

# Simulation/Validation Methods in Data Analytics

## Panel on SIMUL/VALID

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Edward Williams, University of Michigan - Dearborn, USA

Philipp Helle, Airbus Group Innovations, Germany

# Background

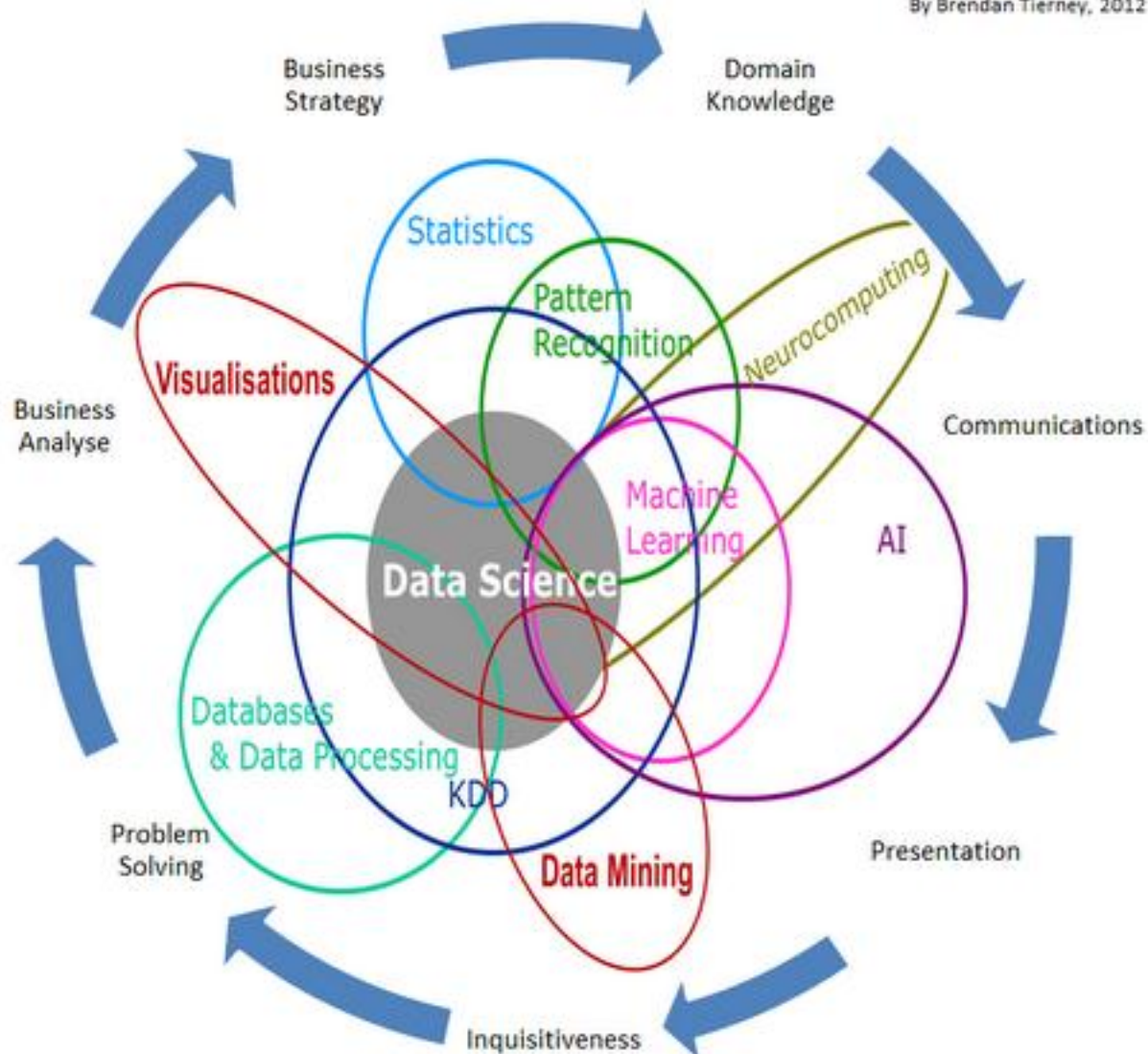
- Research Engineer at Airbus Group Innovations since 2003
- Member of the Model-based Systems and Software Engineering team
- Studied Linguistics, Computer Science and Media Culture

