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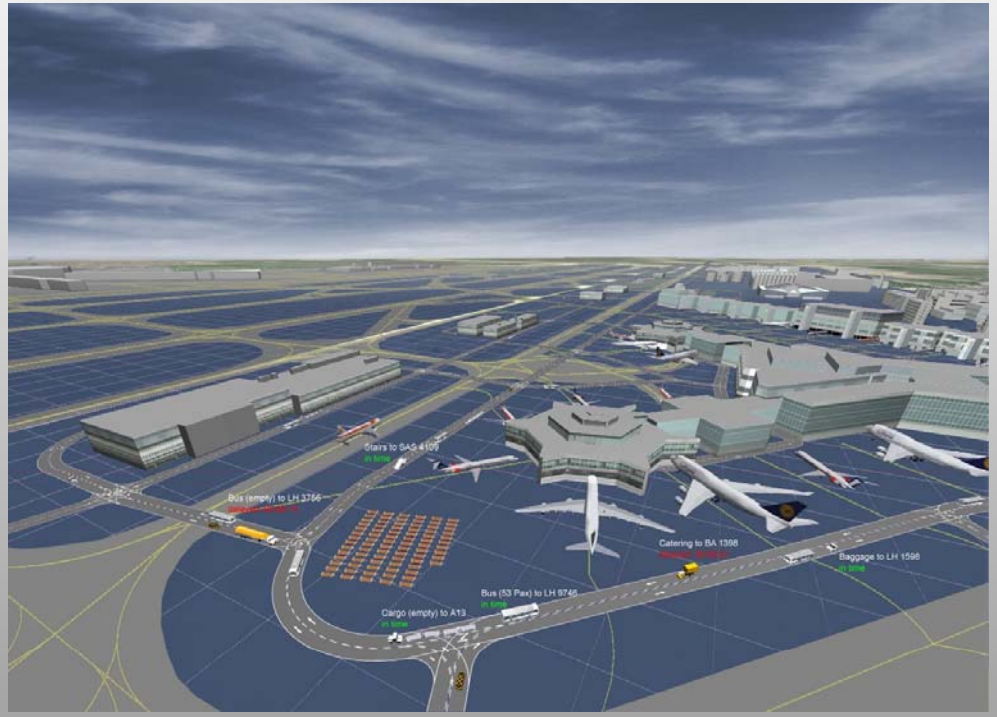
Airport Research Center



CAST Vehicle

Simulation tool for

- Vehicle traffic
- Ground handling processes
- Apron traffic

Michael Laubrock, Airport Research Center

Andreas Quick, Fraunhofer IML

MATHMOD VIENNA

11.02.2009

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Content

A. Quick – Task and Motivation

- Short presentation of the developing partners
- Background and trigger for the development of CAST Vehicle

M. Laubrock - Presentation of CAST Vehicle

- History of CAST
- Overview on the scope of functions
- Some selected features of the software
- Some technical aspects
- Video-Demos
- Perspective

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Developing Partners & Contact

Customer:

Fraport AG
Traffic & Terminal Management
Airport Expansion (FBA-IL2)

Co-operation partner:

Fraunhofer-Institute for Material Flow and Logistics
Airport Project Center

CAST Vehicle

Contractor:

Airport Research Center GmbH

Aachen

Time Schedule:

Software:	started end of 2005 finished mid of 2008
Airportmodel: „FRA“	started beginning of 2008 finished approx. mid of 2009

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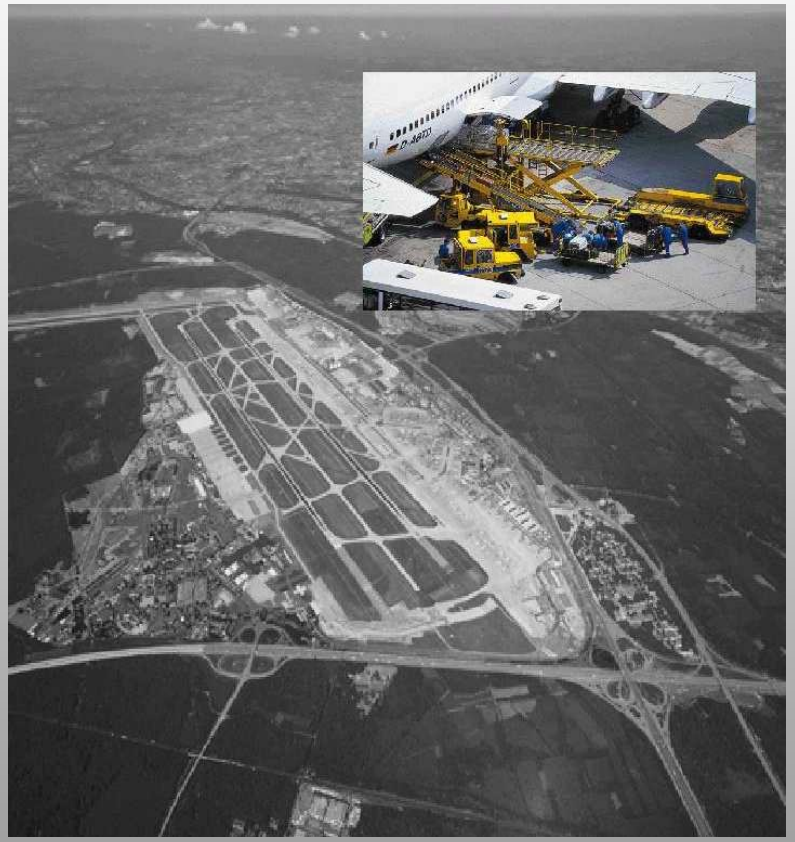
Apron Key Facts – Frankfurt Main Airport



Sources & sinks

- ~ 189 ha apron area
- ~ 133 flight gates (2 passenger terminals)
- ~ 84 in- & outfeed locations (airside) of baggage handling system
- ~ 20 cargo facilities (freight & mail) with multiple delivery and pick-up-points
- ~ 200 aircraft positions

Peak system load (2007)

- ~ 181,500 passengers per day
- ~ 104,000 pieces of luggage per day
- ~ 8,300 tons of freight per day
- ~ 440 tons of mail per day
- ~ 20 different handling services per aircraft movement

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Challenges and Goals

Fundamental apron/system characteristics:

- Heavy loaded traffic- & handling infrastructure
- Non-linear and dynamic traffic processes
- Many complex, time sensitive and interlocked transportation and service processes (e.g. passengers, luggage and freight transportation)
- High number of participants with limited resources

? How to plan and optimize infrastructure, resources, dispatching strategies and system load as a whole ?

