SIMULATION AS A DECISION SUPPORT TOOL

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LAS LABORATORY OF APPLIED SOFTWARE SYSTEMS TRANSPORT AND TELECOMMUNICATION INSTITUTE

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Laboratory of Applied Software Systems

- integrate modern software into institute's education programs
- research and consulting using powerful software systems
- provide access and consulting for master and PhD students for unique software

Research and Consulting

- Optimal traffic movement organization
- Traffic forecast
- System Bottleneck research
- Architectural plan checking up according to requirements
- Public transport schedule optimization

- Critical state of the system research
- Best variant selection
- Logistics system optimization
- Economical substantiation of the strategies

- Investigation of the efficiency of using resources
- Planning in the service and production sphere
- Distributed system research
- Financial flows modelling
- Business process reengineering

Software

- PTV VISION VISSIM & VISUM – Microscopic and macroscopic transportation system modelling
- ExtendSim, AnyLogic, GPSS – universal simulation modelling tools
- SPSS , Statistica, R – statistical data processing
- MatLab, MathCAD – mathematical operations
- Business Studio, BPWin, Aris – business process modelling
- SIDRA INTERSECTIONS – crossroads modelling based on ICU and HCM standard

Few words about simulation

Fundamentals of simulation theory

- **Modeling** – it is a replacement of studied object (original) by its representation or by other object (model) and studding original object properties by the research of model properties

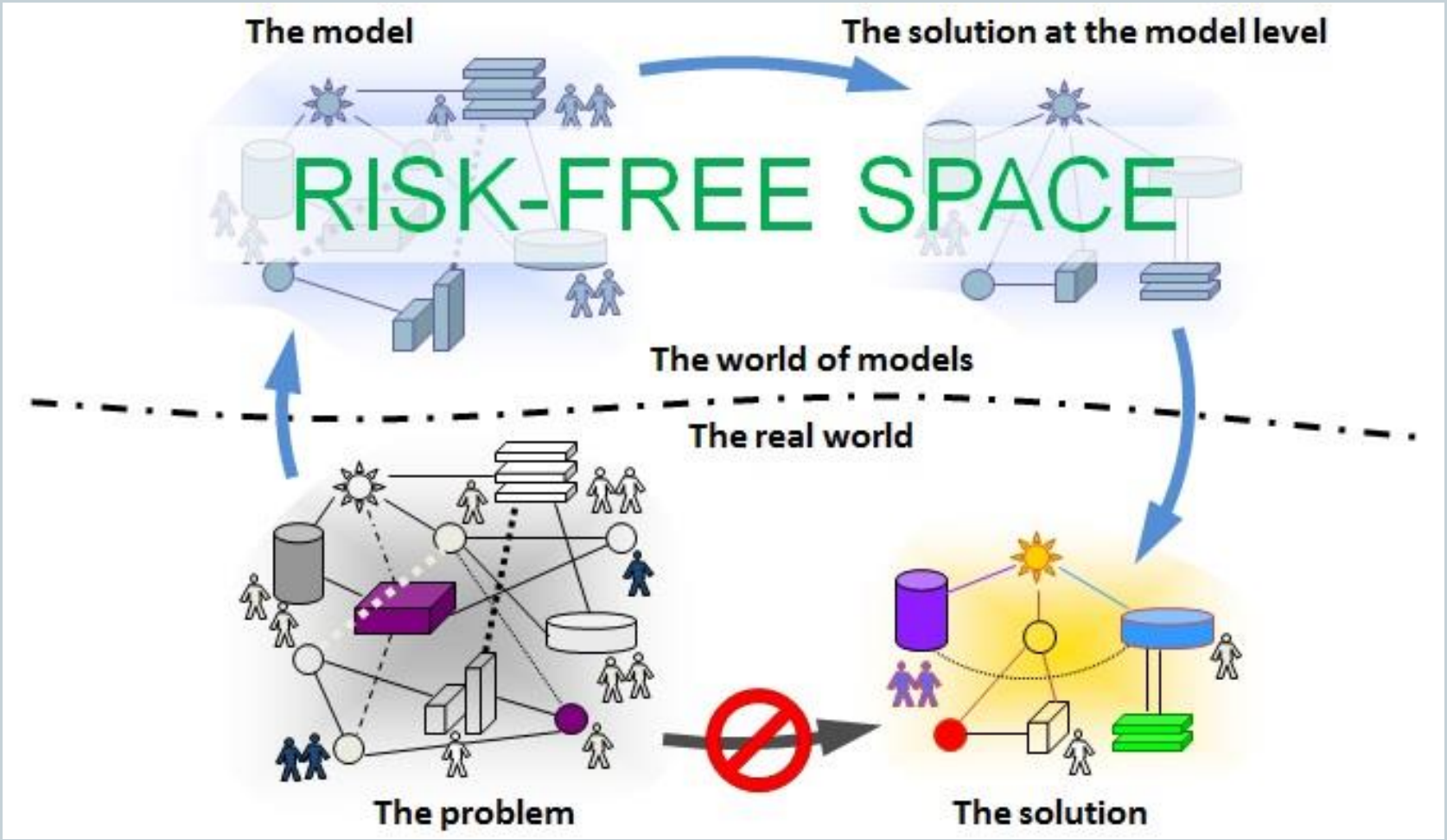
Fundamentals of simulation theory

- **Simulation**– it is a **process** of real system model development and experimentation with model in order to understand the behavior of the systems or different strategies of management testing

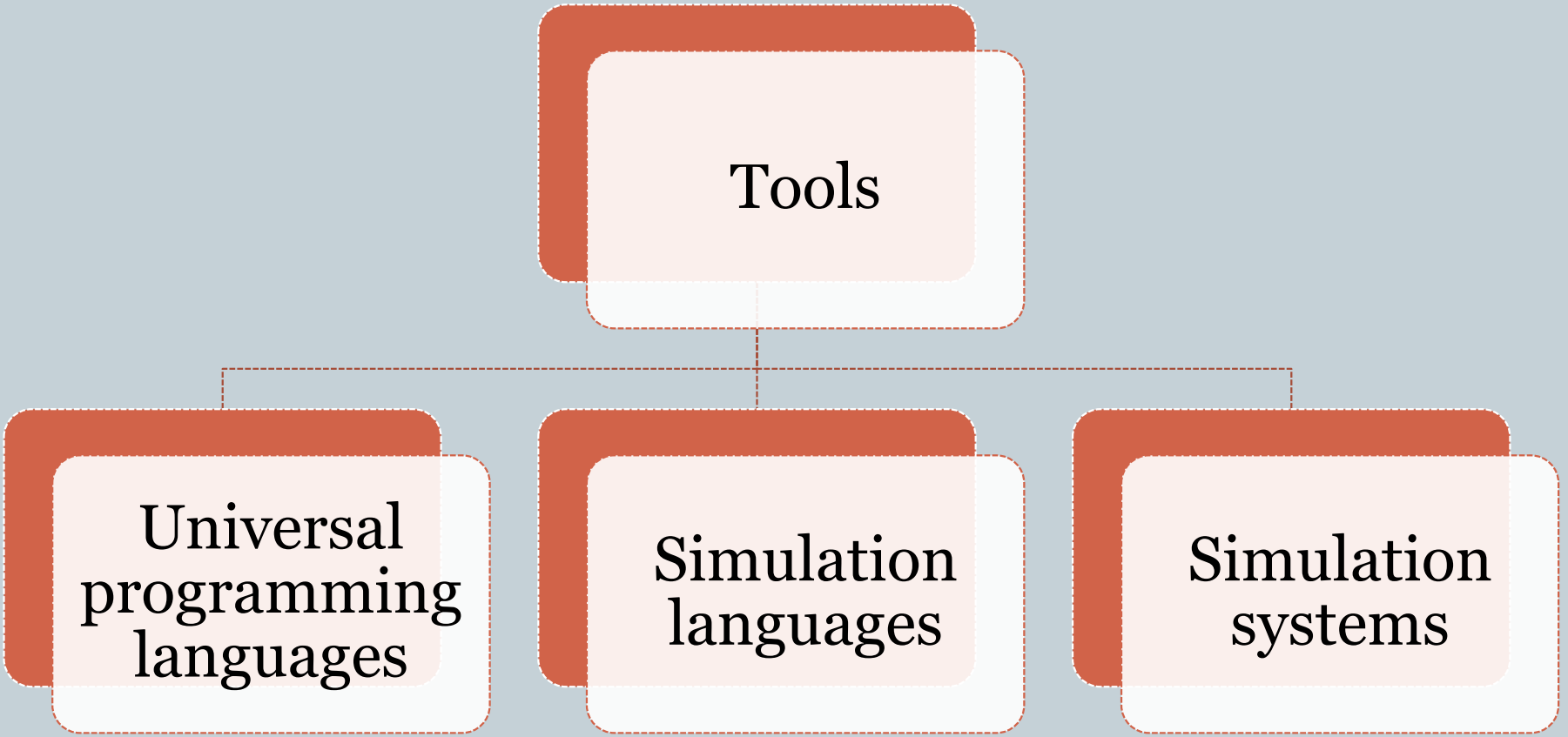
Two approaches to construct mathematical model

- Analytical modeling
  - implies an use of mathematical model in form of different equations, which connects input and output of the system

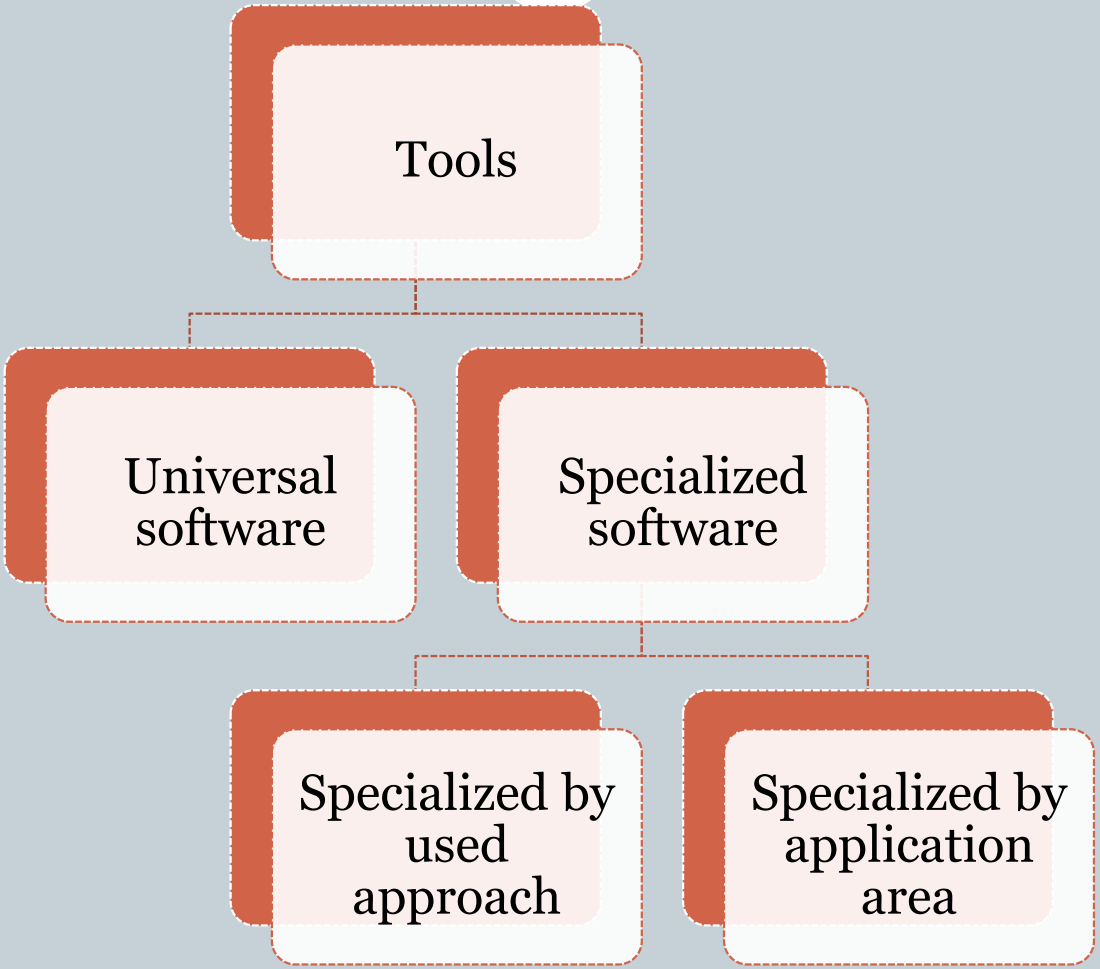
- Simulation modeling
  - mathematical model reproduce a logic of system functioning in time with different combinations of system parameters and environment factors


The model
The solution at the model level
RISK-FREE SPACE
The world of models
The real world
The problem
The solution

Classification of tools (1/2)



Classification of tools (2/2)