## Current research activities:

- Increase test automation
- Use models to ensure correctness of system specification and design
- Integration of development and testing activities during product development
- Testing of autonomous systems

# Data science is multidisciplinary

By Brendan Tierney, 2012



# Data Analytics for Testing

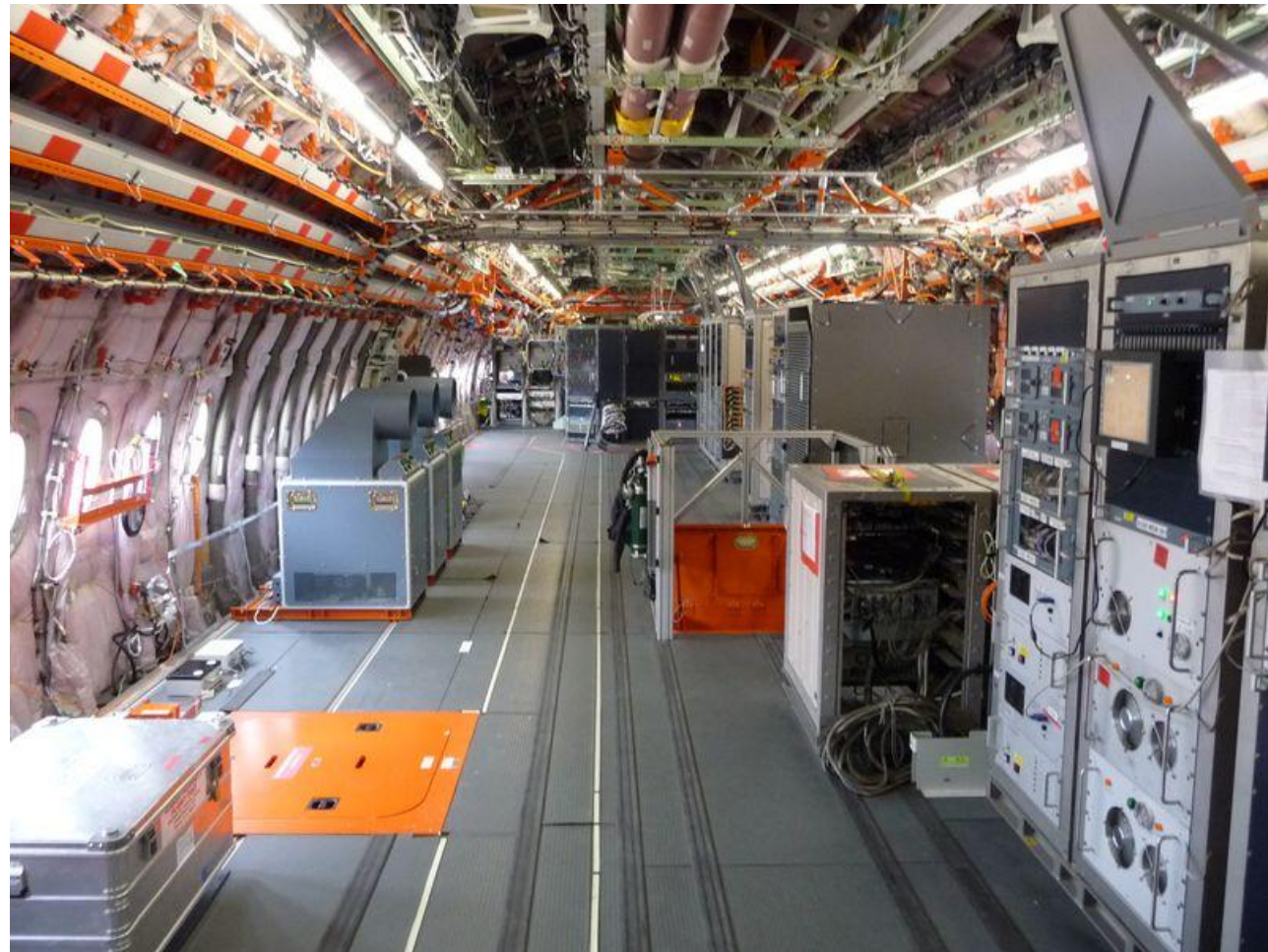
The advance in technology has allowed the aircraft testers to achieve their dream:

- Recording of almost all relevant data during testing

But: this comes with a downside

- The amount of data collected is huge
- Amount of data per flight test: 30-120 GB
- Amount of data per year: 20-60 TB

Finding the right information in this amount of data is equivalent to finding a needle in a haystack.



# Data Analytics for Testing

Current test processes still old-fashioned:

- Evaluation of pass-fail criteria according to the defined test case
- In case of problems: manual investigation of the data around the time of the occurrence of the problem
- Additionally: Using basic statistics on individual signals to find outliers (e.g. deviation from mean)

Possible uses of data analytics for testing:

- Test data evaluation (data mining, pattern recognition, clustering, advanced statistics,...)
- Test data generation (adaptive testing, see VALID 2014)

# Further uses for Data Analytics

## Customer support & maintenance engineering

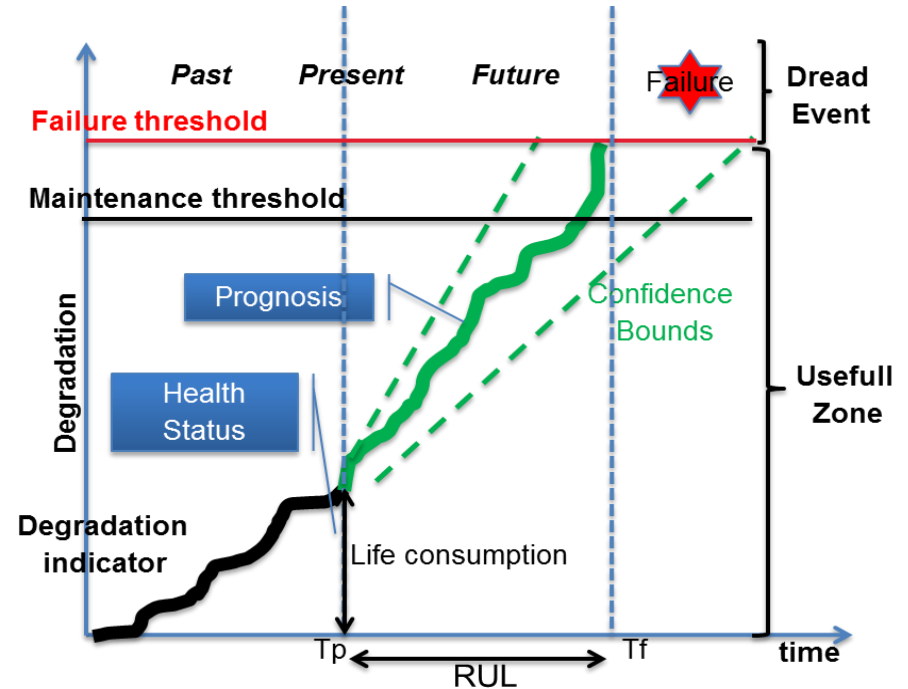
- Product health management
- Predictive maintenance

## Manufacturing & manufacturing engineering

- Adaptive planning
- Intelligent dashboards

## Autonomous Systems

- Autonomous flight
- Self-awareness, self-healing



# Simulation/Validation Methods in Data Analytics

Edward Williams

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PMC<sup>2</sup>

Dearborn, Michigan USA

<sup>1</sup>Teach master's-level course in simulation

<sup>2</sup>Undertake industrial engineering consulting work

# Laying the Error Trap

The screenshot displays a software interface with a top toolbar and a main workspace. The toolbar includes various icons for table manipulation, such as 'Add Data Table', 'Add Sequence Table', 'Remove Table', 'Convert to Repeat Group', 'Standard Property', 'Element Reference', 'Object Reference', 'Foreign Key', 'Set Column As Key', 'Move Left', 'Move Right', 'Change Type', 'Remove Column', 'Insert Row', 'Remove Row', 'Bind To', 'Remove Binding', and 'Binding Options'. The main workspace shows a table titled 'Customer Parameters Table' with the following data:

	NCones Ordered	Prob Rejection	ServiceTimeDistribution (Seconds)
I 1		0.04	random.triangular(24,54,90)
2	2	0.09	random.triangular(36,65,110)
3	3	0.25	random.triangular(55,100,99)
*			

The cell containing '0.25' in the 'Prob Rejection' column for row '3' is circled in red. The left sidebar contains navigation options: 'Views', 'Tables', 'Lookup Tables', 'Rate Tables', 'Schedules', 'Changeovers', and 'Input Parameters'.



# Setting the Parameters

The screenshot displays the Simio software interface for a project named "IceCreamStoreExample-1-6-3RevisedExpression". The main workspace shows a process flow diagram with three main sections: "Entry Add-On Processes", "Output@Cashier Add-On Processes", and "Sink1 Add-On Processes".

- Entry Add-On Processes:** A linear flow starting with "Begin", followed by "SetWalkSpeed" (Assign), "NConesWanted" (Assign), "SetColor" (Assign), and "End".
- Output@Cashier Add-On Processes:** A flow starting with "Begin", followed by "SetDestination" (Decide). A decision diamond branches into "True" and "False". The "True" path leads to "SatisfiedGoT" (Assign), and the "False" path leads to "NeedsAdjustment" (Assign). Both paths then merge and lead to "End".
- Sink1 Add-On Processes:** A linear flow starting with "Begin", followed by "RecordConesOrder..." (Tally), and "End".

A tooltip for the "NConesWanted" step is visible, containing the text: "NConesWanted (Assign Step)", "Does customer want 1, 2, or 3 cones?", "State Variable Name: ModelEntity.NConesOrdered", and "New Value: Random.Discrete( 1,0.6,2,.95,3,1 )".

The right-hand pane, titled "Browse: IceCreamStore : NConesWanted", shows the properties for the selected step. The "Basic Logic" section is expanded, showing the following configuration:

Property	Value
State Variable Name	ModelEntity.NConesOrdered
New Value	Random.Discrete( 1,0.6,2,.95,3,1 )
Assignments (More)	0 Rows

The bottom status bar indicates the simulation is "Stopped" and the system clock shows 12:33 PM on 10/26/2015.

# Error Realized

The screenshot displays a simulation software interface with a central workspace showing a process flow diagram. The diagram includes nodes labeled 'Entry', 'ServeCone', 'Cashier', and 'FixOrder', connected by arrows representing flow paths. A red arrow points to a specific location on the flow path between 'ServeCone' and 'Cashier', indicating the point of the error.

An 'Error' dialog box is open in the foreground, containing the following text:

Entity: Customer.58  
A runtime error was detected at time 0.43212294 Hours at the following process step:  
Object: ServeCone  
Process: OnEnteredProcessing  
Token: Token.3  
Step: [Delay] ProcessingTime  
Property: ServiceTimeDistribution  
Unable to get value of the property 'CustomerParametersTable.ServiceTimeDistribution'.  
Invalid parameters for Triangular probability distribution.  
Possible causes:  
min, mode, and max parameters are out of order.

The software interface includes a top menu bar with 'File', 'Project Home', 'Run', 'Drawing', 'Animation', 'View', 'Visibility', and 'Support'. Below the menu is a toolbar with various icons for simulation control, including 'Pause', 'Stop', 'Step', 'Fast-Forward', 'Reset', 'Breakpoint', 'Model Trace', 'Advanced Options', 'Adjust Speed', and 'Units Settings'. The 'Run' button is highlighted.

On the left side, there is a 'Libraries' panel with 'Flow Library' and 'Standard Libr'. The 'Flow Library' contains various flow-related components like 'FlowSource', 'FlowSink', 'Tank', 'ContainerE...', 'Filler', 'Emptier', 'ItemToFlow...', 'FlowToItem...', 'FlowNode', 'FlowConne...', and 'Pipe'. The 'Standard Libr' and 'Flow Library' are both expanded to show their contents.