Strategy
Planning
Operations

Focus of Development

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Typical Questions of a Planning Department

impact on	setting and changing of infrastructure	resources	dispatching	system load
traffic quality	Where could be actual/future bottlenecks?	How much parking space for vehicles and equipment is needed?	How must an optimal traffic guidance look like?	Does the infrastructure provide enough capacity to meet the flight-plan?
process quality	Is the location of roads, intersections and parking spaces correct?	What is the influence of vehicle type to average driving time?	Which strategies of disposition are beneficial? (trade-off between punctuality and resource demand)	Is the system stable, i.e. insusceptible against lower or higher system load?
resources demand	How will modification of infrastructure influence demand?	How does a change of vehicle type influence demand of parking space?	How many resources (vehicles, equipment, space) can be saved with a new disposition strategy ?	How does the demand grow due to a future flight-plan ?

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Need for a New Simulation Tool

- Application of a model calculation due to the high grade of complexity, interaction and dynamics on the apron hardly possible and ineffective
- Application of a software to model and simulate all these issues more feasible
- Existing simulation tools do not provide the required functions, quality and efficiency (especially the combination of traffic and process simulation aspects)

→ Fraport AG and Fraunhofer IML retain ARC to develop a new simulation tool that meets all requirements

→ Analysis and optimization by means of Fast-time-simulation (infrastructure, resources, disposition)

▶ *CAST Vehicle*

CAST Vehicle

History and Overview

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CAST - History

1994 ▶ ***Airbus***
Cabin Boarding, Ground Handling Stand,
Towcurve: **A380**

▶ ***Fraport***
2003 Virtual Apron Control

▶ ***BAA***
Terminal Passenger Flow and Processes

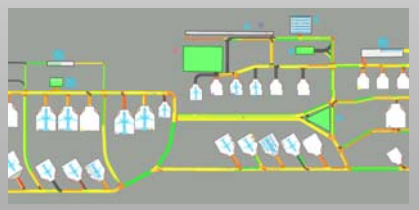
2006 ▶ ***Fraport / Fraunhofer IML***
Ground Handling Traffic

▶ ***Eurocontrol Experimental Centre***
CDM - information flows
Integration,
Full dynamisation of the model

▶ ***Eurocontrol, European Commission***
Unique Zurich, NASA
2008 Aircraft, optimised allocation modules
+ several other enhancements

