


Behavioural models or experiments? Mind the gap

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Why do we need traffic models?

Predict and control our nr 1 traffic problem

- Facilitate shifts in route choice by providing traffic information

- Ex-ante evaluation of effects of new measures
  - New roadway signs
  - ADAS, such as ACC
  - Road infrastructure: narrow lanes, additional lanes, dynamic lanes
  - New traffic laws (trucks in right lane)

Example…

Bad example: Decision making
Good example: what happens if….

Peak hour traffic lanes

Effects on traffic flow < than models predicted

Green wave advice

First traffic model estimations: good results!

Assumption: 100% obedience

Difference in design, algorithms behind advice, type of driver, regions??

Modelling behaviour starts with…

What is driving behaviour?

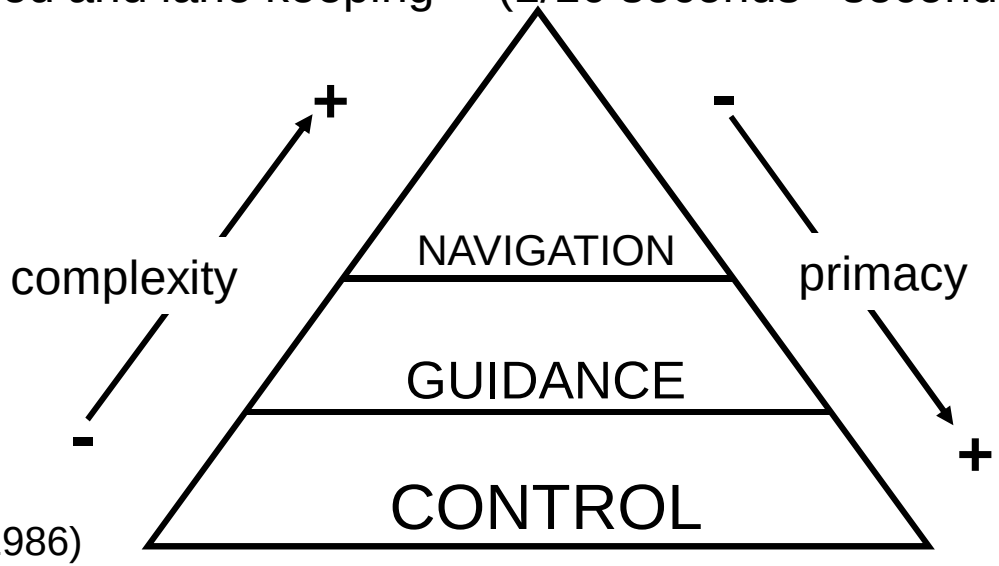
Driving is a complicated multi-level task

- Steering behaviour
- Using brake and gas pedal
- Giving priority
- Check mirrors
- Keeping distance to lead vehicles
- Attend to road signs and traffic lights
- Making route choices
- …

Infrastructure matters

Driving Task Hierarchy

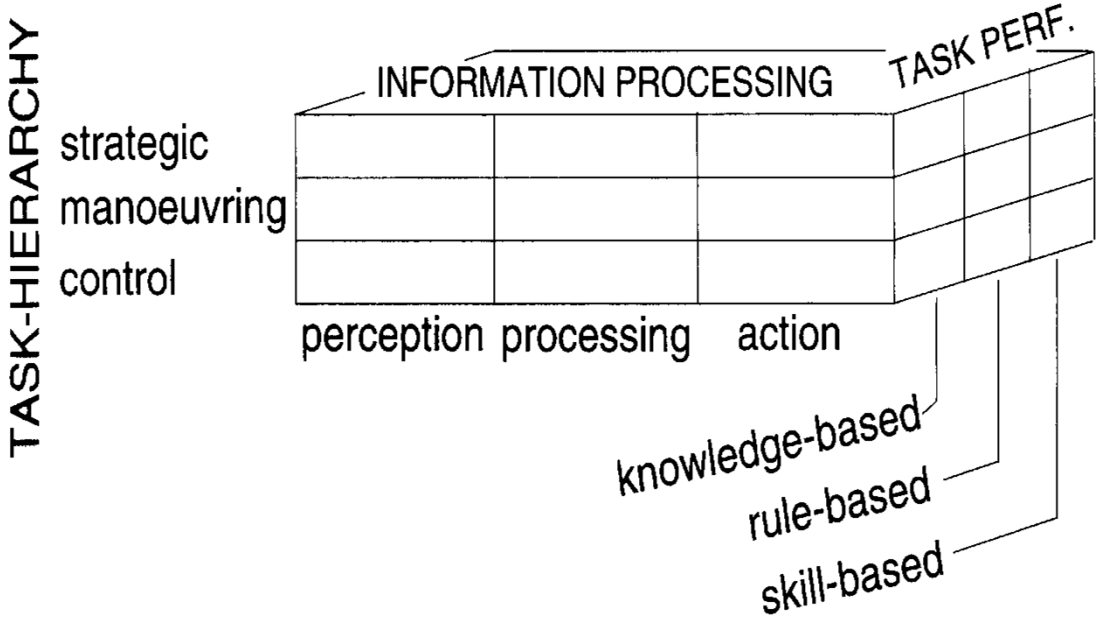
- Strategic level
  - Route planning and route guidance (minutes-hours)
- Manoeuvring level
  - Interaction with road and other road users (seconds - minutes)
- Control level
  - Controlling speed and lane keeping (1/10 seconds - seconds)