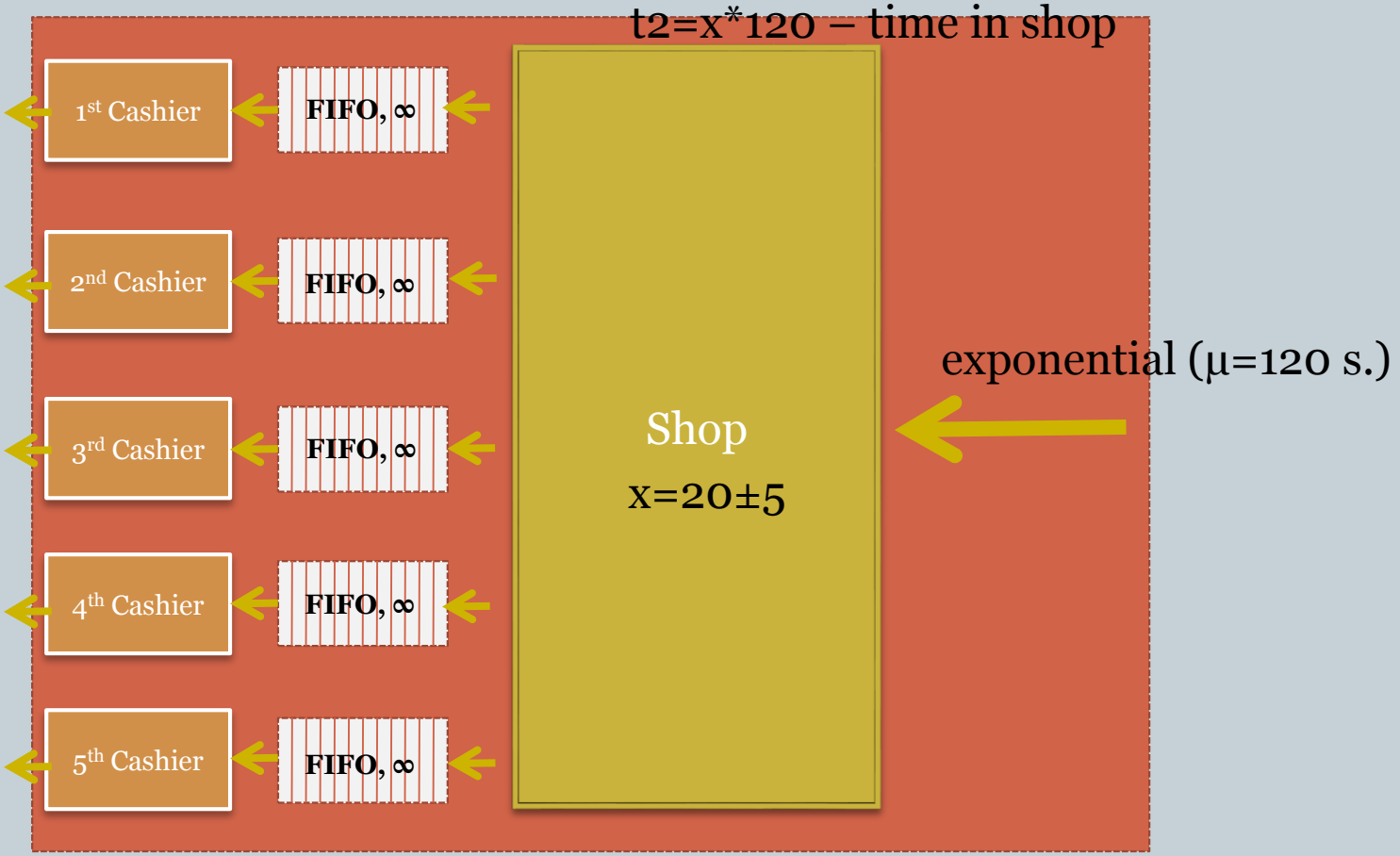
Examples of tools

- Programming languages
  - C#
  - Visual Basic
  - Pascal
  - C++
  - Java, …
- Simulation languages
  - GPSS
  - SIMAN, …
- Simulation systems
  - Extend
  - AnyLogic
  - eM-Plant, …

- Universal software
  - AnyLogic
  - Extend
  - Arena
  - GPSS
  - …
- Specialized software
  - eM-Plant
  - VISSIM
  - VISUM
  - VENSIM
  - …

Conceptual model

t1=x*5 – service time



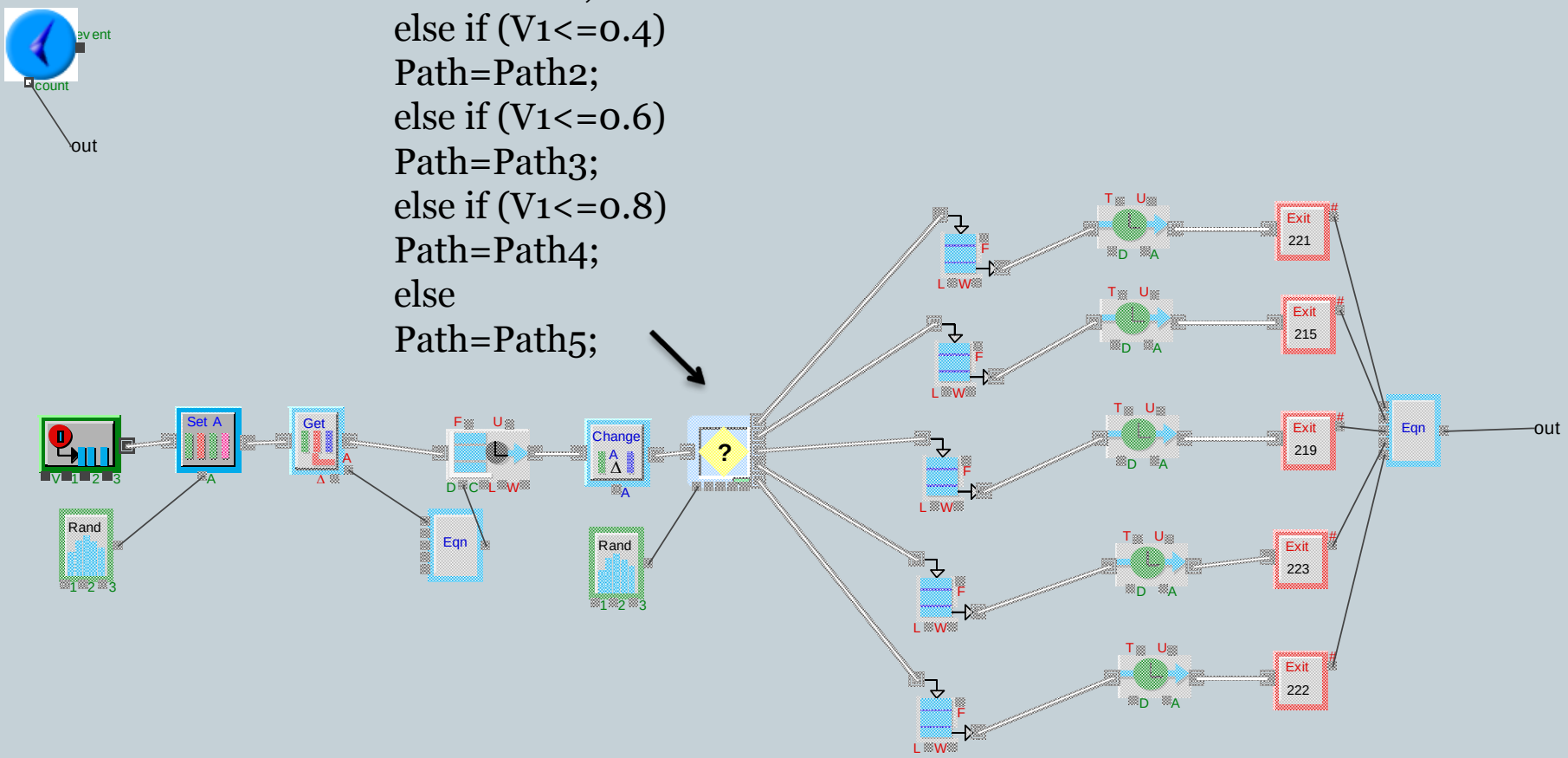
x – number of shopping items

GPSS

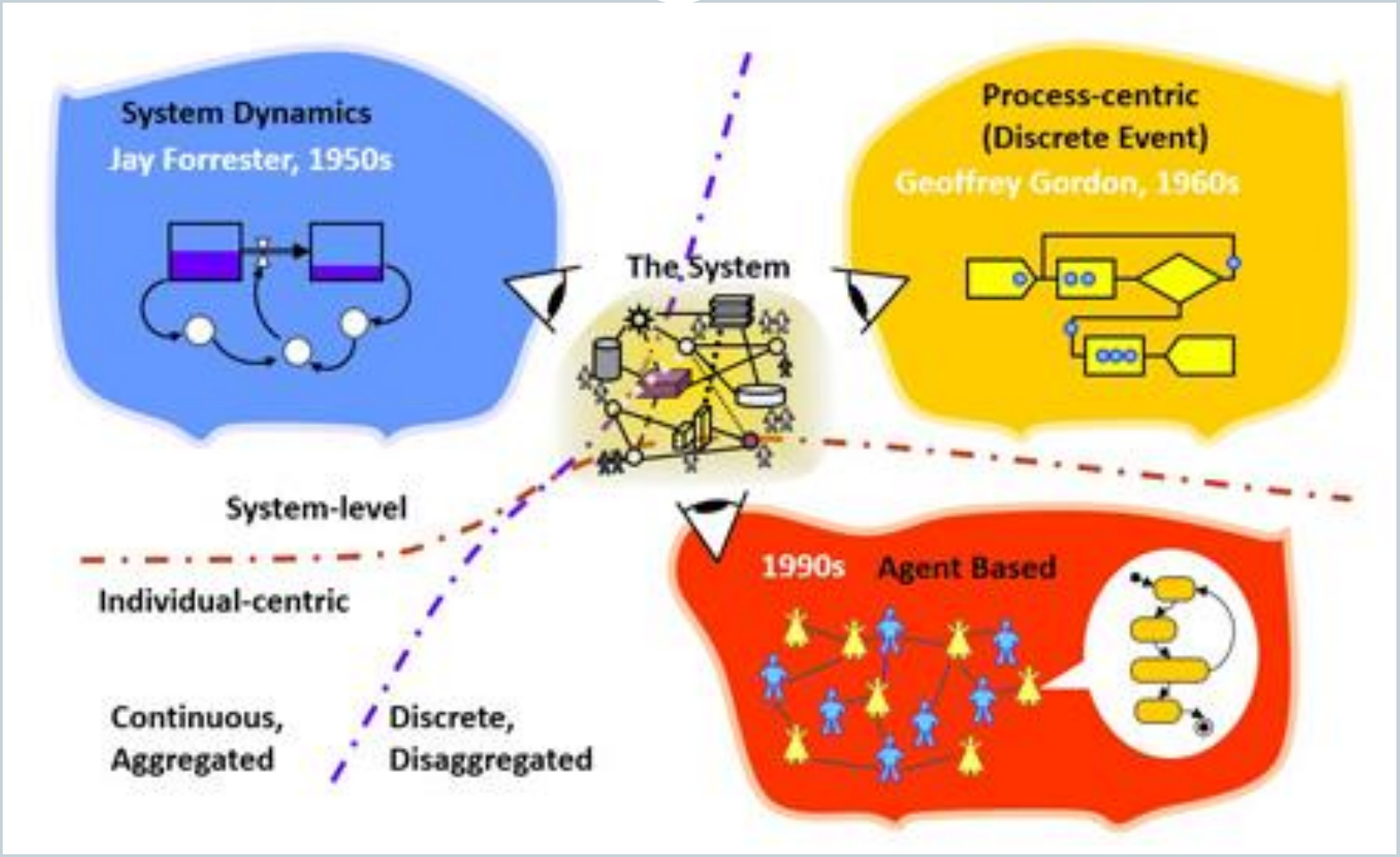

```
Cashier FUNCTION RN1,D5
0.2,met1/0.4,met2/0.6,met3/0.8,met4/1,met5

SHOP STORAGE 1000
GENERATE (EXPONENTIAL(1,0,12))
ASSIGN Items,(UNIFORM(1,15,25))
ENTER SHOP
ADVANCE (P$Items*120)
LEAVE SHOP
TRANSFER  ,FN$Cashier

met1 SEIZE Cashier1
ADVANCE (P$Items*5)
RELEASE Cashier1
TRANSFER ,out

met2 SEIZE Cashier2
ADVANCE (P$Items*5)
RELEASE Cashier2
TRANSFER ,out

met3 SEIZE Cashier3
ADVANCE (P$Items*5)
RELEASE Cashier3
TRANSFER ,out

met4 SEIZE Cashier4
ADVANCE (P$Items*5)
RELEASE Cashier4
TRANSFER ,out

met5 SEIZE Cashier5
ADVANCE (P$Items*5)
RELEASE Cashier5
TRANSFER ,out

out TERMINATE 1
```

ExtendSim - realization


```
if (V1<=0.2)
Path=Path1;
else if (V1<=0.4)
Path=Path2;
else if (V1<=0.6)
Path=Path3;
else if (V1<=0.8)
Path=Path4;
else
Path=Path5;
```



Approaches


System Dynamics
Jay Forrester, 1950s
Process-centric
(Discrete Event)
Geoffrey Gordon, 1960s
The System
System-level
Individual-centric
1990s Agent Based
Continuous,
Aggregated
Discrete,
Disaggregated

Agent-based simulation

Agent-based simulation

Agent based model structure

Main principle

- **Agent based simulation** — it is an simulation approach, which research a behavior of individual object influence
- Comparing AM with SD the behavior of each object (agent) is defined
- The global system behavior appears as a result of agent activity (simulation from bottom to top).