On the right side, there is a 'Browse: IceCreamStore: IceCreamS' panel showing a tree view of the simulation model. Below it is a 'Properties: IceCreamStore (Fixed Model)' panel with sections for 'Controls', 'Model Properties', and 'Advanced Options'. The 'Model Properties' section shows 'Model Name: IceCreamStore', 'Author: Edward Williams', and 'Description: Example training mo...'. The 'Advanced Options' section is currently empty.

At the bottom of the interface, there is a status bar showing 'Running', '10%', '(0.43 Hours) Monday, September 28, 2015 12:25:55 AM'. The Windows taskbar at the very bottom shows the system clock as '12:34 PM 10/26/2015'.

# A Useful Technique

- Fosters a healthy suspicion – what can go wrong?
- Yes, the lookup data table is being used
- Yes, Simio<sup>®</sup> notices the invalid parameters of the triangular distribution – eventually!
- Yes, the assignment of number of cones wanted seems to be working (few customers want 3 cones)

# Questions and Discussion



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# **Simulation/Validation Methods in Data Analytics**

## **Verification vs validation (in modelling transportation systems)**



**PhD Marek Bauer**

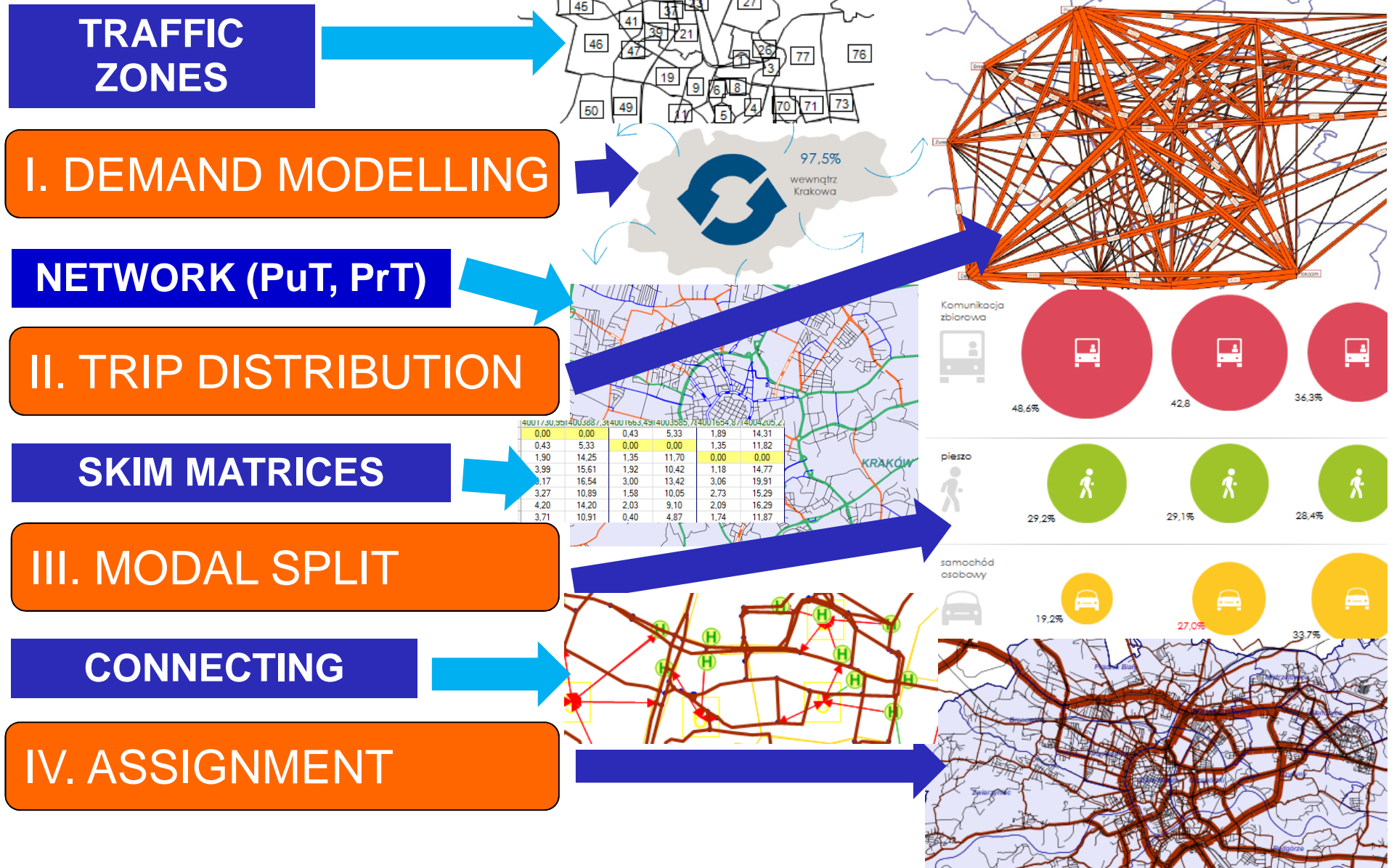
Cracow University of Technology

Faculty of Civil Engineering

Institute of Road and Railway Engineering