▶ Tatical and operational application

2010



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CAST - Modules

CAST Airport Simulation

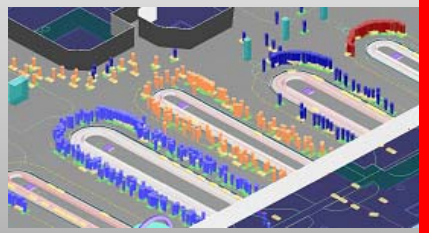
Terminal Pedestrian

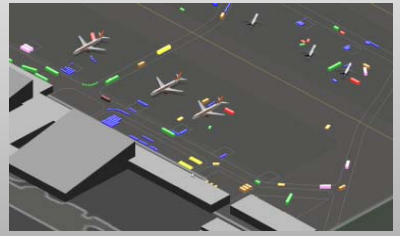
Vehicle Operations

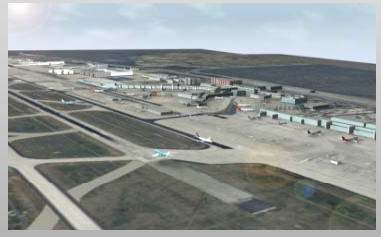
Aircraft Operations

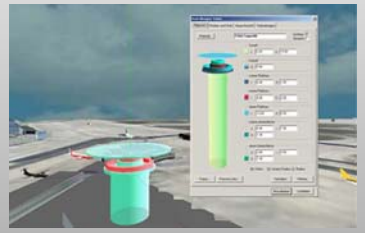
Visualisation Animation

INTEGRATED SIMULATION









Developement partners

BAA

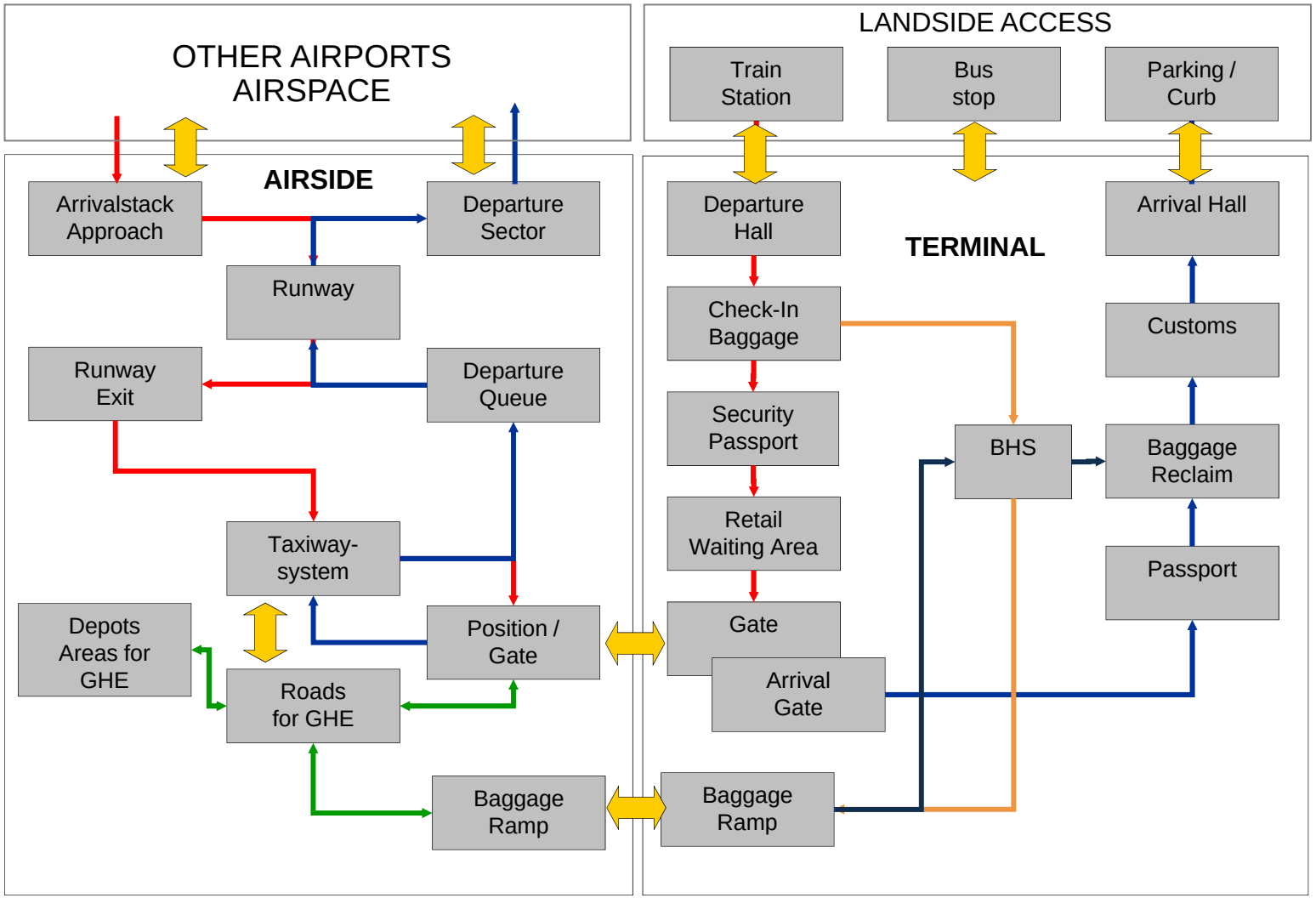
IML

Fraport

EUROCONTROL

AIRBUS

CAST Total Airport Simulation



Actors

- Car
- Train
- Bus
- Aircraft
- Passenger
- GHE
- Baggage
- Cargo

Load

- Flight schedule

ATC / Tower | Airline | Airport | Ground-Handler | Public Transport

Stakeholders (Operational Strategies / Systems)

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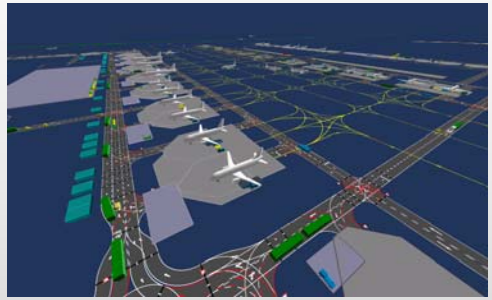
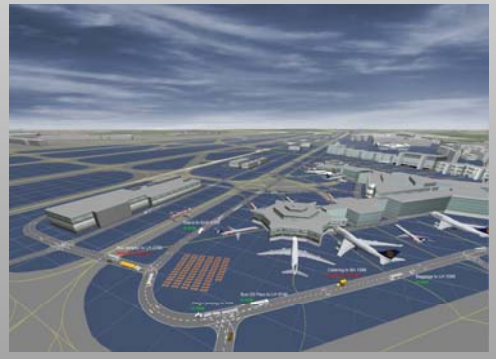
Technical aspects of CAST

- Discrete event simulation - Flexible simulation time steps
- Fast time simulation
- Multi-agent technology
- Agent based simulation: Direct representation of actors (e.g. vehicles)
- Agents act according intentions / tasks and capabilities
- Not deterministic, pseudo random variable for relevant parameters
- 3D Simulation Environment: Modelling and Simulation





CAST Vehicle

Overview and Simulation Environment

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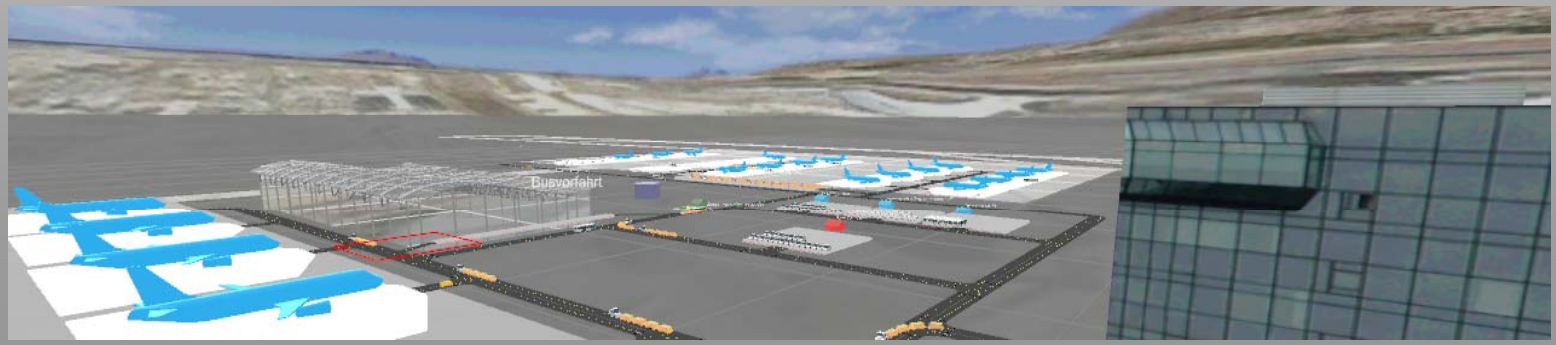
CAST Vehicle – Overview on the main components