Agent

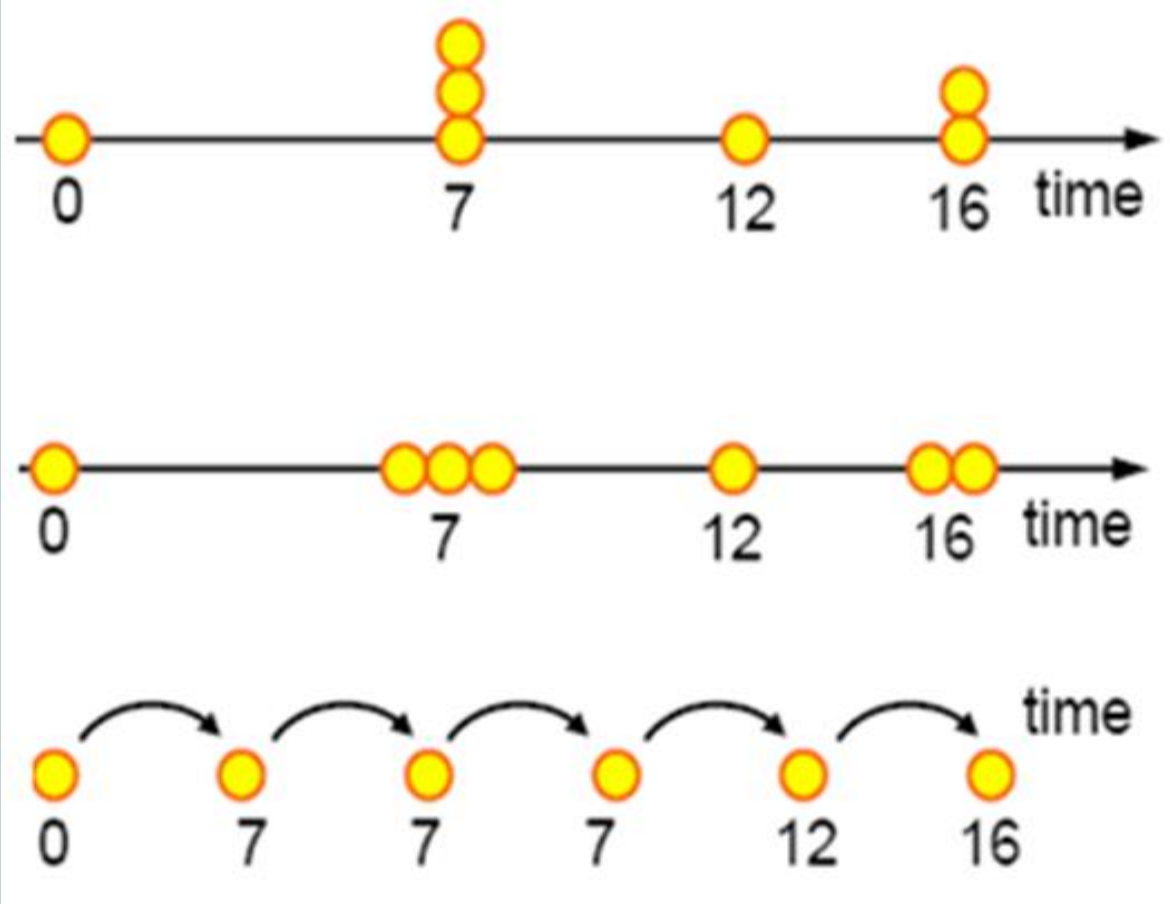
Discrete-event simulation

Main principles

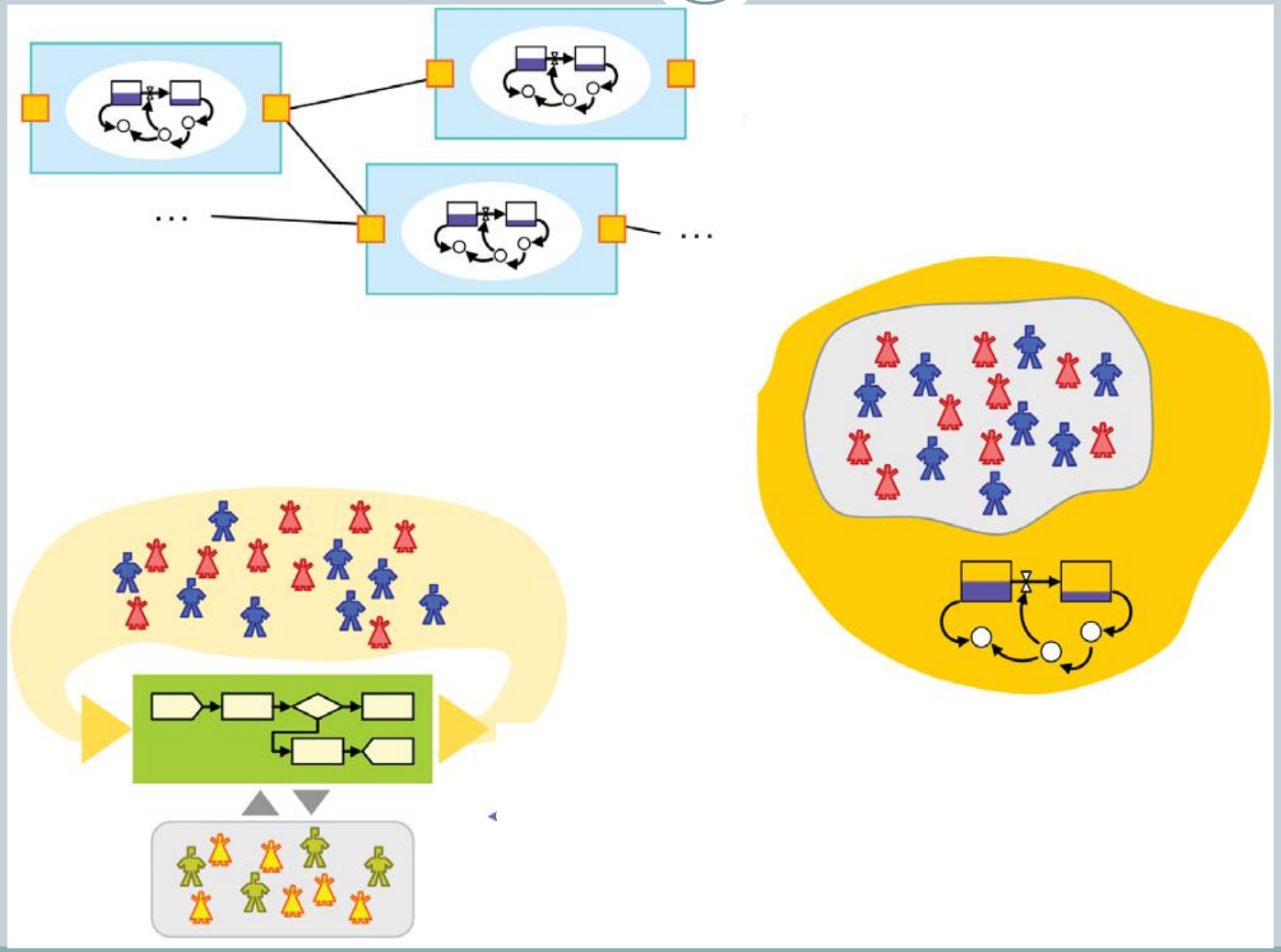
Any changes in model happens only because of events

Events could happen in same time

The model timer “jumps” from one event to another



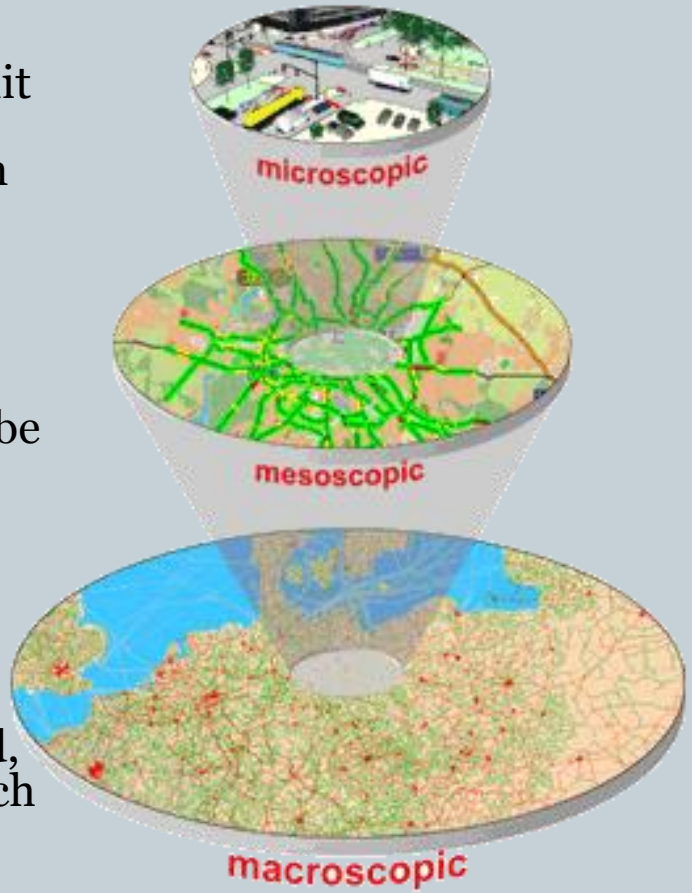
Mixed modeling



Cases

Transport modelling

- Microscopic models
  - Each vehicle is moved through the network of transportation facilities on a split second by split second basis according to the physical characteristics of the vehicle (length, maximum acceleration rate, etc.)
- Mesoscopic models
  - models simulate individual vehicles, but describe their activities and interactions based on the aggregate (macroscopic) relationships
- Macroscopic models
  - simulate traffic flow, taking into consideration cumulative traffic stream characteristics (speed, flow, and density) and their relationships to each other



Software used for traffic flow simulation and analysis

- PTV VISION VISSIM
- PTV VISION VISUM
- SIDRA INTERSECTIONS
- AnyLogic

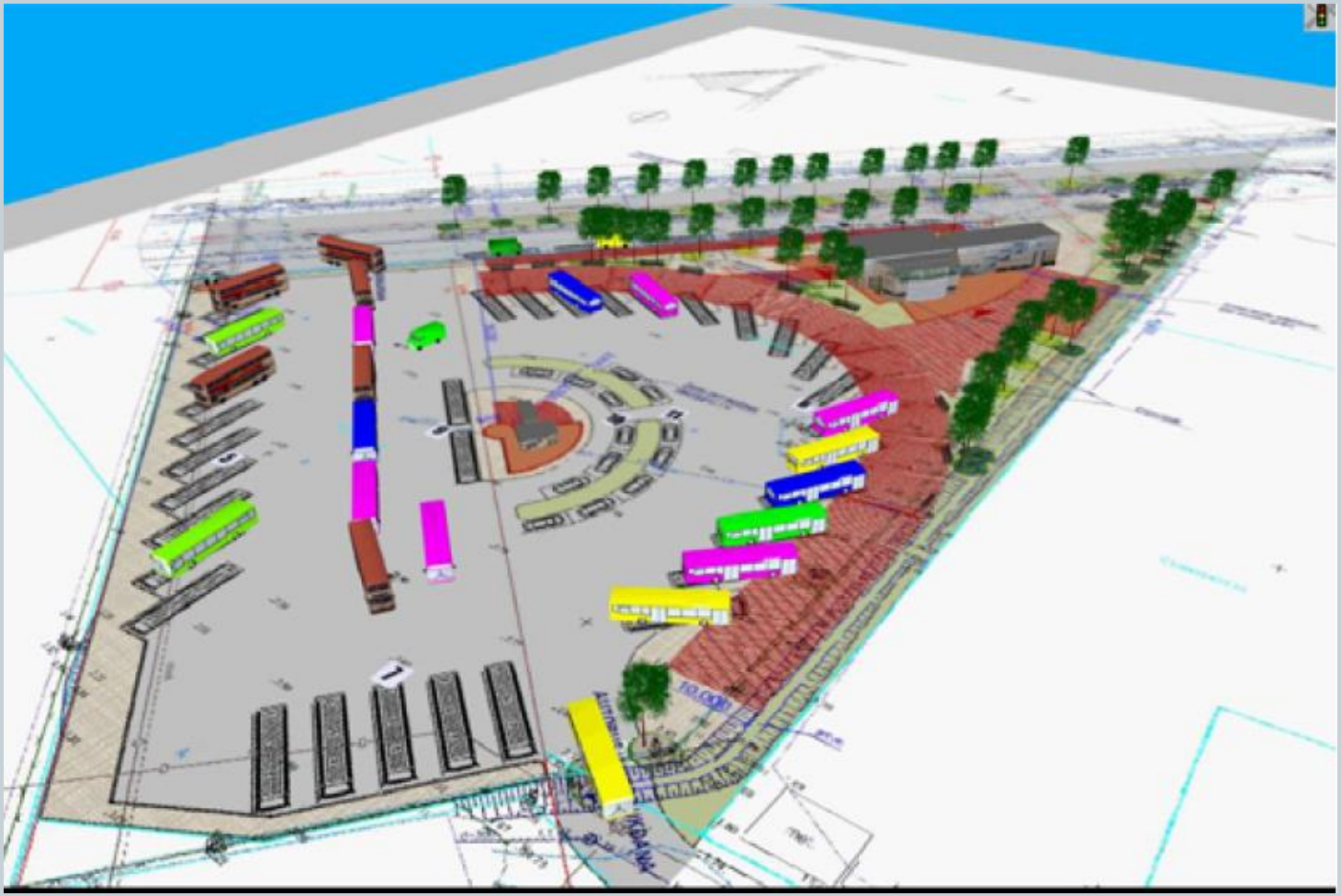
Case study

MODELLING OF NEW COACH STATION PROJECT IN RIGA

Modelling of new coach station project in Riga

- Goal:
  - different architectural plans checking up according to requirements
- Tasks:
  - to analyze the possibilities of the new station design for fulfilling the schedule in different modes;
  - to investigate the impact of a number and geometrical layout of sites for embarkation and debarkation, sites for bus parking on the capacity of the coach station.