Department of Transportation Systems

# General modelling procedure in transportation planning



## Verification vs validation: measures/indicators

Modelling stage	Kind of data
Traffic zones defining	Socio-demographic data (number of inhabitants, employees, students, services, ...)
Demand modelling	Number of trips beginning and ending in traffic zone with division onto trip motivations (all trips)
Network building	Capacity, speed, time losses, ... (PrT) Standard running time, dwell time, offered capacity, ... (PuT)
Trip distribution	Number of trips between traffic zones (all trips)
Skim matrices calculating	Travel times between traffic zones for different means of transport (empty network - PuT, PrT)
Modal split	Number of trips between traffic zones (PuT, PrT, non-motorized)
Traffic connecting	Procedure parameters (PrT, PuT)
Assignment	Traffic volume, speed, transportation work, ... (PrT) Passenger volume, number of transfers, travel time, transportation work, ... (PuT)

## Verification vs validation: importance

Modelling stage	Verification	Validation
Traffic zones defining	+	++
Demand modelling	++	+
Network building	++	++
Trip distribution	++	+
Skim matrices calculating	+	-
Modal split	++	+
Traffic connecting	+	-
Assignment	++	++



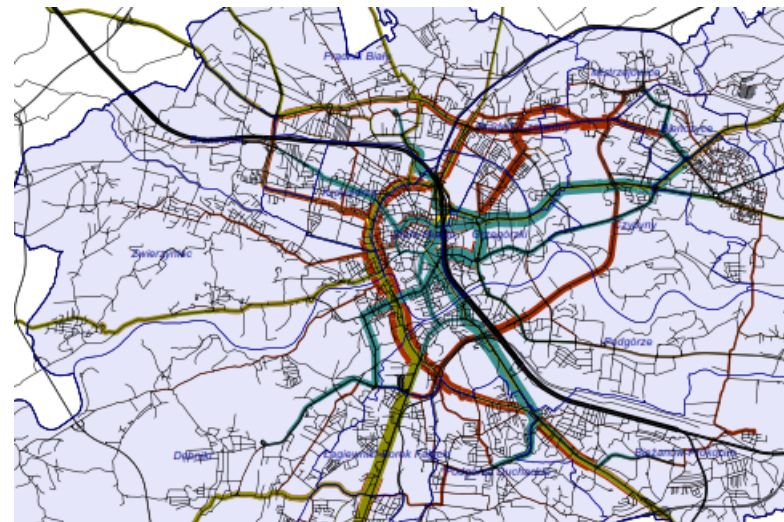
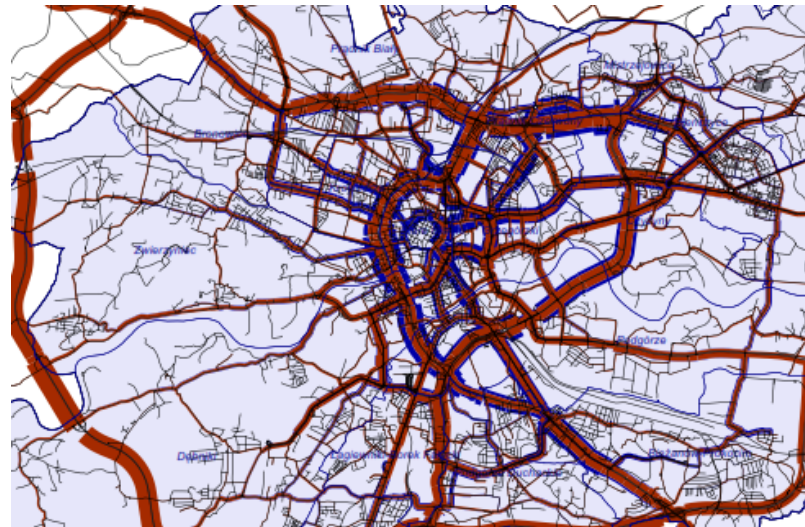
## Verification vs validation: Level of accuracy

