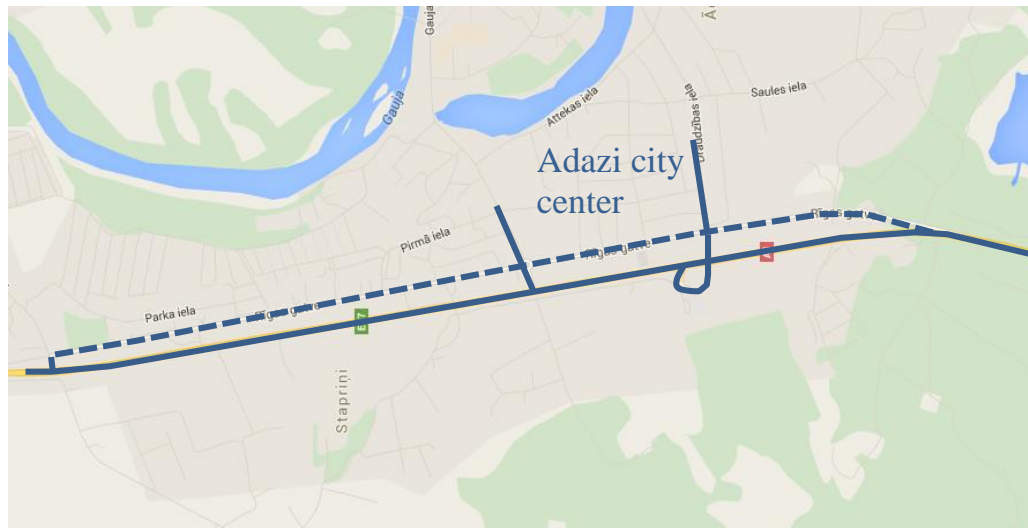
# Research: Sample Projects - NexIT



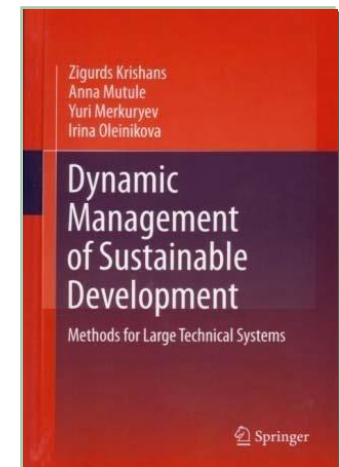
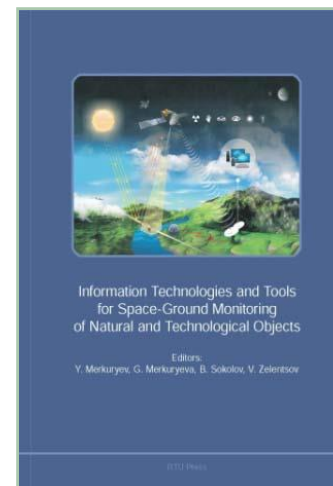
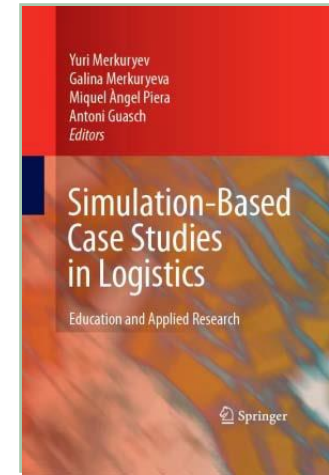
## HMS 2015 Paper:

**Title:** "Intelligent transport measures as a component of cyber-physical systems: case study for Adazi city" *by Yuri Merkuryev, Nadezhda Zenina and Andrejs Romanovs, RTU*

**Idea:** Using simulation to evaluate ITS performance measures in order to compare different transportation management scenarios in a particular area, including both hard (e.g., installation of roundabouts) and soft (e.g., Variable Message Signs, VMS, and Accident management System, ACM) actions



- About 330 research publications, including 3 books, 37 journal papers, 11 book chapters, and about 150 conference papers
- Regular participation at international conferences, including 6 keynote speeches
- Promoted 8 Dr.sc.ing. theses; 4 former Dr. students are already professors
- Promoted 78 Master theses





## Courses in the Following Areas:

- Discrete-event simulation (both introductory and advanced)
- Supply chain management

## Teaching experiences at:

- RTU:
  - Fac. of Computer Science and Information Technology: Bachelor and Master
  - Fac. of Mechanical Engineering, Transport and Aeronautics: Master
  - Fac. of Engineering Economics and Management: Master
  - Baltech study centre: Master
- Rezekne University (regional): Master
- Internationally: Guest lectures (Belgium, The Netherlands, Italy, UK, Slovenia, Poland, Spain, USA/Arizona, Thailand, Malaysia, Brazil, Uzbekistan)



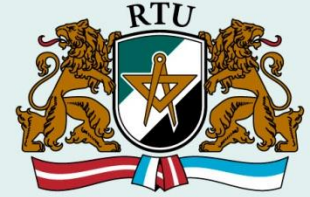
## Co-ordinator:

- Specialization on Industrial Logistics Management within the Master study programme "Information Technology"

## Programme director:

- International Joint Master Study Programme "Logistics and Supply Chain Management" (LSCM):
  - in cooperation with Spanish (UAB/Barcelona) and German (Technical University of Applied Sciences Wildau) universities
  - 1st semester - at UAB, 2nd semester - at RTU, 3rd and 4th semesters – specialization at one of the universities;
  - RTU specialization: Logistics Information Systems

# Organizational



- Latvian Academy of Sciences: Full Member
- IEEE and SCS (*The Society for Modeling and Simulation International*): Senior Member
- Latvian Simulation Society: President
- Latvian Council of Science: Expert in Information Technology, and in Transport and Logistics
- Promotional Councils (Latvia) in Information Technology, in Telematics and Logistics, and in E-learning: Member
- *Simulation: Transactions of The Society for Modeling and Simulation International*: Associate Editor
- EUROSIM (Federation of European Simulation Societies): Board Member
- I3M International annual conference «International Multidisciplinary Modeling and Simulation Multiconference»: General Co-Chair (since 2012; [www.msc-les.org/conf/i3m2015](http://www.msc-les.org/conf/i3m2015))

## Riga Technical University:

- Established in 1862
- The main university of technology in Latvia
- About 15 000 students
- 9 faculties:
  - Architecture and Urban Planning
  - Civil Engineering
  - Computer Science and Information Technology
  - Electrical Engineering
  - Electronics and Telecommunications
  - Engineering Economics and Management
  - Material Science and Applied Chemistry
  - Mechanical Engineering, Transport and Aeronautics
  - E-Learning Technologies and Humanities

## Riga Technical University:

- Member of Baltech: The University Consortium for Science and Technology, [www.baltech.info](http://www.baltech.info)

## Baltech:

- Incorporates 7 universities of technology from the Baltic Sea region countries: Sweden (Linköping, Lund, Stockholm), Latvia (Riga), Lithuania (Kaunas, Vilnius) and Estonia (Tallinn)
- Is aimed at establishing A Virtual Baltic Sea University of Science and Technology
- At RTU:
  - Study programme "Industrial Engineering and Management"
  - With the following courses provided by Dept. of M&S:
    - Applications of Manufacturing Simulation
    - Supply Chain Management
    - Production Planning and Control



Thank you very much  
for your kind attention !