Modelling of new coach station project in Riga



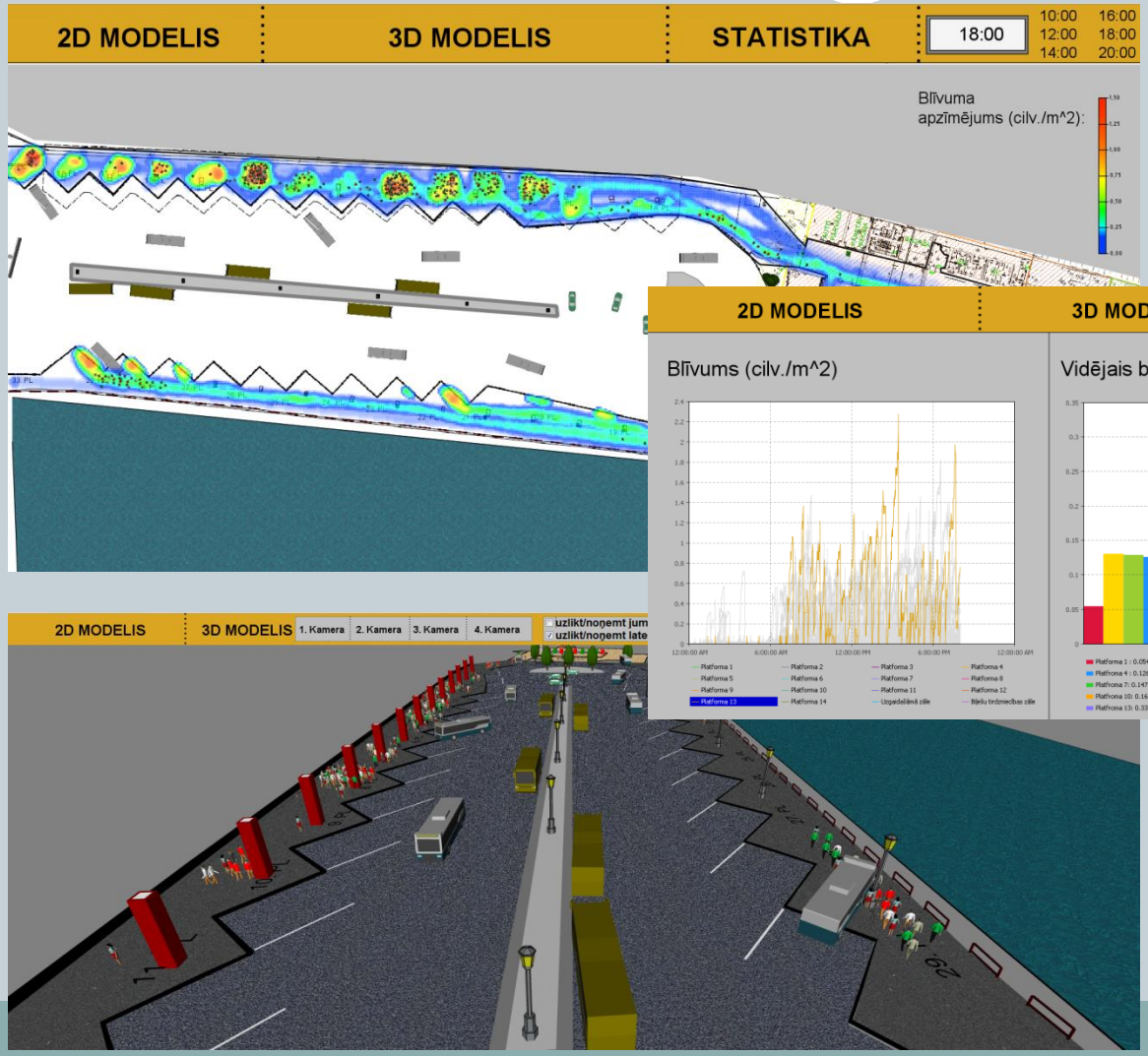
Case-study

TRANSPORT AND PASSENGER FLOW ORGANISATION MODEL DEVELOPMENT FOR RIGA INTERNATIONAL COACH TERMINAL

Transport And Passenger Flow Organisation Model Development For Riga International Coach Terminal

- Goal:
  - to develop a decision making tool for effective planning of reconstruction activities on Riga International Coach Terminal
- Tasks:
  - to develop, calibrate and validate microscopic model of the coach terminal, which presents current situation, taking into account transport and passenger flows;
  - to develop a 3D animation of the model
  - to estimate the density of the passengers in the territory of the coach terminal;

Transport And Passenger Flow Organisation Model Development For Riga International Coach Terminal



Case study

MODEL OF THE TRANSPORT NODE KRASTA STREET - MASKAVAS STREET - SLAVU BRIDGE WITH THREE LEVEL FLYOVER

Model of the transport node Krasta street - Maskavas street - Slavu bridge with three level flyover

- Goal:
  - to indicate possible bottlenecks in the new project of transport node in Riga city

- Tasks:
  - simulation models development of the transport node Krasta Street - Maskavas Street -Slavu Bridge, which also includes three-level trestles;
  - analysis of the former and future states with transport flows in this transport node, which was indicated on the second place in 2004 according to work-load (104% on the basis of the ICU method) and is being reconstructed at present;
  - development of animation video in 3D.

Model of the transport node Krasta street - Maskavas street - Slavu bridge with three level flyover

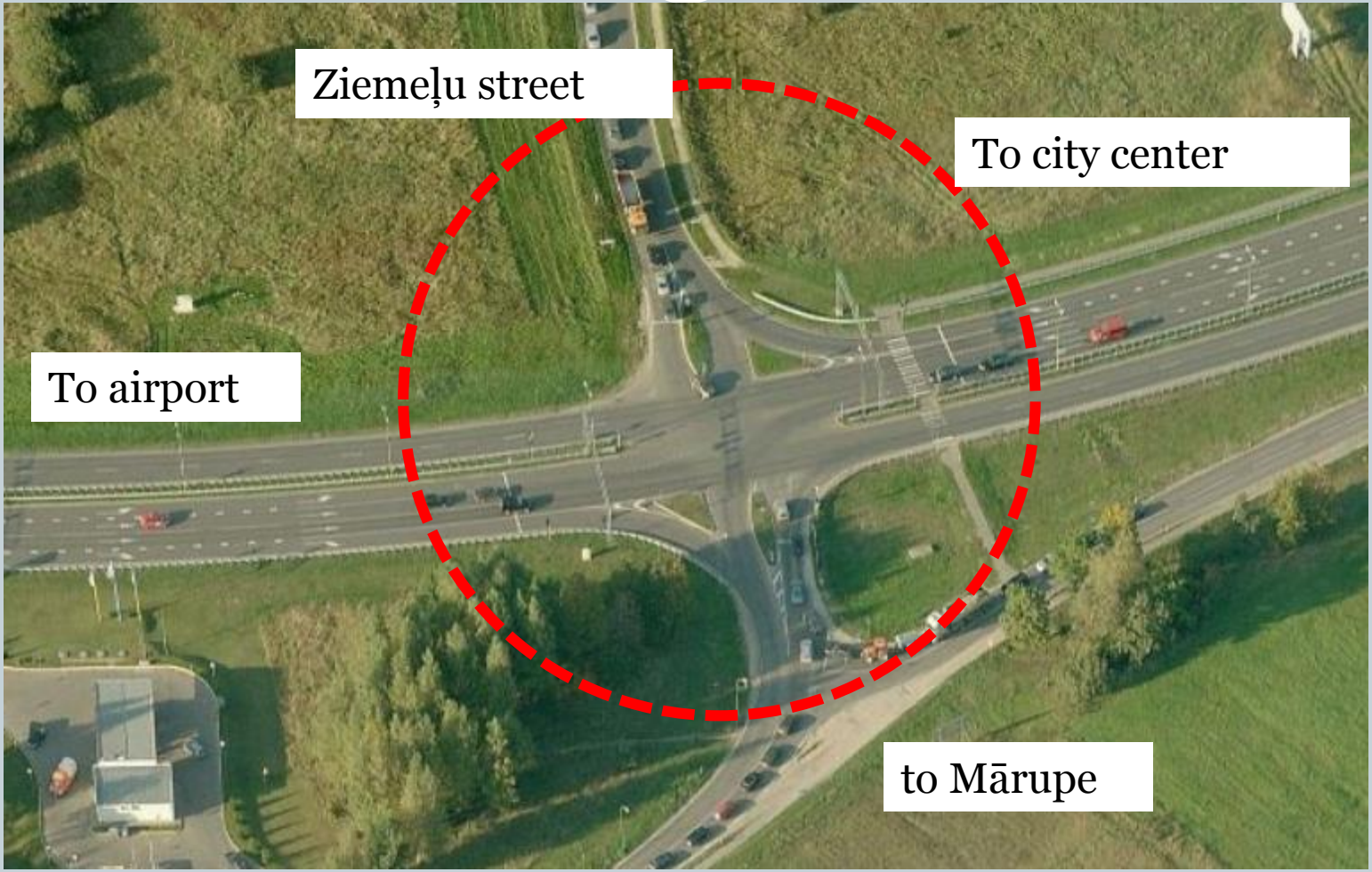
Case-study

HIGHWAY P133 AND ZIEMELU STREET INTERSECTION SIMULATION AND CAPACITY ESTIMATION

Highway P133 and Ziemelu street intersection simulation and capacity estimation

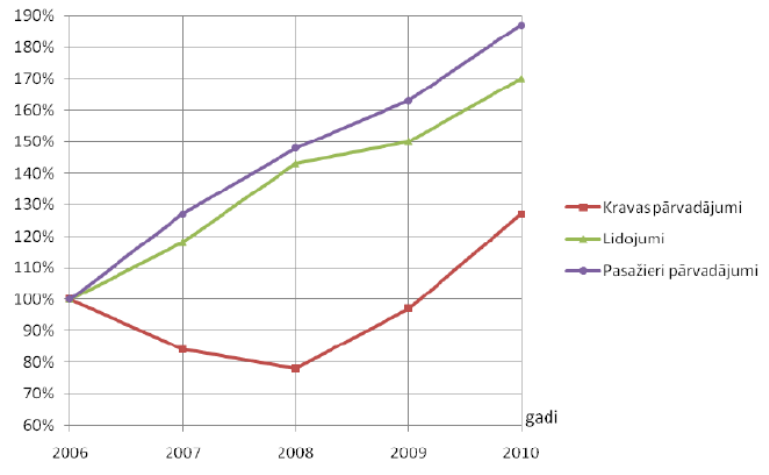
- Goal:
  - to test different scenarios on P133 and Ziemelu street intersection capacity improvement
- Tasks:
  - to develop microsocpic model of the intersection;
  - to test different development scenarios
  - to estimate level of services (LOS) for crossroads according to HCM standard
  - to produce 3D animation of the model

Research object

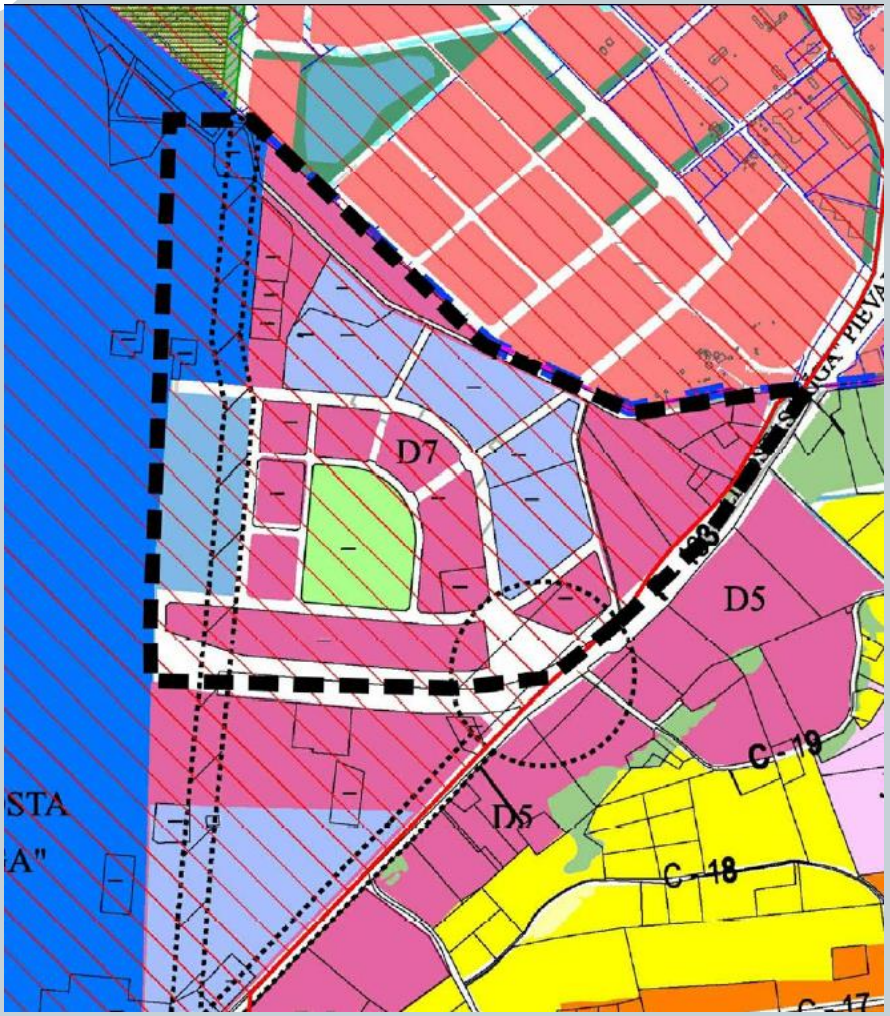


Development plans

- Cargo and passenger growth



- Territory development
  - Expedition hall
  - Business center
  - ...

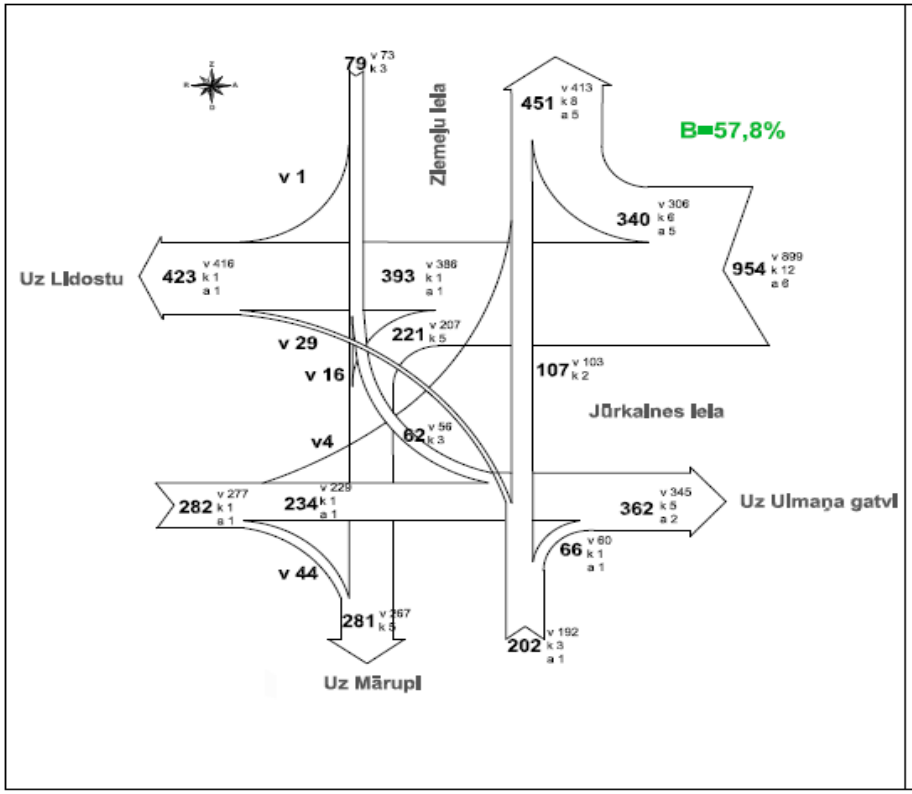


Input data (traffic flow intensity)

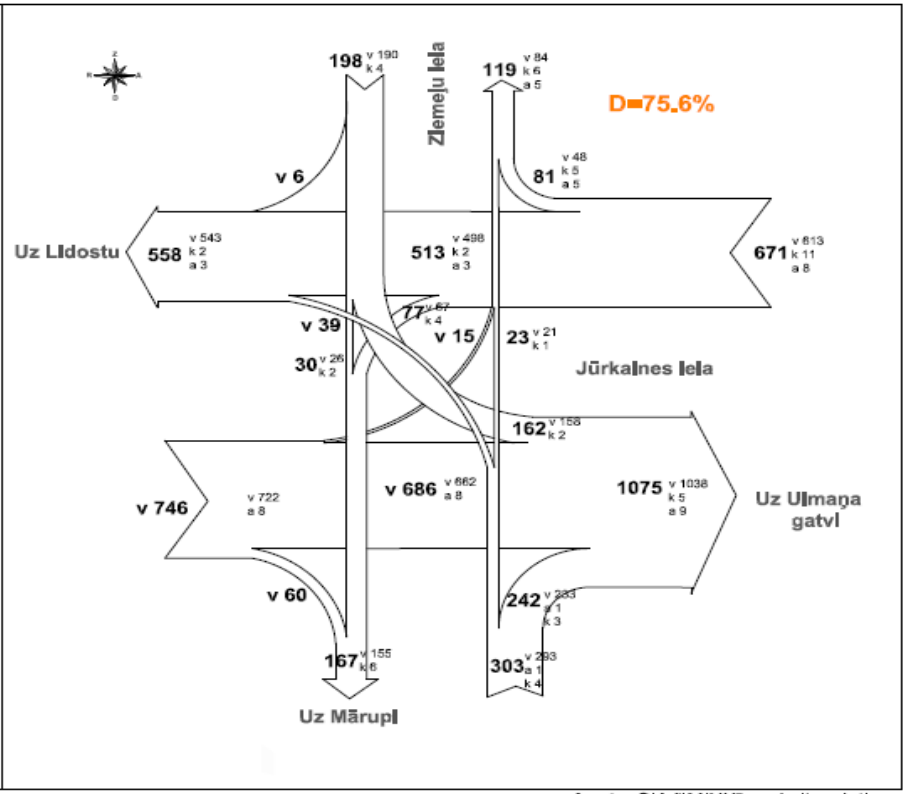
A/c P133 un Ziemeļu ielas krustojums

Transporta plūsmu sadalījums pa virzieniem darbadienā
(10.03.2011)

rīta maksimumstundā 8:00-9:00



vakara maksimumstundā 17:00-18:00



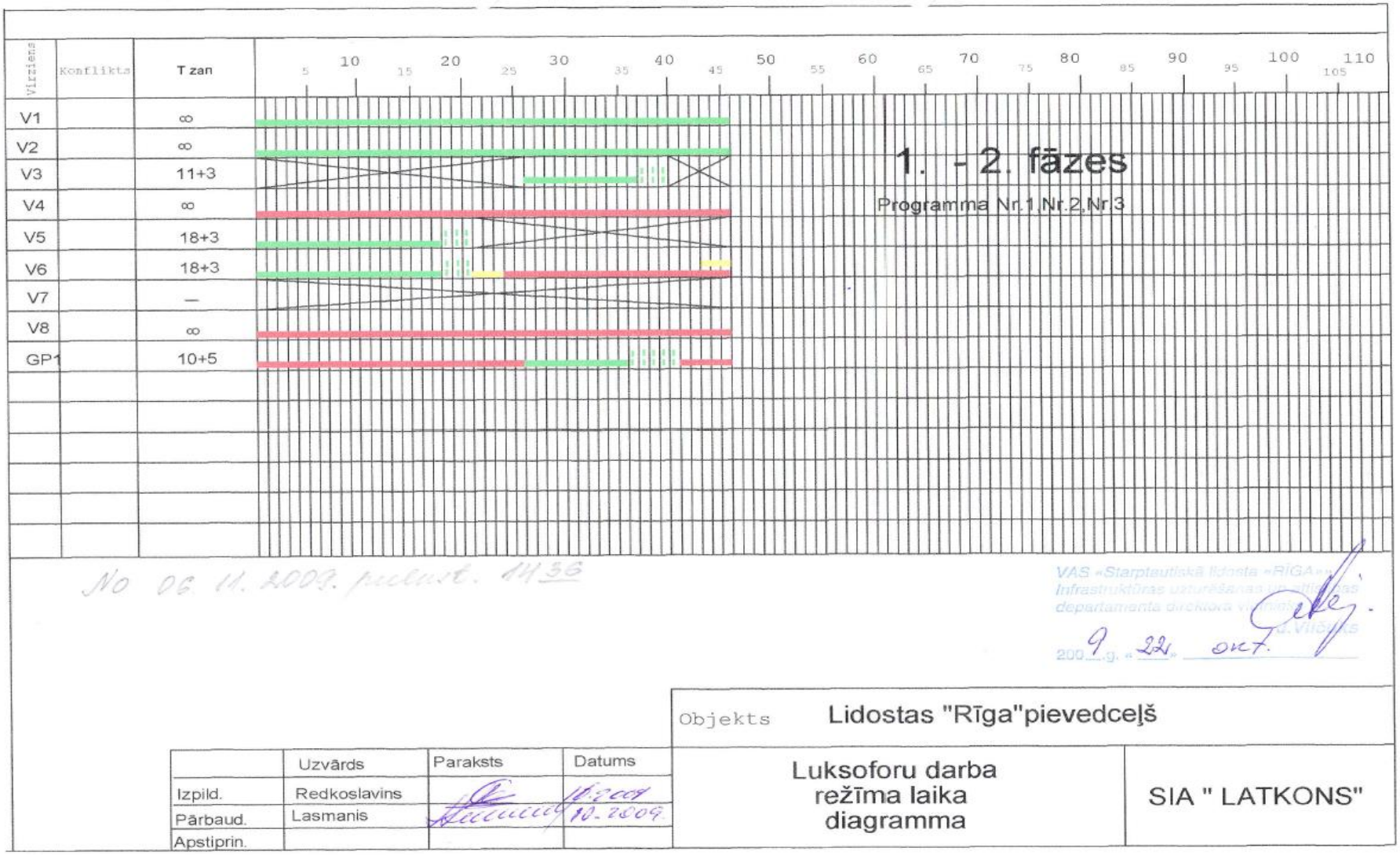
Satīksmes komforta līmeņi krustojumā notekti saskaņā ar ICU 2003:

B- *zems krustojuma noslogojums*

D - *pieļaujamais noslogojums*

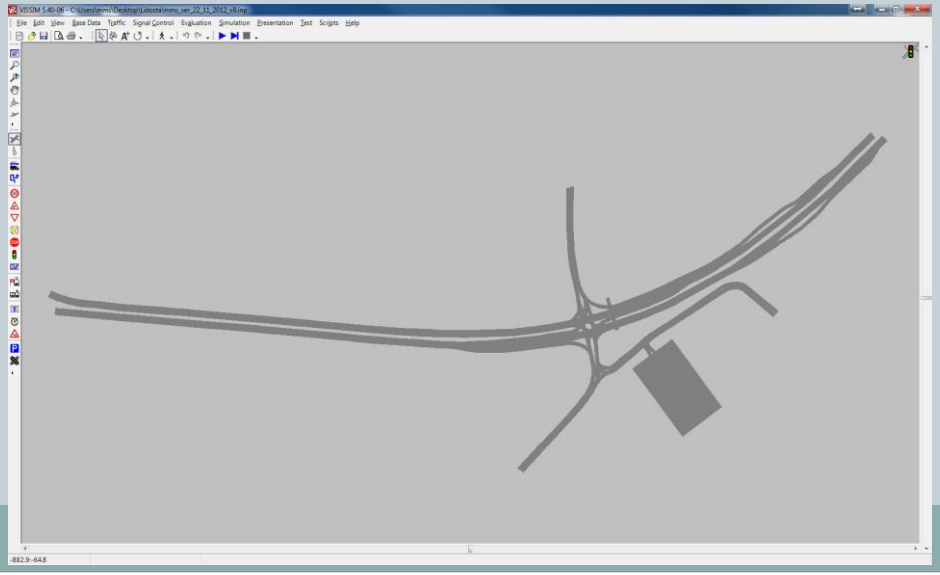
Avots: SIA "IMINK" uzskaites dati

Input data (traffic light data)



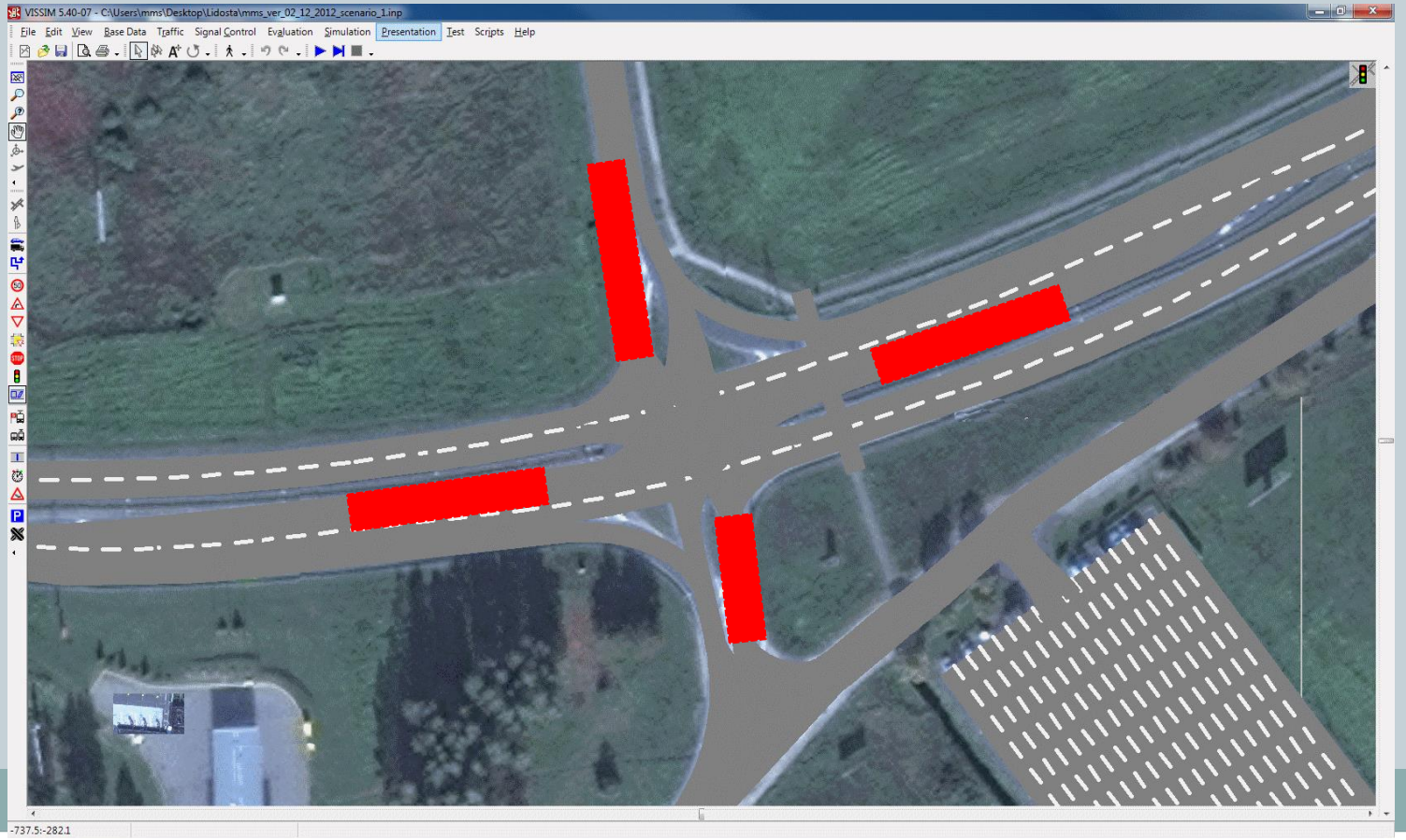
Simulation model development

- PTV VISION VISSIM 5.6
  - 162 – links and connectors
  - 76 - conflict areas
  - 5 – traffic input point
  - 2 – public transport stops
  - 1 – public transport route
  - 12 – traffic lights
  - > 100 3D objects



Particularities of the model

- Some directions are controlled by detectors



Scenarios

№	Title	Description
1	**Scenario 1:** P	• Intensity: Forecasted
2	**Scenario 2:** P+2J	• Intensity: Forecasted • 2 lanes from Ziemeļu iela
3	**Scenario 3:** P+2J+L1	• Intensity: Forecasted • 2 lanes from Ziemeļu iela • Fix traffic light cycle (1st variant)
…	…	…
7	**Scenario 7:** P+2J+L2	• Intensity: Forecasted • 2 lanes from Ziemeļu iela • Fix traffic light cycle (2nd variant)
…	…	…
11	**Scenario 11:** P175+2J+L3	• Intensity: Forecasted • (Marupe direction– 175 v/h) • 2 lanes from Ziemeļu iela • Fix traffic light cycle (3rd variant)

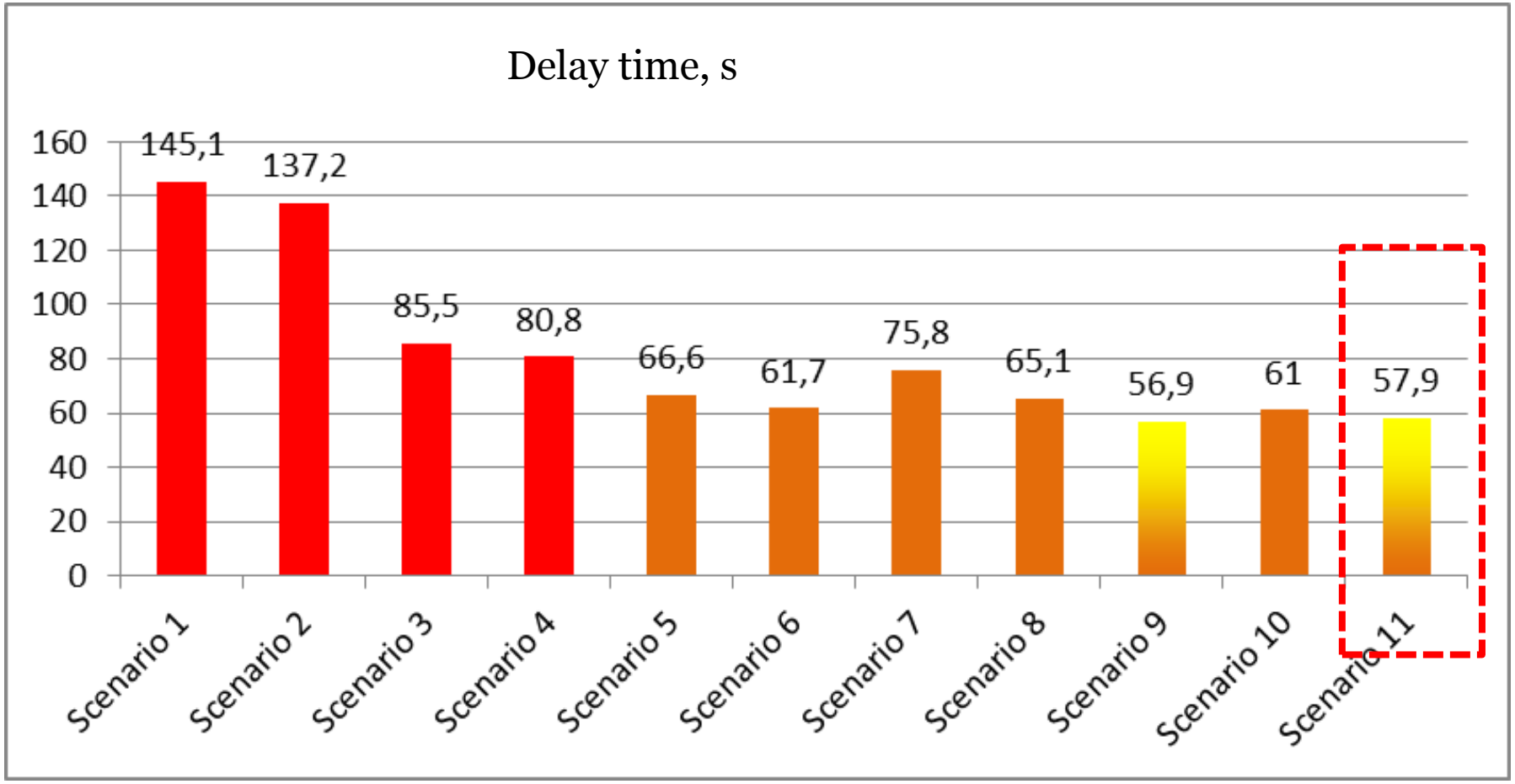
Level of Service

LOS	Delay time (s)
A	≤10
B	> 10 – 20
C	> 20 – 35
D	>35 – 55
E	> 55 - 80
F	>80

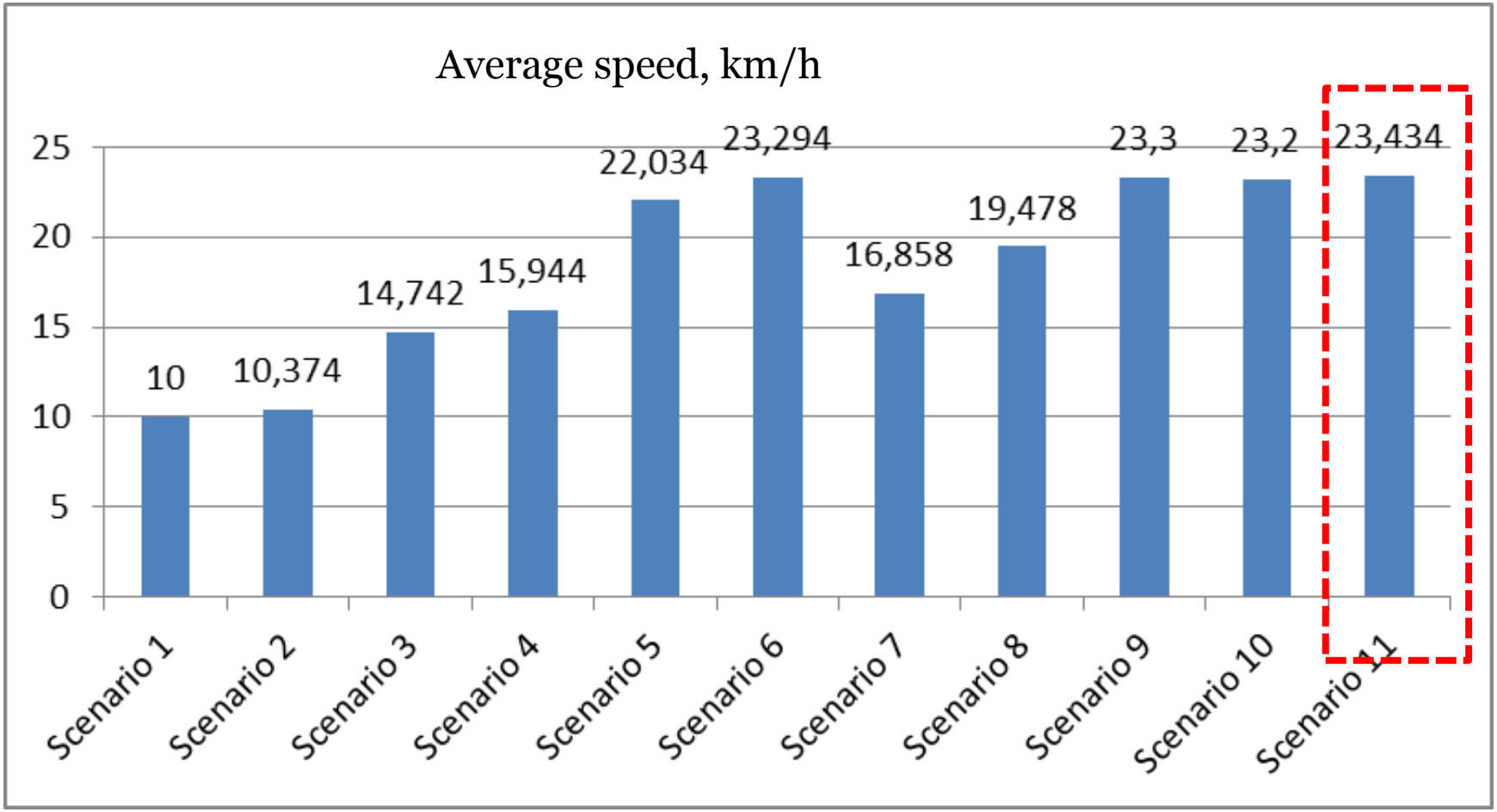
Simulation results

LOS												
Krustojums	**Virziens**	**Braukšana**	Scenāriji									
			1	2	3	4	5	6	7	8	9	10	11
1	NB (Developing territory)	Left 2											
		Through											
		Right 2											
		Total	F	F	F	F	F	E	F	F	E	D	E
	EB (Airport)	Left 2											
		Through											
		Right 1											
		Total	C	C	C	C	C	C	D	D	D	D	D
	SB (Marupe)	Left 2											
		Through											
		Total	F	F	F	F	F	F	E	E	E	F	E
	WB (City center)	Left 2											
		Through											
		Right 2											
		Total	D	D	D	D	D	D	D	D	D	D	D
	Total		F	F	F	F	E	E	E	E	E	E	E

Simulation results



Simulation results



3D animation

Case-study

PEDESTRIAN AND TRANSPORT FLOWS ANALYSIS FOR PEDESTRIAN STREET CREATION IN RIGA

Pedestrian and transport flows analysis for pedestrian street creation in Riga city

- Goal:
  - to test different development scenarios of the Terbatas street
- Tasks:
  - to make a traffic counts survey to obtain information about current use of the street and around lying region;
  - to estimate public transport loading level and to make public transport passenger questionnaire about origin, destination, travel goal and preferences;
  - to develop and calibrate microscopic model, which describes current situations;
  - to test different development scenarios;
  - to forecast traffic flow redistribution and to estimate level of services (LOS) for crossroads according to HCM standard.

Traffic counts

- Date and time:
  - 29 September from 7:30 till 9:30
  - 29 September from 16:30 till 18:30

  } Wednesday

  - 30 September from 7:30 till 9:30
  - 30 September 16:30 till 18:30

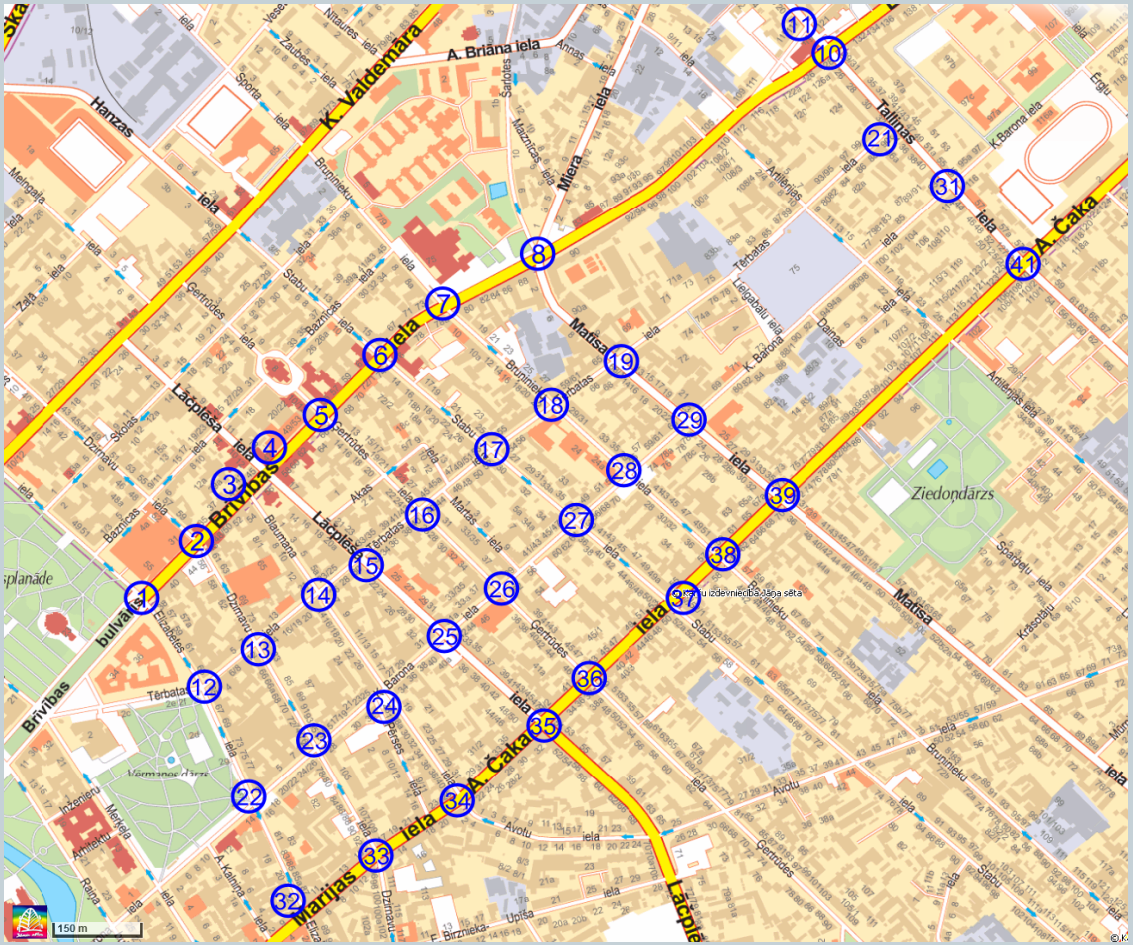
  } Thursday

- 150 TTI students (traffic counts)
- 10 students (data processing, analysis, visualization)

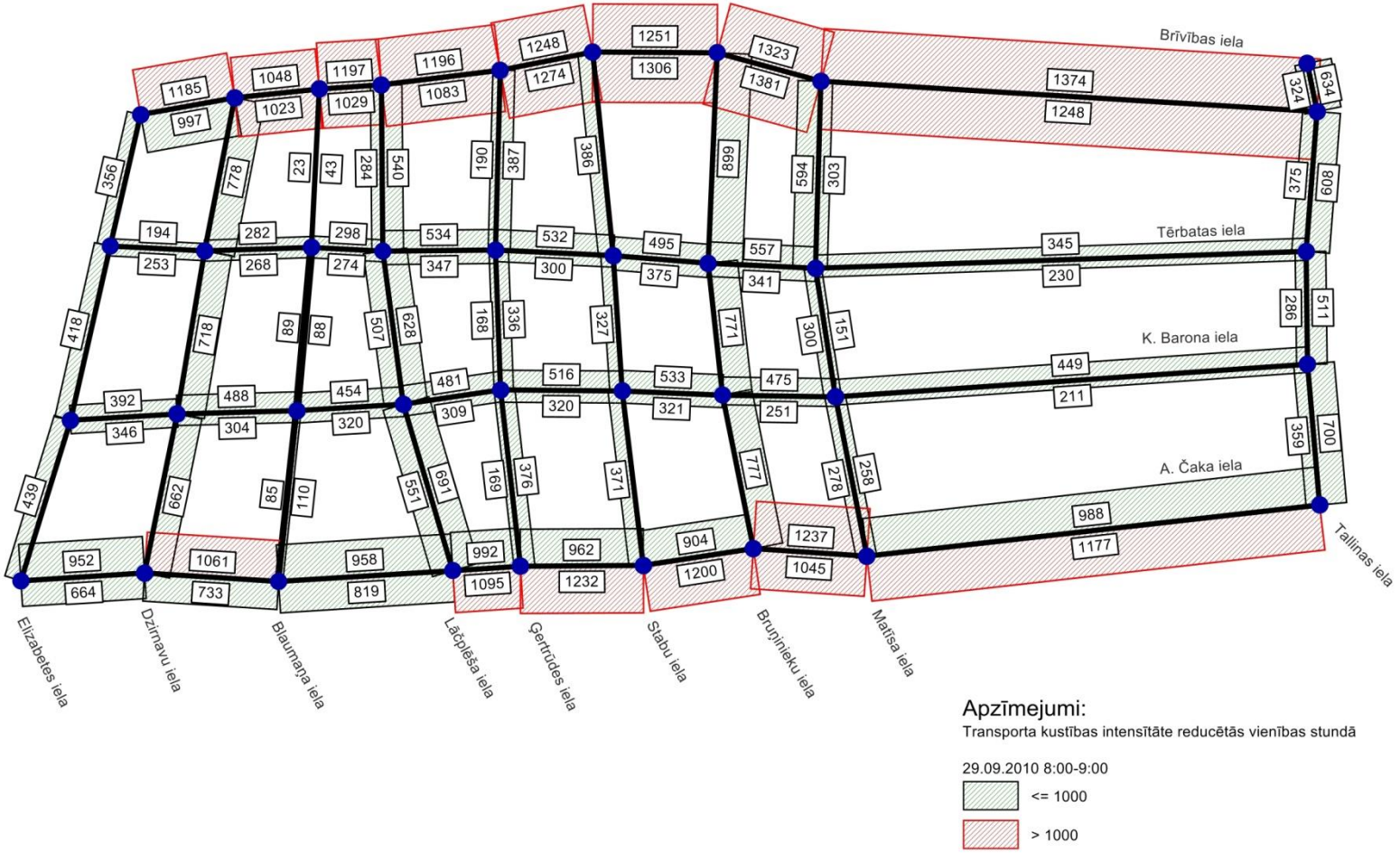
Object

37 Crossroads:

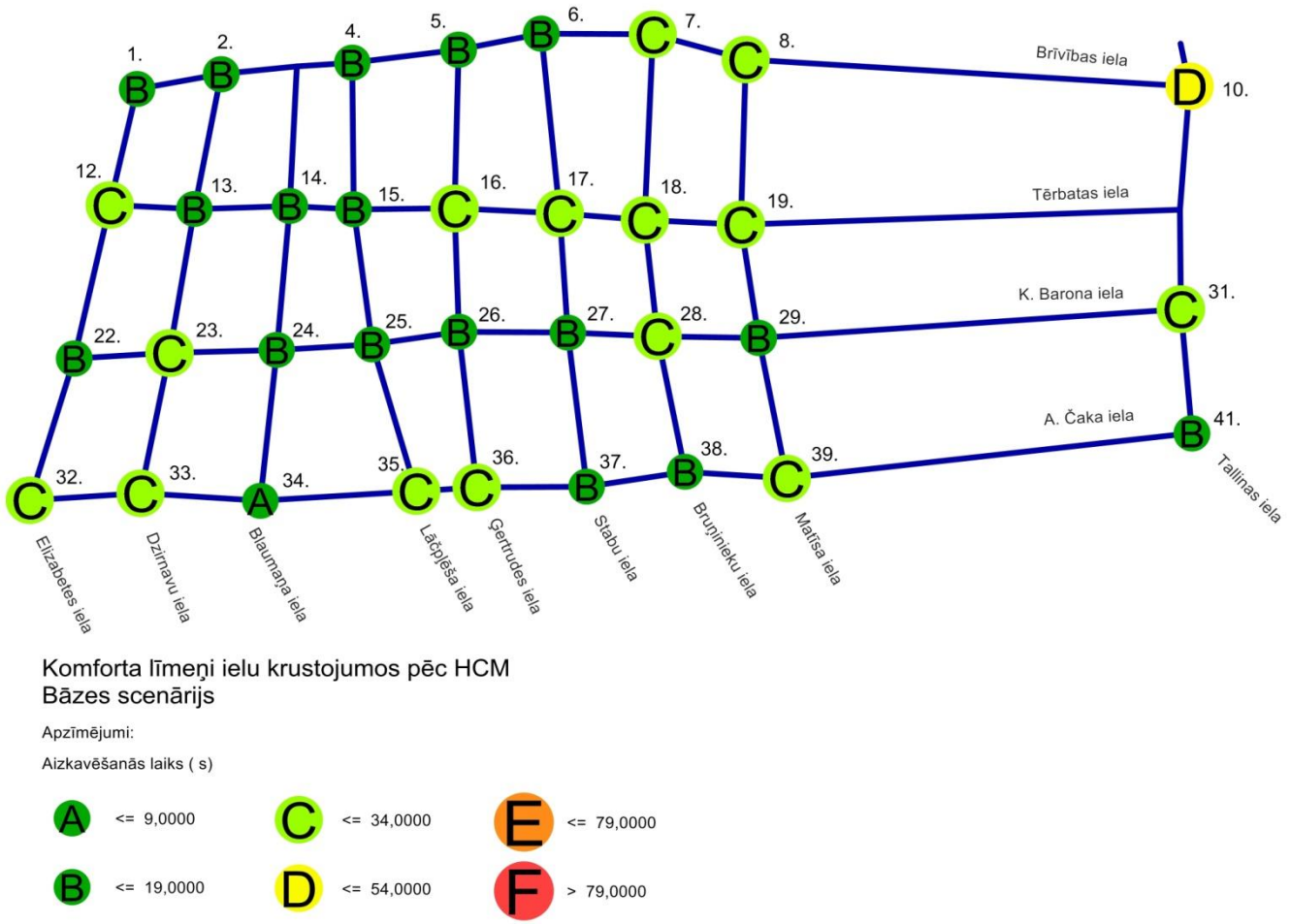
Brīvības iela – Elizabetes iela
Brīvības iela – Dzirnavu iela
Brīvības iela – Blaumaņa iela
Brīvības iela – Lāčplēša iela
Brīvības iela – Ģertrūdes iela
Brīvības iela – Stabu iela
Brīvības iela – Bruņinieku iela
Brīvības iela – Matīsa iela
Brīvības iela – Tallinas iela
Brīvības iela – Cēsu iela
Tērbatas iela – Elizabetes iela
Tērbatas iela – Dzirnavu iela
Tērbatas iela – Blaumaņa iela
Tērbatas iela – Lāčplēša iela
Tērbatas iela – Ģertrūdes iela
Tērbatas iela – Stabu iela
Tērbatas iela – Bruņinieku iela
Tērbatas iela – Matīsa iela
Tērbatas iela – Tallinas iela
Krišjāņa Barona iela – Elizabetes iela
Krišjāņa Barona iela – Dzirnavu iela
Krišjāņa Barona iela – Blaumaņa iela
Krišjāņa Barona iela – Lāčplēša iela
Krišjāņa Barona iela – Ģertrūdes iela
Krišjāņa Barona iela – Stabu iela
Krišjāņa Barona iela – Bruņinieku iela
Krišjāņa Barona iela – Matīsa iela
Krišjāņa Barona iela – Tallinas iela
Marijas iela – Elizabetes iela
Marijas iela – Dzirnavu iela
Aleksandra Čaka iela – Blaumaņa iela
Aleksandra Čaka iela – Lāčplēša iela
Aleksandra Čaka iela – Ģertrūdes iela
Aleksandra Čaka iela – Stabu iela
Aleksandra Čaka iela – Bruņinieku iela
Aleksandra Čaka iela – Matīsa iela
Aleksandra Čaka iela – Tallinas iela



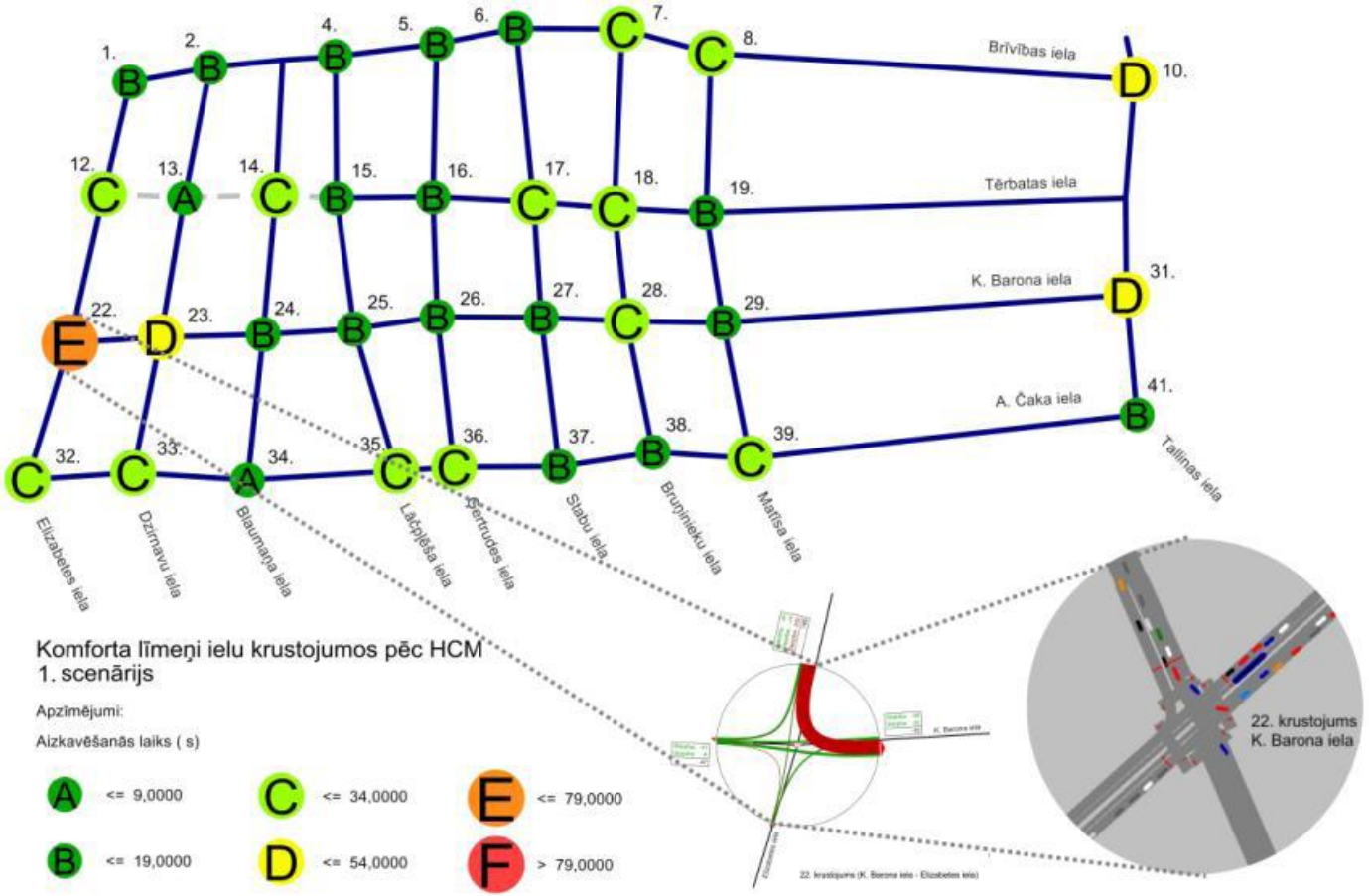
Traffic count results



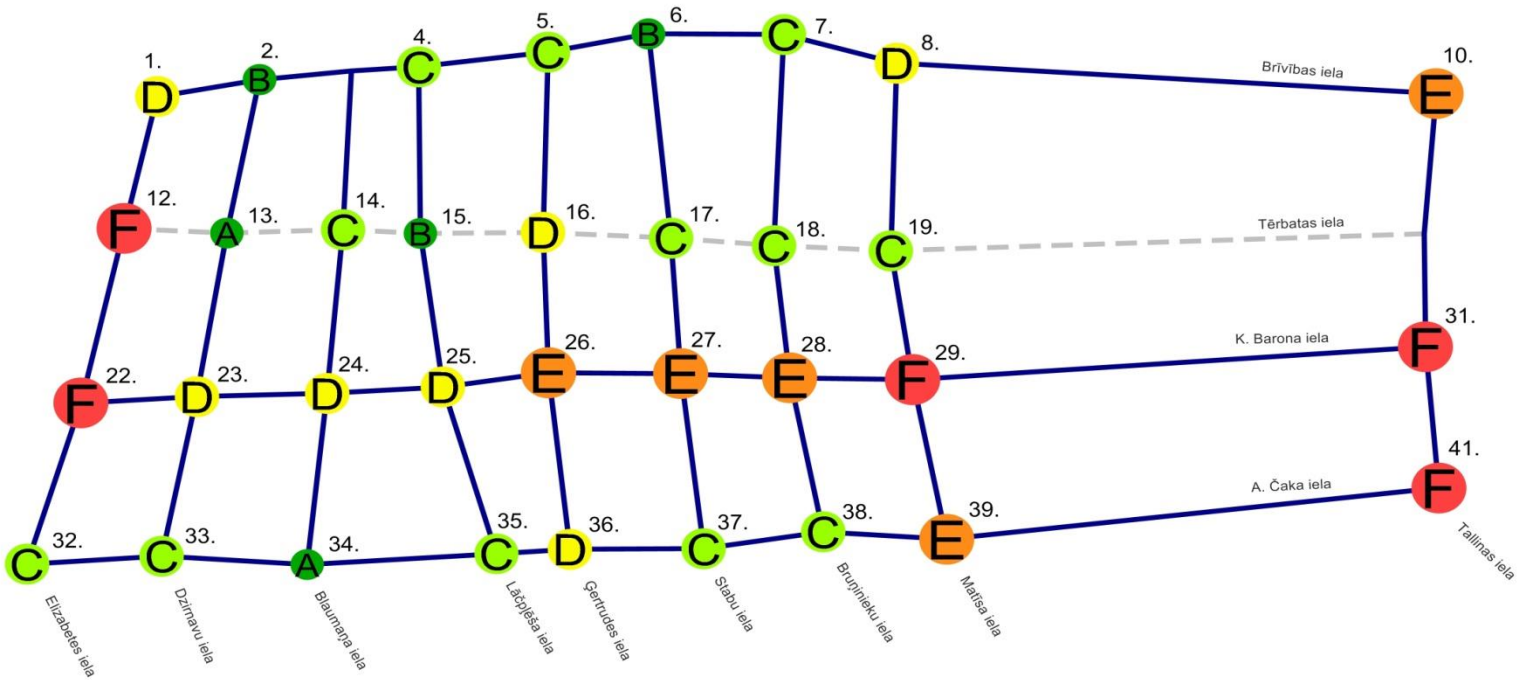
Simulation Results (1/3)



Simulation Results (2/3)



Simulation Results (3/3)



Komforta līmeņi ielu krustojumos pēc HCM
5. scenārijs

Apzīmējumi:

Aizkavēšanās laiks (s)

A	<= 9,0000	C	<= 34,0000	E	<= 79,0000
B	<= 19,0000	D	<= 54,0000	F	> 79,0000

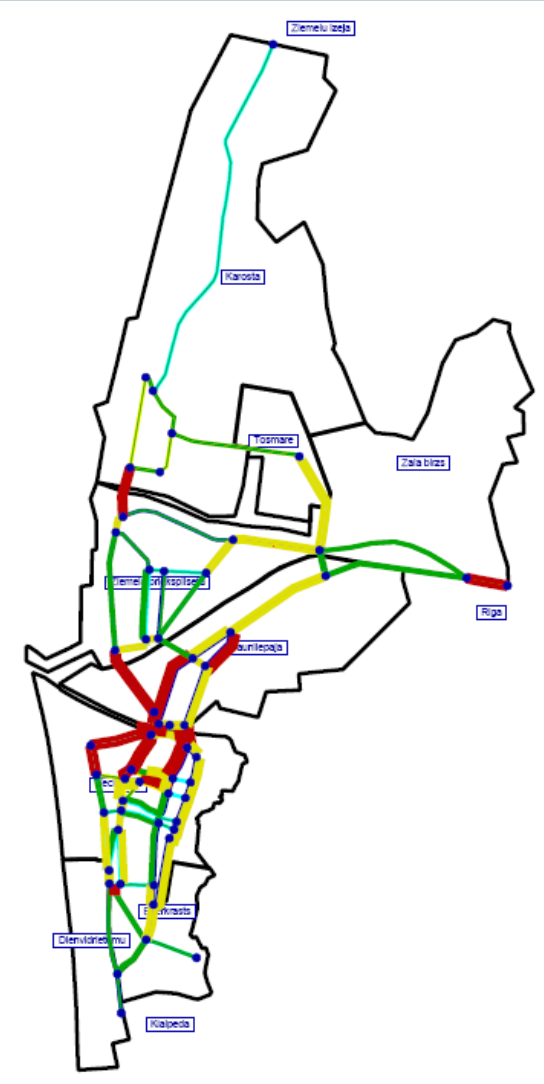
Case study

DEVELOPMENT OF LIEPAJA CITY MACROSCOPIC MODEL FOR DECISION MAKING

Development of Liepaja city macroscopic model for decision making

- Goal:
  - develop macroscopic model of Liepaja city for decision making on implementation of new transport infrastructure elements
- Tasks:
  - to develop a supply model and demand model
  - to test different development scenarious

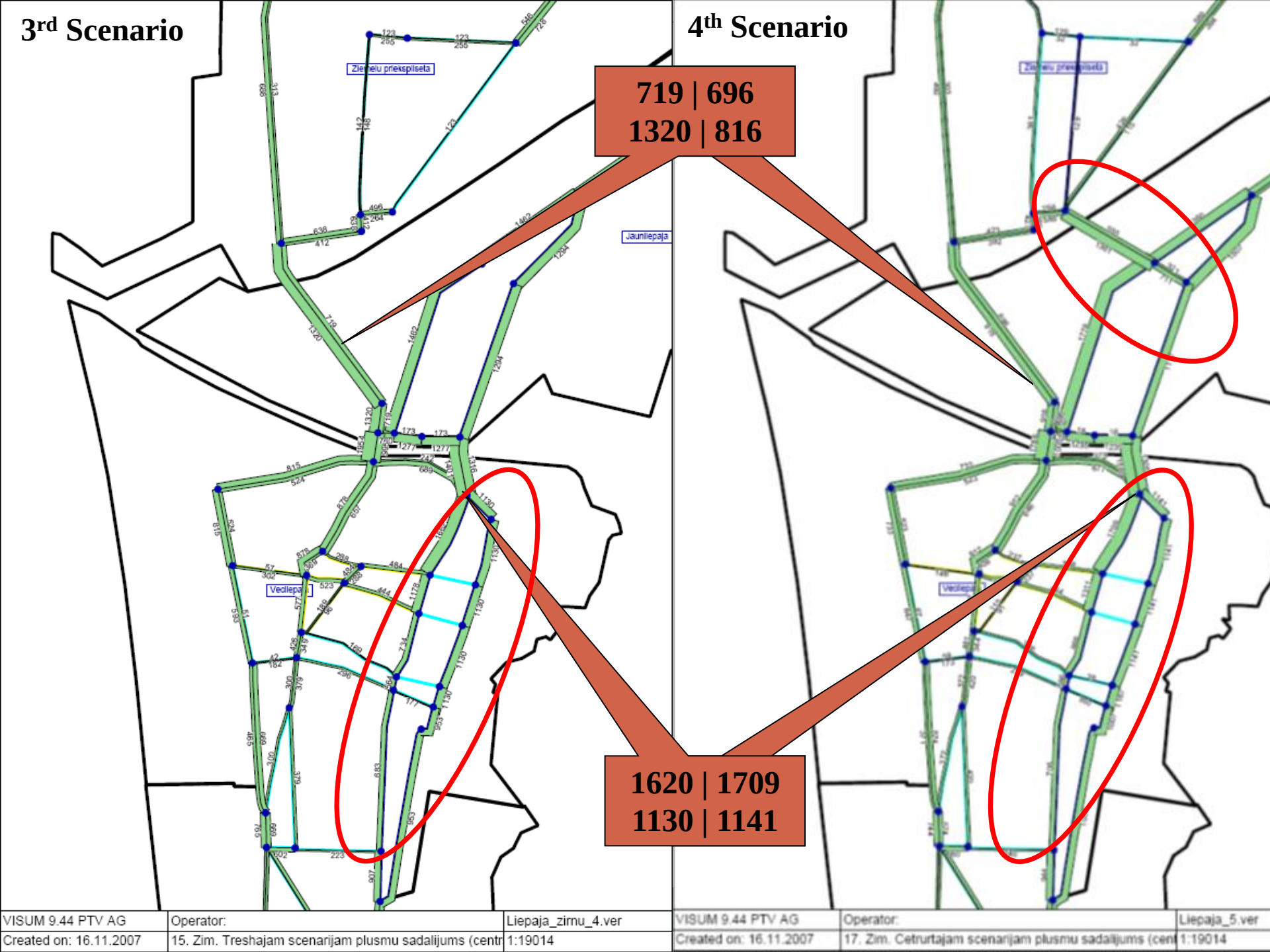
Model



< 80%

< 120%

> 120%


3rd Scenario
4th Scenario
719 | 696
1320 | 816
1620 | 1709
1130 | 1141
Jaunliepaja
Vecliepaja
VISUM 9.44 PTV AG
Operator:
Liepaja_zirnu_4.ver
Created on: 16.11.2007
15. Zim. Treshajam scenarijam plusmu sadalijums (centr
1:19014
VISUM 9.44 PTV AG
Operator:
Liepaja_5.ver
Created on: 16.11.2007
17. Zim. Cetrurtajam scenarijam plusmu sadalijums (cen
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