### □ General approach:

- Individual transport (PrT)  
(cars, passengers)
- Public transport (PuT)  
(passengers)

### □ Detailed approach:

- Individual transport (cars)
- Public transport – separately: rail, metro, tram, bus,... (passengers)
- Non-motorized (bikers, pedestrians)



## The Seventh International Conference on Advances in System Simulation

# PANEL on SIMUL/VALID

## Topic: Simulation/Validation Methods in Data Analytics

November 18, 2015

Dr.-Ing. Dipl.-Math. Arash Ramezani  
Helmut-Schmidt-University  
University of the Federal Armed Forces Hamburg  
Holstenhofweg 85, D-22043 Hamburg

- Arash Ramezani currently works for the Federal Ministry of Defence.
- He has studied Applied Mathematics at the University of Bremen and the University of Queensland in Australia and received his Diploma degree in 2010.
- In 2015 he received his doctor's degree in engineering science with his studies on
  - "Numerical Simulation of Terminal Ballistic Processes for the Analysis of Selected Armor Structures and the Optimization of Modern Security Vehicles".
- His research interests include modeling, simulation and visualization of ballistic problems.

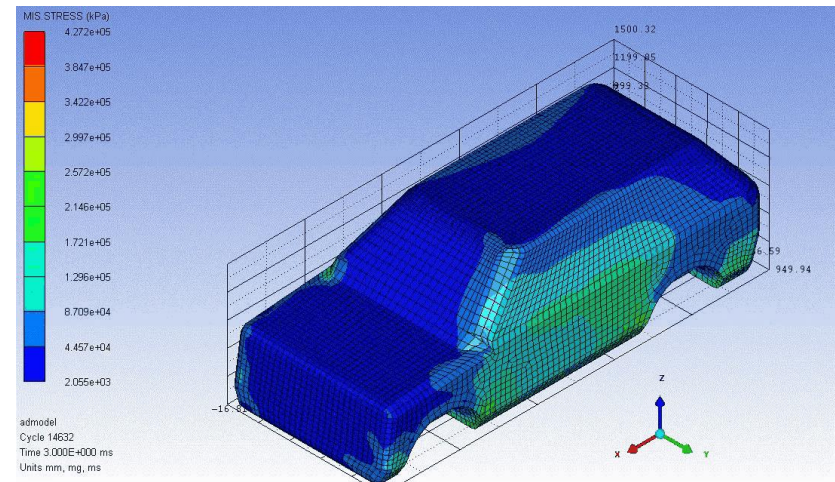
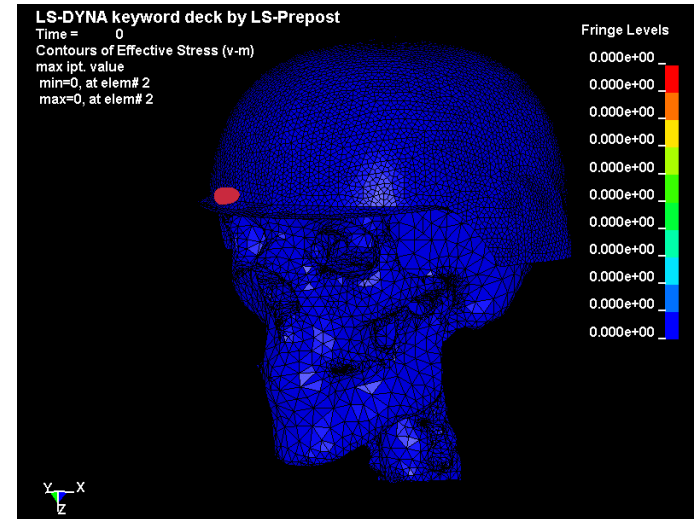
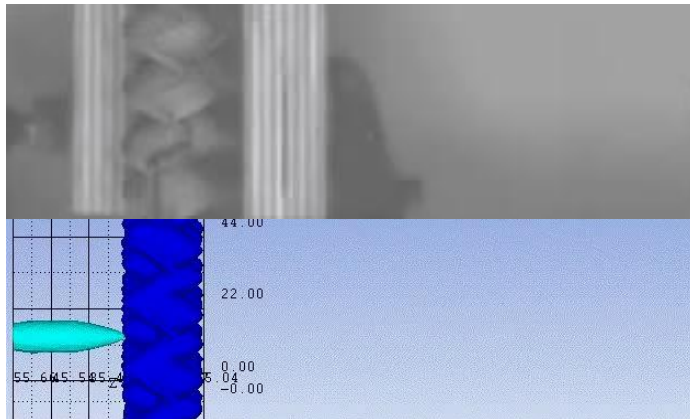
# Investigation of Modern Armor Structures with Numerical Simulations