(Alexander & Lunenfeld, 1986)

Car driving not 1 task

- Continuous task (lane keeping)
- Planned actions (overtaking, turning)
- Sudden actions (braking lead vehicle)
- Changes in road environment (work zone)
- Use of in-vehicle system (navigation)



Types of models

- Route choice models (strategic level)
- Lane chance model (manoeuvre level)
- Acceleration model (control level)
- …….

Microscopic traffic model:

Translate individual behaviour to traffic flow parameters

Driver is control loop

Personal characteristics, workload, fatigue?


Driver modeling workshops

- Transportation Research Board
- HF workshop Driver Model: Design, Integration, Applications.

- ISPRA workshop
  - Cacciabuie, P.Carlo (Ed.). (2007). Modelling Driver Behaviour in Automotive Environments. Critical issues in Driver Interactions with Intelligent Transport Systems. London: Springer Verlag.

- HUMANIST workshop


Input for traffic flow models

Microscopic traffic flow models need valid and calibrated driver models to test/assess/evaluate road design/traffic management/ITS measures in terms of traffic throughput, safety and environment

- Time series data collected by an instrumented vehicle, and its use in the validation of the *car following* performance of a fuzzy logic based car following model:
  - Wu, J., Brackstone, M., & Mcdonald, M. (2003). The validation of a microscopic simulation model: a methodological case study. *Transportation Research Part C - Emerging Technologies, 11* (6), 463-479.

- What cues do drivers use?
  - Andersen, G.J., & Sauer, C.W. (2007). Optical information for car following: The driving by visual angle (DVA) model. *Human Factors, 49* (5), 878-896.
  - Salvucci, D.D., & Gray, R. (2004). A two-point visual control model of steering. Perception, 33 (10), 1233-1248.
  - Horst, A.R.A. van der (2007).. Time-related measures for modelling risk in driver behaviour.In: Cacciabuie, P.Carlo (Ed.). (2007). Modelling Driver Behaviour in Automotive Environments. Critical issues in Driver Interactions with Intelligent Transport Systems. London: Springer Verlag.

- Variability between drivers (cross-cultural differences, driving styles, experience, etc.)
  - Ozkan, T., Lajunen, T., Chliaoutakis, J.E., Parker, D., & Summala, H. (2006). Cross-cultural differences in driving behaviours: A comparison of six countries. *Transportation Research Part F Traffic Psychology and Behaviour, 9* (3), 227-242.
  - Farzaneh, M., & Rakha, H. (2006). Impact of differences in driver-desired speed on steady-state traffic stream behavior. Transportation Research Record 1965, 142-151.
  - Salvucci, D.D., Chavez, A.K., & Lee, F.J. (2004). Modeling effects of age in complex tasks: A case study in driving. proceedings of the 26th Annual Conference of the Cognitive Science Society Chicago, USA: August 4-7 2004. (pp. 1197-1202) .

Design is important

How do drivers respond to changes in speed limits?

- Large scale field studies
- Various locations
- Video data, loop data, interviews…

Results show that behaviour depends upon:

- Reason for the speed limit
- Credibility of the speed limit
- Electronic speed indication
- Dynamic or static signs
- Location of sign and number of repetitions
- Presence of enforcement
- Additional warnings for enforcement
- Etc.

New speed limit

How do drivers respond to an increased limit to 130 km/h?

What about new measures?

Driving simulator

Is driving simulator always the solution?

MIND THE GAP:

Models are not valid

Experimental studies are not valid

- People are attentive
- They are confronted with design A and B under specific conditions
  - But what about LT effects?
  - What about behavioural adaptation?
  - What about interaction between users and non-users?
  - What explains this behaviour?

Mind the gap – bridge the gap

Using behavioural variables, such as obedience (0-100%)

Using models as a first scan about potential effects

Use model for exploring trends and directions

Use models to make explicit what is unknown

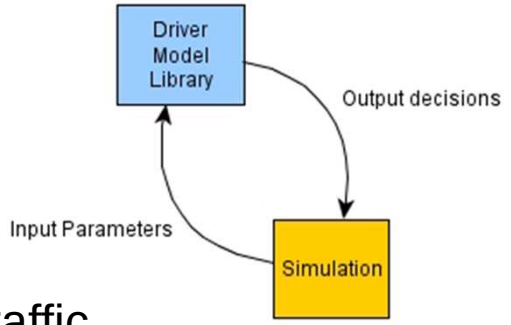
Use pilots and controlled to studies for the unknown


Overall driver model?

- Not realistic:
- Kantowitz et al. (2005)
  - Human Factors Cognitive Models have highest priority
  - Efforts needed to develop computational driver model estimated at 12.000.000,- $ (12 year time)

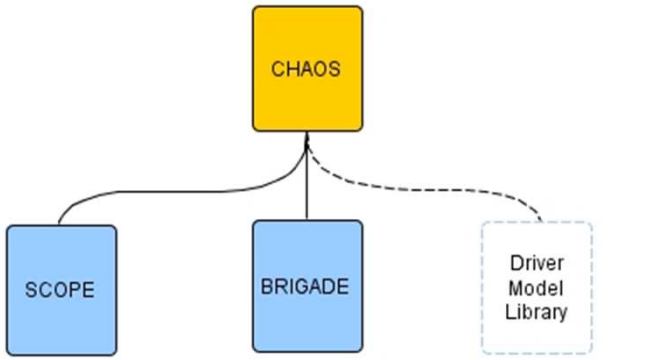
- Think in terms of:
  - partial driver models
  - for specific subtasks
  - that fit into a general framework


Driver Model Library (DML)



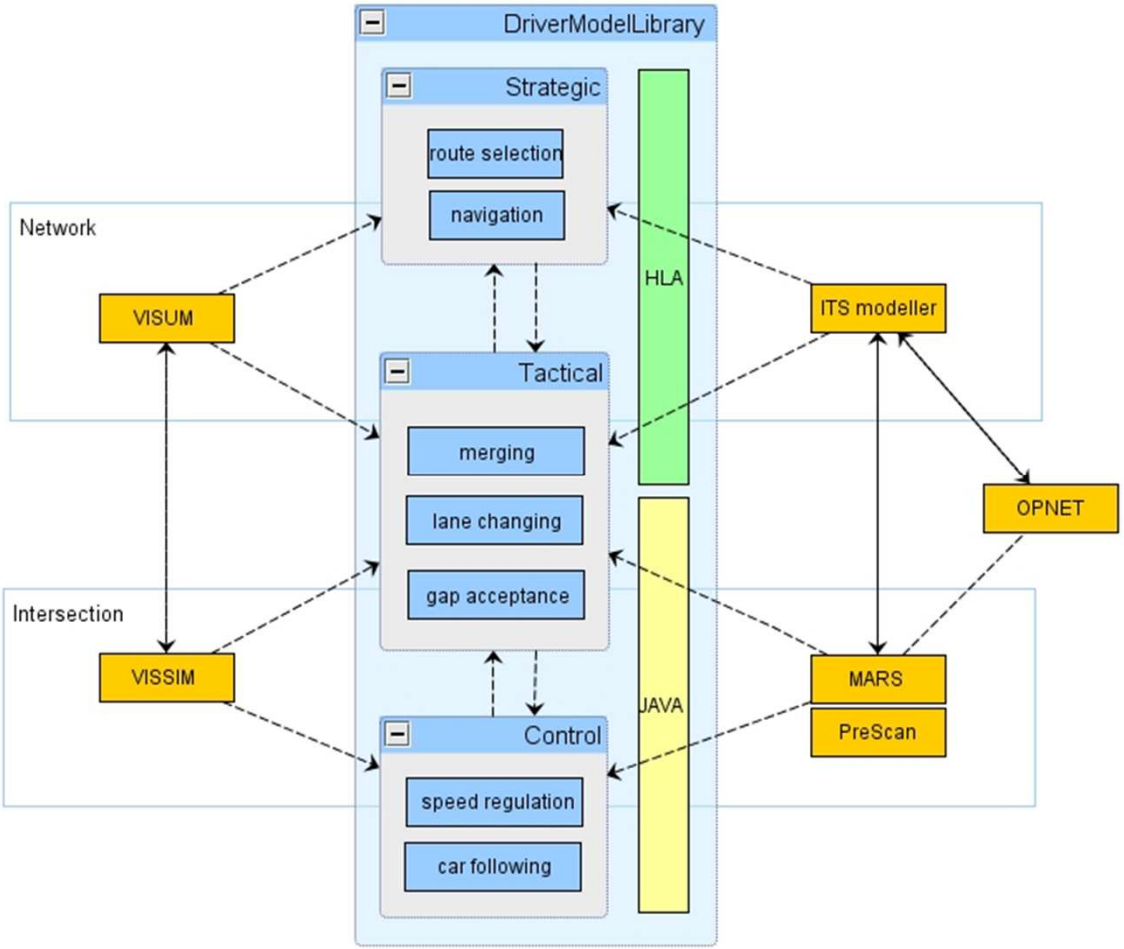
- Driver Model Library is a cross-platform plug-in
- Provides driver behaviour and decision making for traffic simulations

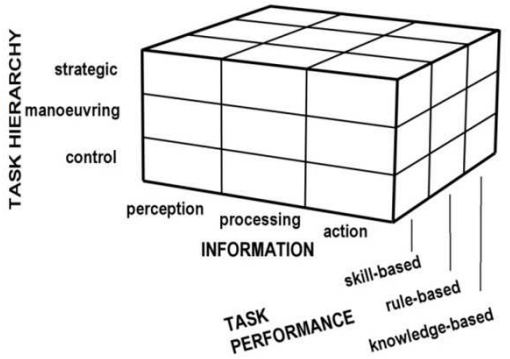
- Based on behavioural framework: CHAOS (**C**apability-based **H**uman-performance **A**rchitecture for **O**perational **S**imulations)



Driver Model Library for:

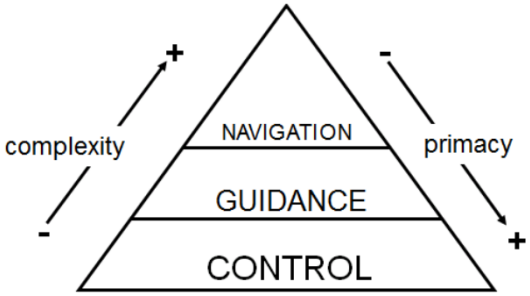
- Microscopic simulation (e.g. individual driver behaviour at intersections)
- Network simulation





Driver Model Library

- Driving tasks arranged in a hierarchy
  - as demons (also stressors)
  - competing in pandemonium for resources



Multi-agent system

Pandemonium theory (Selfridge, 1959: *Pandemonium: a paradigm for learning*)

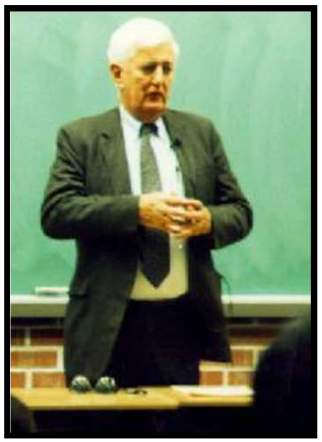
Agents (*demons*) represent *behaviour chunks*

Demons compete over limited *resources (=capabilities)*

Monitor

Interpret situation

Use resources to (re)act accordingly




CHAOS Behaviour Model

- **C**apability-based **H**uman-performance **A**rchitecture for **O**perational **S**imulations

- Multi-agent system
  - Pandemonium theory (Selfridge, 1959: *Pandemonium: a paradigm for learning*)
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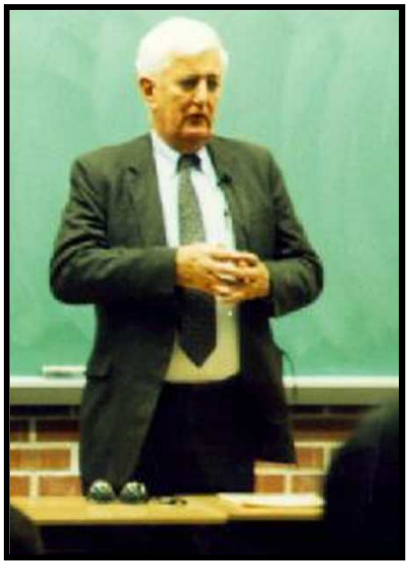
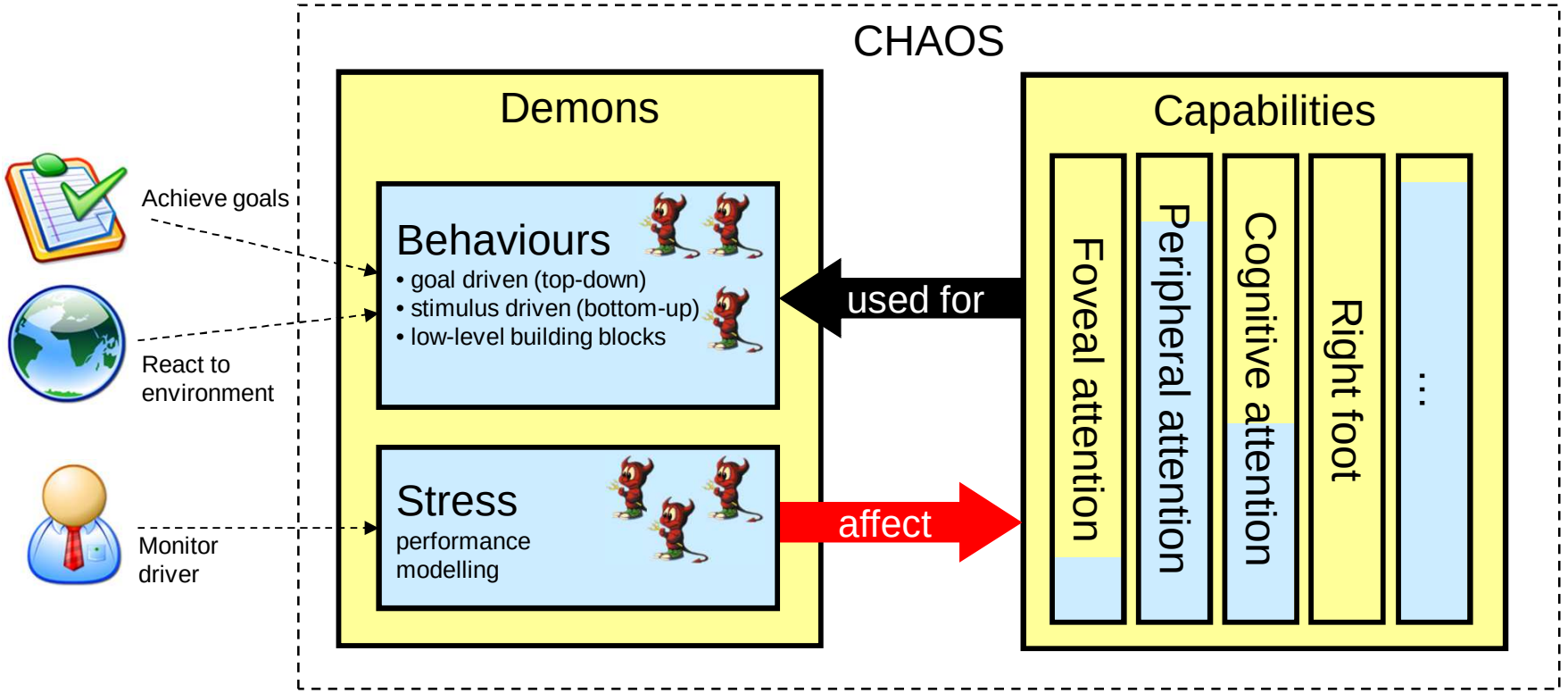
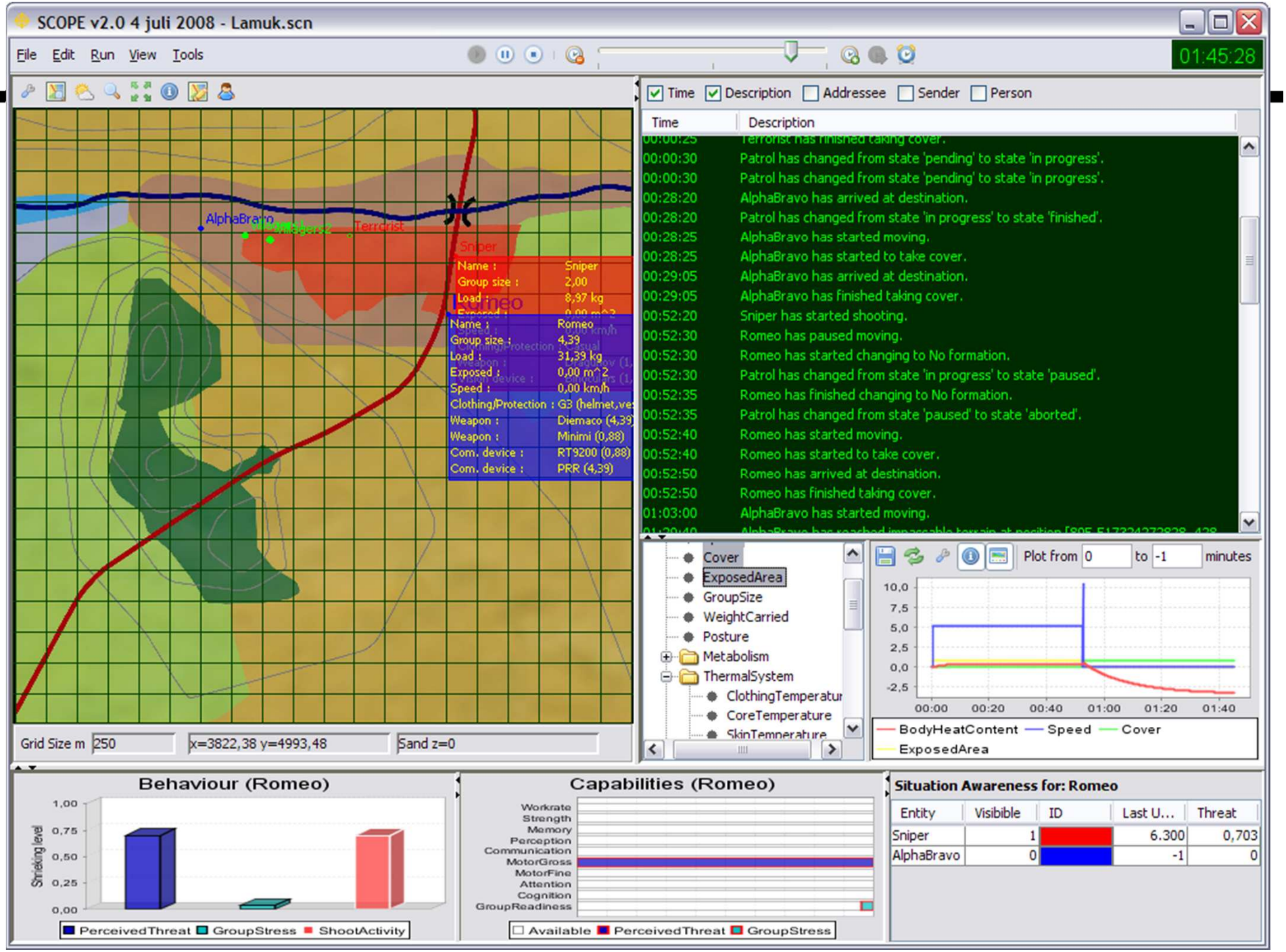
  - Demons compete over limited *resources (=capabilities)*
    - Monitor
    - Interpret situation
    - Use resources to (re)act accordingly

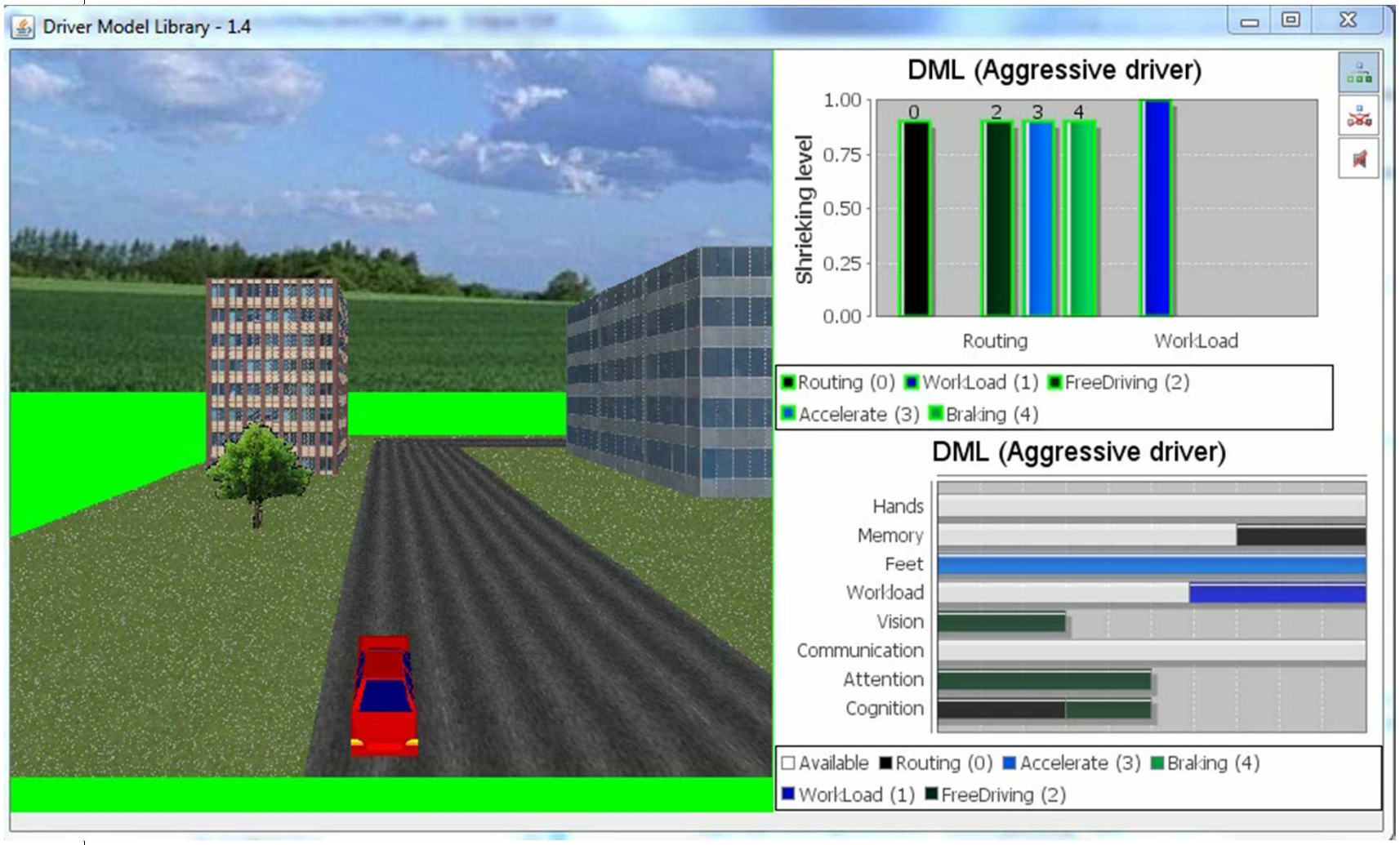


CHAOS

- Behaviour demons
- Stress demons
- Resources




SCOPE v2.0 4 juli 2008 - Lamuk.scn
File Edit Run View Tools
01:45:28
Time Description Addressee Sender Person
Time Description
00:00:30 Patrol has changed from state 'pending' to state 'in progress'.
00:00:30 Patrol has changed from state 'pending' to state 'in progress'.
00:28:20 AlphaBravo has arrived at destination.
00:28:20 Patrol has changed from state 'in progress' to state 'finished'.
00:28:25 AlphaBravo has started moving.
00:28:25 AlphaBravo has started to take cover.
00:29:05 AlphaBravo has arrived at destination.
00:29:05 AlphaBravo has finished taking cover.
00:52:20 Sniper has started shooting.
00:52:30 Romeo has paused moving.
00:52:30 Romeo has started changing to No formation.
00:52:30 Patrol has changed from state 'in progress' to state 'paused'.
00:52:35 Romeo has finished changing to No formation.
00:52:35 Patrol has changed from state 'paused' to state 'aborted'.
00:52:40 Romeo has started moving.
00:52:40 Romeo has started to take cover.
00:52:50 Romeo has arrived at destination.
00:52:50 Romeo has finished taking cover.
01:03:00 AlphaBravo has started moving.
AlphaBravo
Terrorist
Sniper
Name : Sniper
Group size : 2,00
Load : 8,97 kg
Romeo
Name : Romeo
Group size : 4,39
Load : 31,39 kg
Exposed : 0,00 m^2
Speed : 0,00 km/h
Clothing/Protection : G3 (helmet,ve
Weapon : Diemaco (4,39)
Weapon : Minimi (0,88)
Com. device : RT9200 (0,88)
Com. device : PRR (4,39)
Grid Size m 250
x=3822,38 y=4993,48
Sand z=0
Cover
ExposedArea
GroupSize
WeightCarried
Posture
Metabolism
ThermalSystem
ClothingTemperatur
CoreTemperature
Plot from 0 to -1 minutes
10,0
7,5
5,0
2,5
0,0
-2,5
00:00 00:20 00:40 01:00 01:20 01:40
BodyHeatContent Speed Cover
ExposedArea
Behaviour (Romeo)
Shrieking level
1,00
0,75
0,50
0,25
0,00
PerceivedThreat GroupStress ShootActivity
Capabilities (Romeo)
Workrate
Strength
Memory
Perception
Communication
MotorGross
MotorFine
Attention
Cognition
GroupReadiness
Available PerceivedThreat GroupStress
Situation Awareness for: Romeo
Entity Visibible ID Last U... Threat
Sniper 1 6.300 0,703
AlphaBravo 0 -1 0


Driver Model Library - 1.4
DML (Aggressive driver)
Shrieking level
1.00
0.75
0.50
0.25
0.00
0
2
3
4
Routing
WorkLoad
Routing (0)
WorkLoad (1)
FreeDriving (2)
Accelerate (3)
Braking (4)
DML (Aggressive driver)
Hands
Memory
Feet
Workload
Vision
Communication
Attention
Cognition
Available
Routing (0)
Accelerate (3)
Braking (4)
WorkLoad (1)
FreeDriving (2)


Distraction in the DML

- Non-driving behaviour:
  - Also modelled as demons, to hijack some of the resources

For example…

- Route planning demon uses foveal visual attention and most of peripheral attention resources
- Thus, external visual stimuli are ignored

- Distraction outside: foveal visual attention is used; peripheral attention resources remain available.


Conclusions

- Driver behaviour is adaptive, but what criteria are used?
- Having predictive and valid models for driver behaviour remains a challenge
  - *Degraded control performance; looked-but-failed-to-see; readiness to respond.*
- We believe in the CHAOS framework: proven approach for modelling complex human behaviour in various domains.
- Enabling tool for advice, policy and consultancy
- Tool for first estimates of FOT applications and new measures
- Understand unknown behavioural parameters


Next steps (1)

- Mind the gap – bridge the gap:
  - Models are not valid (missing links & identify possible trends)
  - Controlled studies are not valid (study in-depth parameters and new measures)
  - FOTs and ND studies: we do not know everything

- Conducting experimental studies with deeper understanding:
  - Effect of mobile phone use on driving speed
  - Effect of underlying mechanism of using phone:
    - Cognitive mechanisms
    - What resources are being used?
    - Via what mechanisms is driving behaviour influenced?


Next steps (2)

- Learn more from one study…
  - Effect of VMS on speed
  - Reported is speed, SD speed and headway
- Effect of age on lane change performance?
  - Same experiment!

- Joining forces and exchange information:
  - Standardise behavioural measures (Paul Green, UMTRI)
  - Understand the gap
  - Data, data, data……