- **Infrastructure**
  Parking and preparation spaces, buildings, roads, taxiways, stands
- **Operational concept**: rules, restrictions
- **Flight schedule**: flights, load information (passenger and freight volume)
- **Servicing patterns**:
  Time-resource patterns (transport and service demand)
- **Resources**: vehicles (types, properties, amounts)
- **Disposition**: rules, routing, planning parameters
- **Microscopic** vehicle simulation: effects and conflicts
- Data recoding, visualisation and analysis



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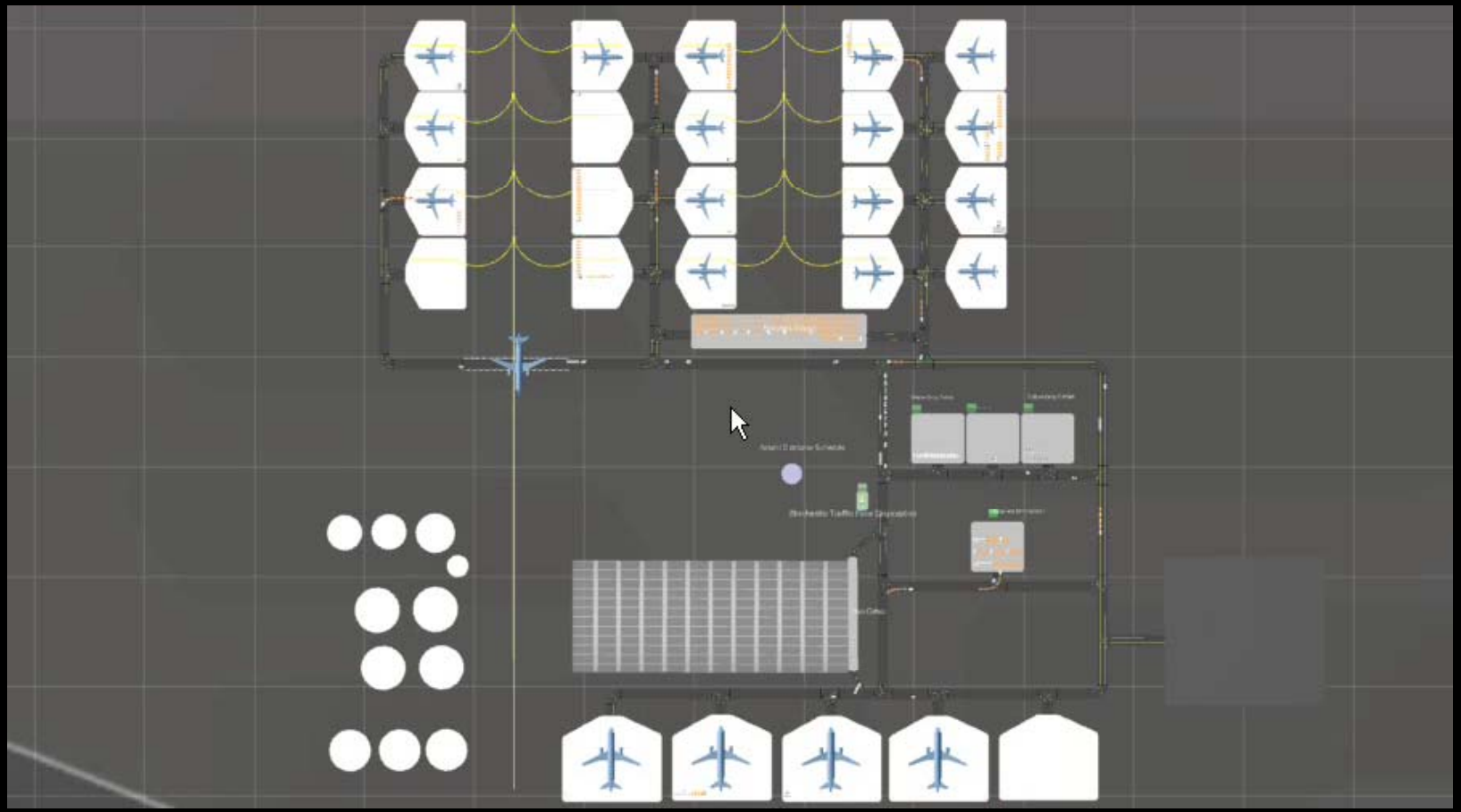
Top view on the airport



All simulation components within the model: network, controls, vehicles etc.

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Top view on the airport

All simulation components within the model: network, controls, vehicles etc.

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Microscopic vehicle simulation

Comprehensive vehicle following behavior
Simulation of allocation and dispostion
Simulation of complex route planning strategies

CAST Vehicle

Main components
(Selection)

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Disposition - Service Patterns

- Service patterns according to **customer definitions**
- **Transport** processes (cargo / baggage / pax / crew)
- **Service** processes (fuelling, catering, documents, ramp agent, GPU etc.,)
- Different types: type, airline, time, origin, destination
- **Load-dependent** passenger and cargo amounts are considered (e.g. units / vehicle and time demand per unit)

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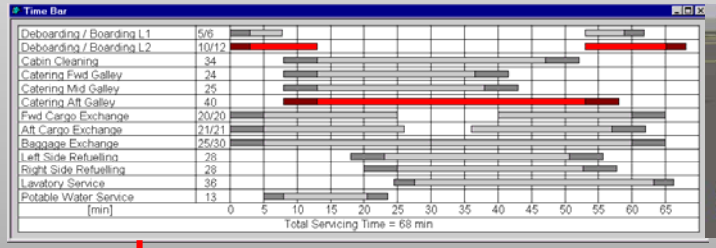

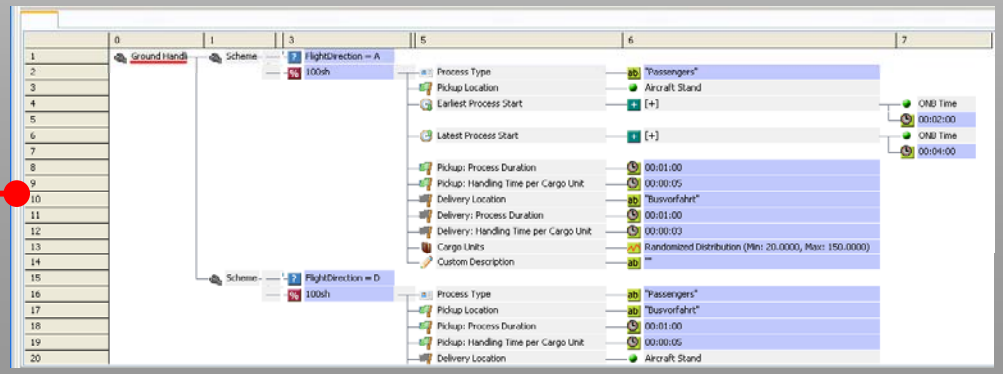

- Reference Time: ELDT, EOBT

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Routing

- A detailed and proper routing is **essential** for good results
- **Full dynamic routing**
- General principles: **cost model**, planning the routing with time margin
- Beginning of the tour: routing based on the **current traffic situation**
- **Factors** for the routing:
  - Definable for vehicles and/or for special route sections
  - Route length
  - Allowed speed
  - Special costs
    (e.g. for blocking probabilities through push-back)
  - Restrictions (clear height, width, weight etc.)
  - Traffic density (limited = realistic foresight)
- **Rerouting**, if congestion or traffic jams occur
  - Comparison of driving times
  - Homogeneous utilisation of the different routes

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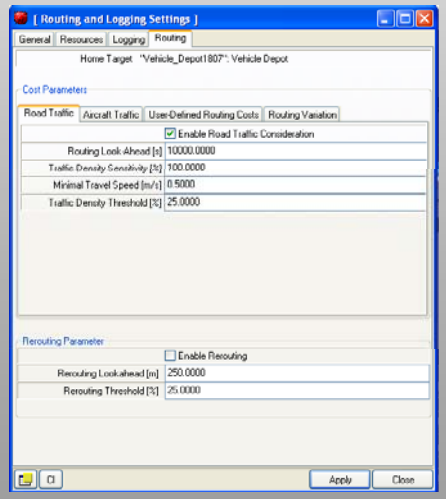

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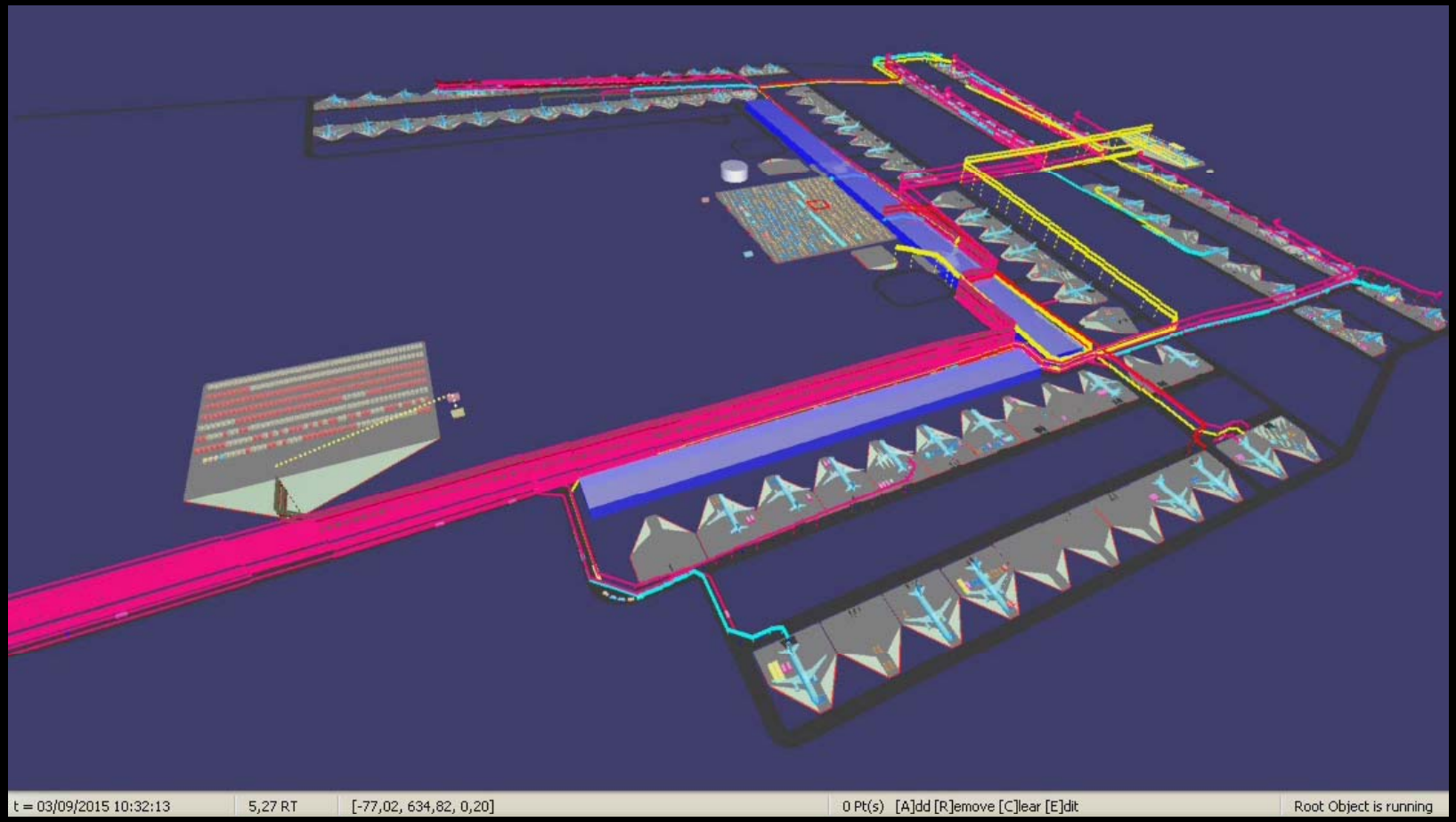
Display of routing



Display of routing: Each line represents one route, stepwise upward to the destination

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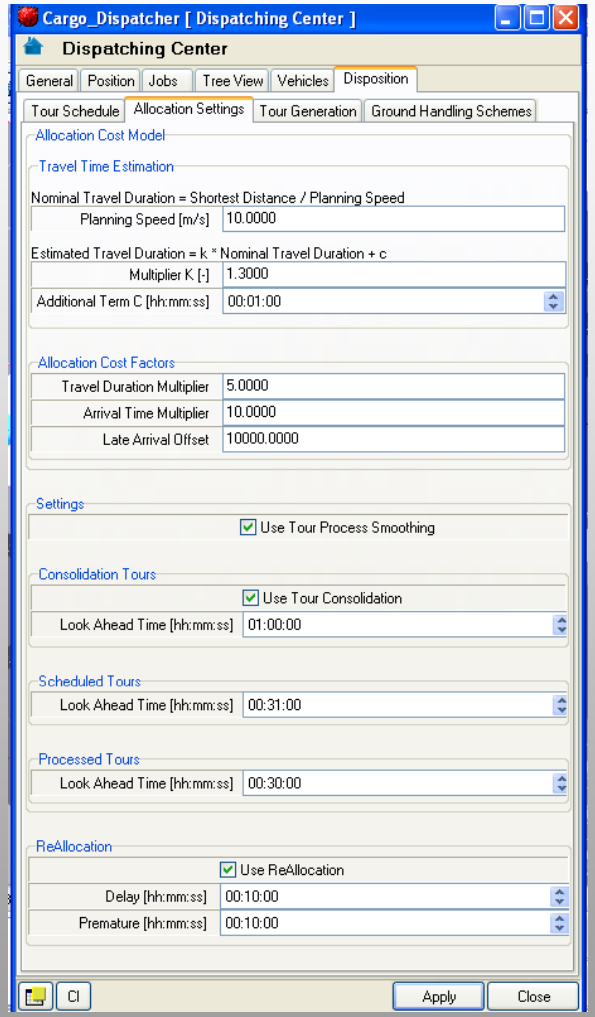
Disposition – Allocation of Tours

1. Searching for the **next order**
2. Identification of location, time, vehicle, operator
3. Identification of **available resources**
4. Determination of drive time and preselection of potential vehicles
5. Evaluation and **selection of the optimal vehicle**
6. **Allocation** of the driving tasks to a vehicle
7. **Execution** of the tour
8. **Feedback** on the effective course (delays) to the disposition

Reallocation



User defined working patterns of the disposition

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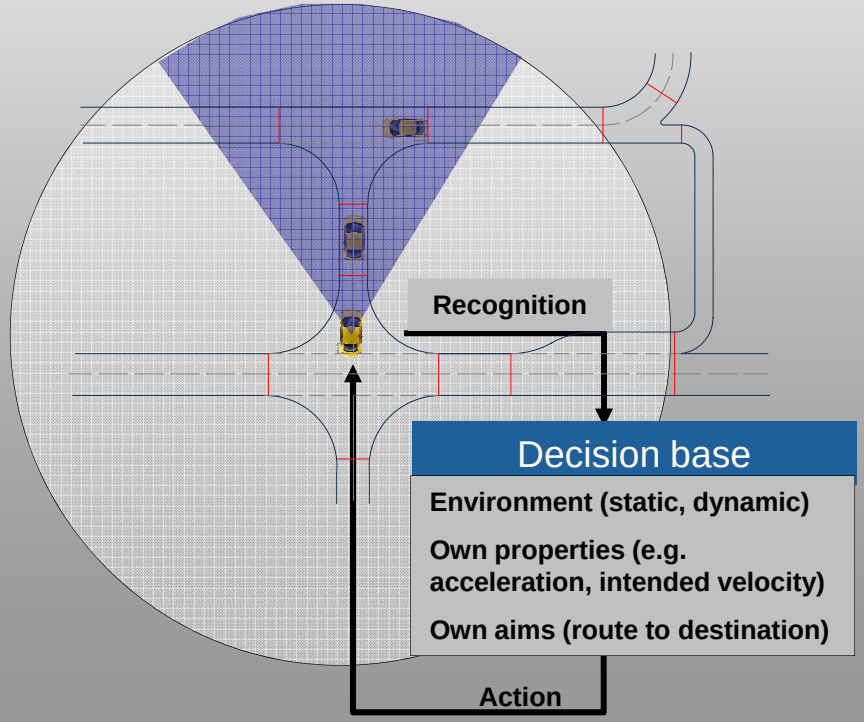
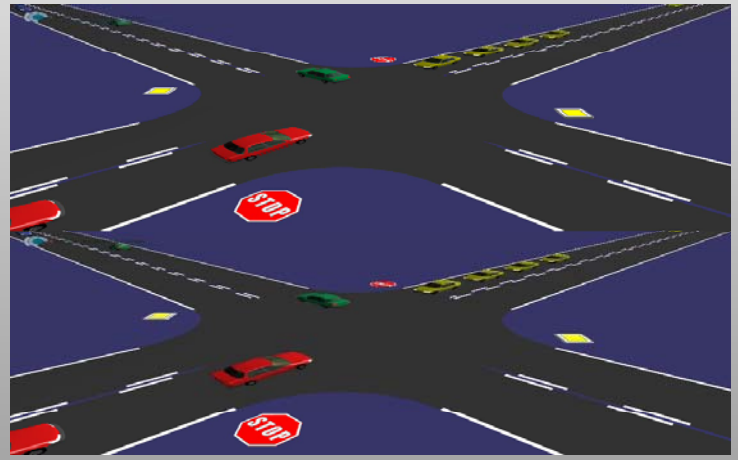
Simulation of the driving behaviour

- Vehicle follow-up behaviour
- Intersection behaviour
- Overtaking
- Lane change

Autonomous Agent Behaviour
Decision making depending on boundary conditions, own properties and tasks.





CAST *Vehicle*

Simulation and Analysis

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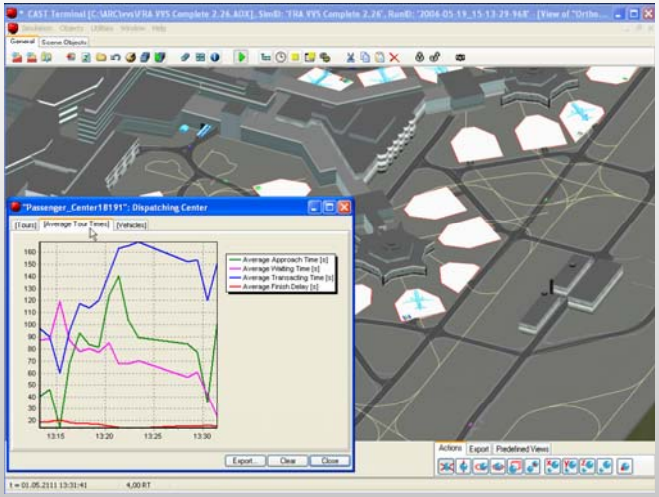
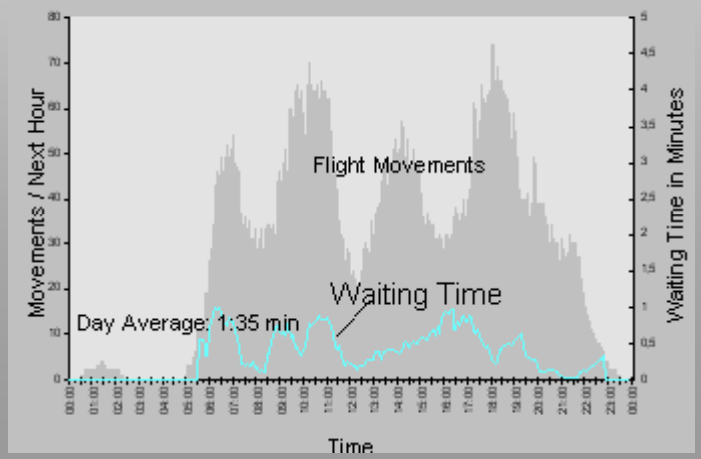
Simulation - Animation and Analysis

- **Animation** of the vehicles
- **Colour coding** of properties
- Route-dependent, **colour-coded analysis** (amount of vehicles, traffic density, average speed)
- Simulation-simultaneous visualisation in **charts**
- Recording of all data and events during the simulations
- **Automated post-processing** of results through the „Log-Analyser“





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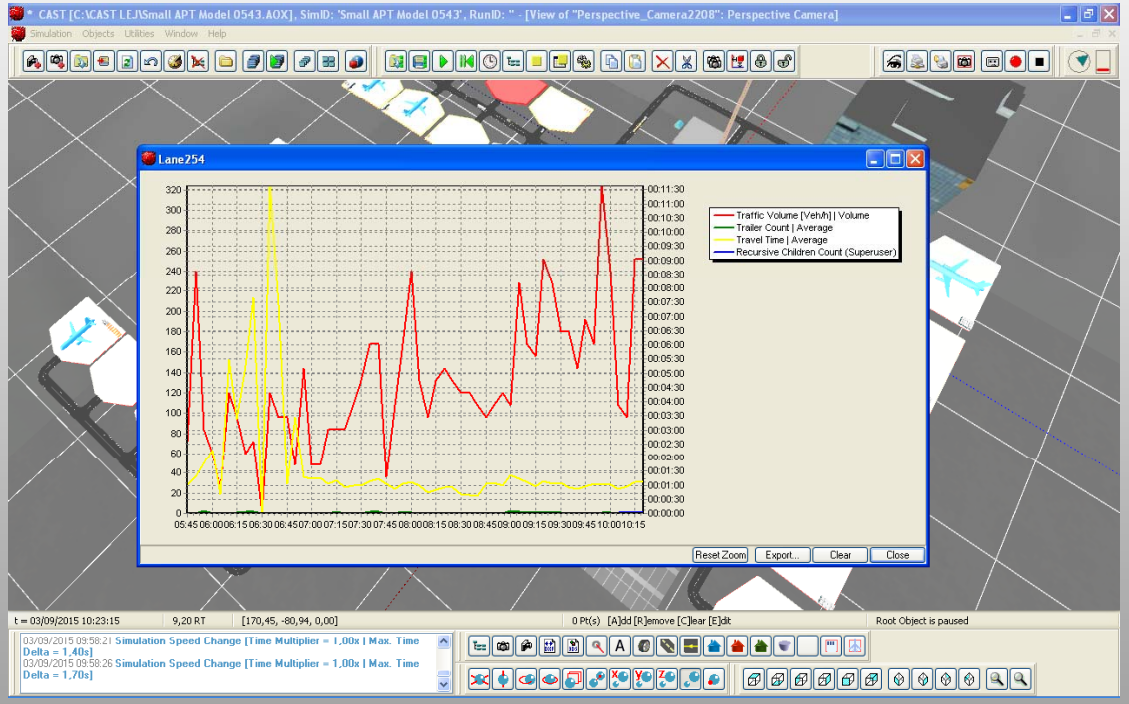
Simulation - Animation and Analysis



- Example: Graphs
- Freely configurable by the user
- Available for all elements
- Online visualisation of results
- Saving of data
- Examples:
  - Drive Time
  - Traffic density
  - Amount of used resources

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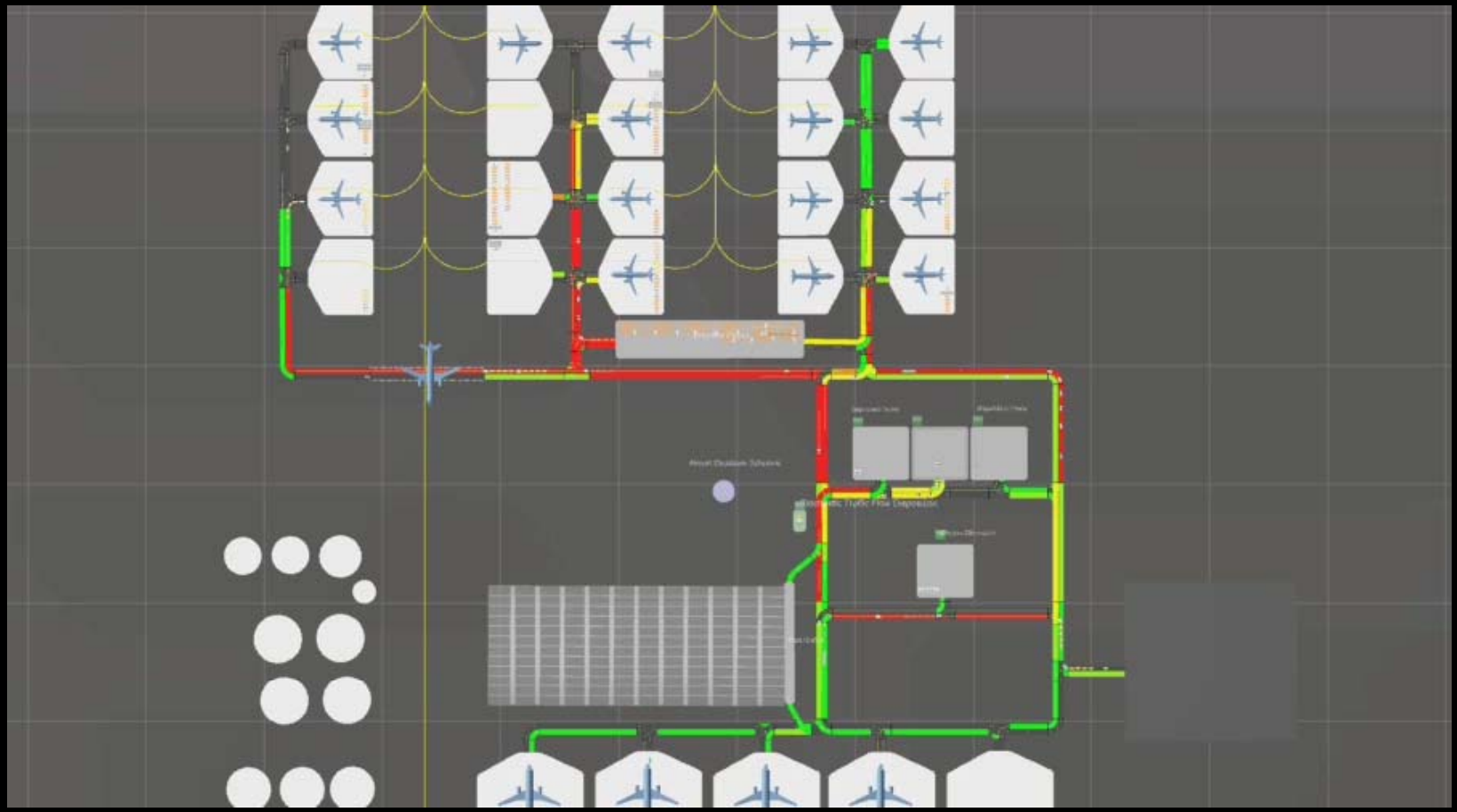
Colour coding and chart – top view



User defined colorcoding and charts for in-run analysis
Data collection for flexible post-processing

CAST *Vehicle*

Frankfurt Model

Frankfurt - Model

- Number of vehicles and trailer: more than 13000
- Lane elements > 7000
- Depots > 440
- Disponents > 30

All in all more than 150.000 Objects

Number of repetitions for some functions:

- GetDistance more than 250 Mio times for 80.000 Routings

Examples for other relevant processes / functions:

- Disposition (choice of vehicle, allocation of tour etc.)
- Microscopic vehicle behaviour (general driving behaviour, routing, conflict detection and resolution)
- Logging


Simulation Objects Utilities Window Help
FedEx
Actions Export predefined views
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Thank you.