- The threat imposed by terrorist attacks is a major hazard for military installations, vehicles and other items
- An important endeavor of international research and development is to avert danger to life and limb
- Ballistic testing is limited due to costs and permissions for experimental results
- This is why numerical simulations are more frequently applied than experimental tests which are thus being replaced gradually



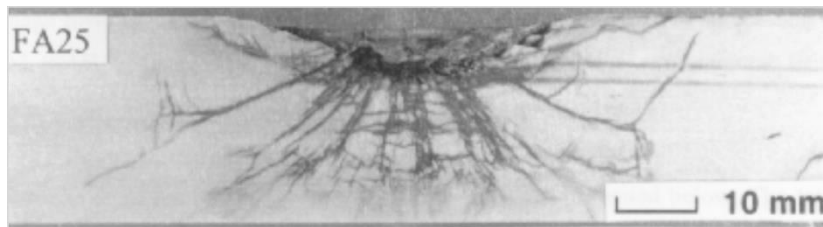
## Fields of application:

- Simulation of impacts
- Ballistic protection
- Energetic systems
- Wave propagation
- Force of detonation
- Testing of materials

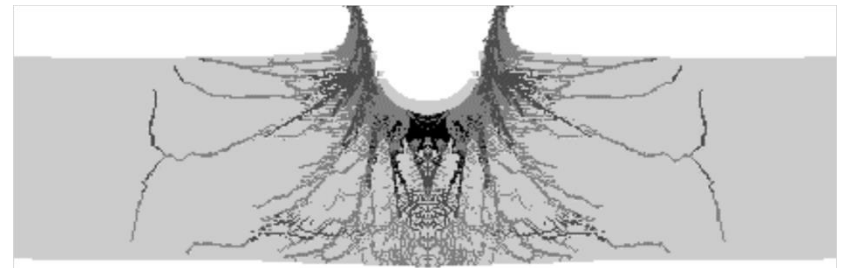


## Challenge:

- The materials of the test objects are normally unknown – they have to be created and optimized for the calculation, so that the material behavior in the simulation can be conveyed in an exact manner
  - Data analysis for a statistical certainty
    - High susceptibility to errors
    - High safety hazard



Experiment



Simulation

# Investigation of Modern Armor Structures with Numerical Simulations

Traditional ballistic testing:

