

Hypotheses and Experimental Design

From Systems to Hypotheses

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Final Event

26-27 June 2012

Autoworld, Brussels

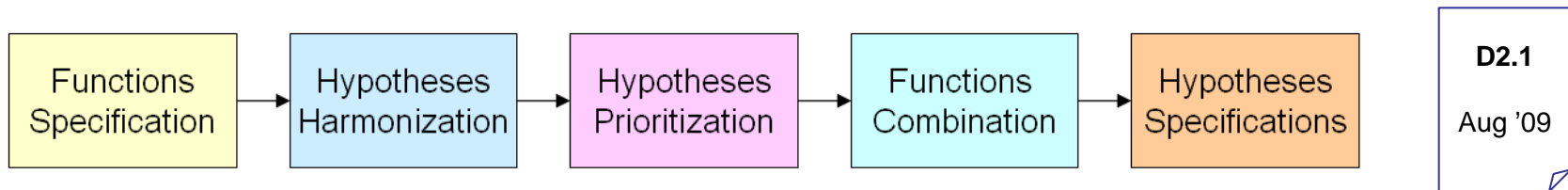


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Process: From Systems to Hypotheses



Research Questions? Hypotheses?

A Research Question is general phrased question.

- ⊗ not very concrete
- ⊗ not statistically testable,
- ⊗ but a good start to derive a hypothesis

Example:

Does ACC change the behaviour of drivers while following a car?



Research Questions? Hypotheses?

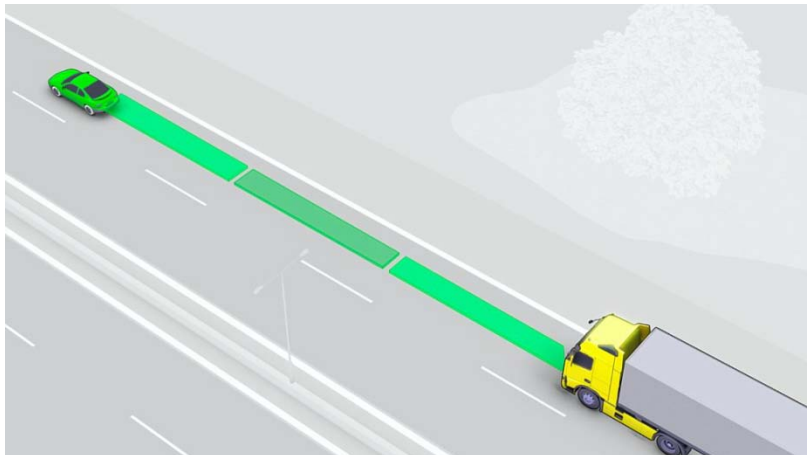


Hypothesis

- ⌘ specific statement linking a cause to an effect, based on a mechanism linking the two
- ⌘ can be tested with statistical means by analyzing specific performance indicators in specific scenarios
- ⌘ gives a direction in the statement

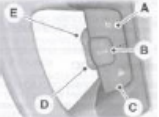

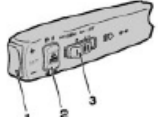


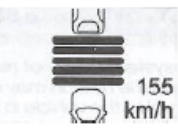
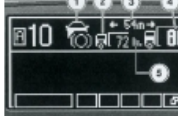



Example

TTC (to leading vehicle) will increase while using ACC compared to not using ACC in normal driving situations on highways.



Step 1: function description and spec.

Example: ACC

Specs	Ford	MAN	VOLVO	VCC	VW
Speed threshold	30 km/h	25 km/h	18 km/h	30 km/h	0/30 km/h
Combination with other functions?	No	No	Yes: with frontal collision warning (same system)	No	Yes: with FCW*
HMI system activation and control	 <p>Left buttons on the steering wheel (see manual for details)</p>	 <p>Right buttons on the steering wheel (see manual for details)</p>	 <p>Left stalk control (see manual for details)</p>	 <p>Left buttons on the steering wheel (see manual for details)</p>	 <p>Left buttons on the steering wheel (see manual for details)</p>
Specific HMI visualization: System status and settings	 <p>(see manual for details)</p>	 <p>(see manual for details)</p>	 <p>(see manual for details)</p>	 <p>(see manual for details)</p>	 <p>(see manual for details)</p>

Result of Step 1: Example: First list of hypotheses

List of Hypotheses for the same function at each OEM: 88 hypotheses for ACC

Volvo	H11 - Using ACC, LDW performance will increase.	Safety	LDW performance
Volvo	H12 - Using ACC, visual monitoring of speed indicator will decrease.	Safety	Time spent looking at the cluster
Volvo	H13 - Using ACC, traffic flow performance will increase.	Mobility	Traffic flow performance from simulator
Volvo	H14 - Using ACC, use of residential roads will decrease.	Mobility	ACC activation time
Volvo	H15 - Use of ACC will increase over time	Usage	ACC activation occurrence
Volvo	H16 - Using ACC, fuel consumption will decrease.	Environment	Fuel level
Ford	H1 - Using ACC the amount of traffic incidents will decrease.	Safety	Number of incidents
Ford	H2 - Using ACC, time to reach the brake pedal will increase.	Safety	Reaction time to brake pedal
Ford	H3 - Using ACC, the driver will be focusing more on secondary tasks.	Safety & Usage	Driver workload
Ford	H4 - Using ACC, driving perceived safety and comfort will increase.	Acceptance	Customer comfort and perceived safety

Step 2: Hypotheses Harmonization

Example

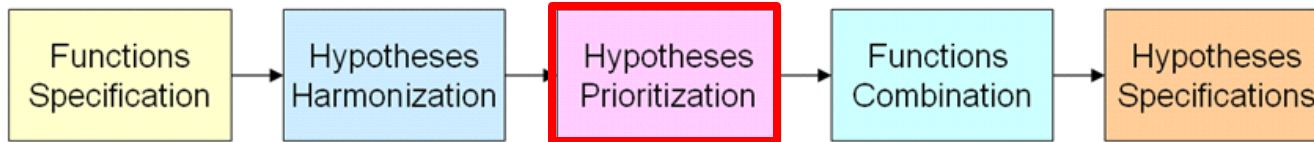
88 ACC hypotheses reduced to 39 by

- ⌘ deleting doubles
- ⌘ rephrasing to common terminology
- ⌘ substituting one PI by a equal, already used PI

Example

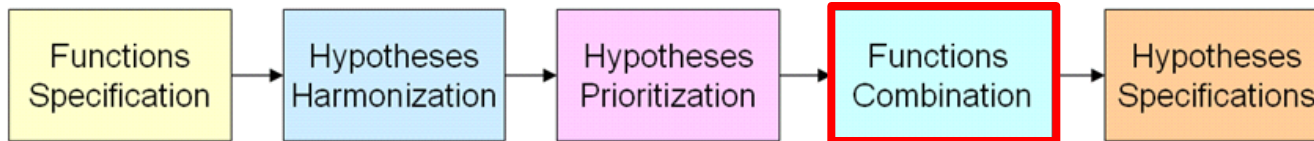
- ⌘ OEM 1: ACC will decrease TTC
- ⌘ OEM 2: With ACC, the driver will drive less close to leading vehicle
- ⌘ Result: Using ACC, TTC will increase compared to not using ACC, in [Situation], [Use Case]

Step 3: Hypotheses Prioritization



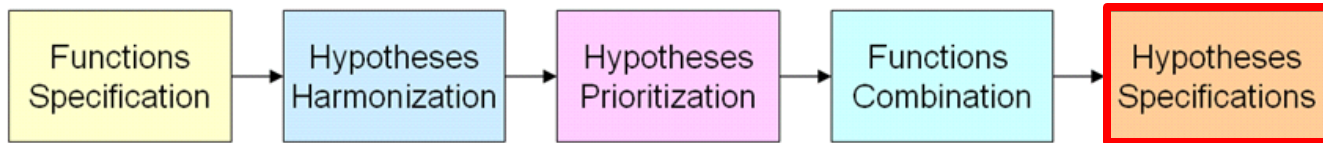
- ♂ Ranking of hypotheses for each function according to feasibility index
 - ▷ SP 3: collection of data
 - ▷ SP 4: exp. design and testability
 - ▷ SP 6: data analysis
 - ▷ OEMs: desirability
- ♂ Input from Jim Sayer (UMTRI) taken into account

Step 4: Function Combination



- ♂ Some functions are only available in combinations
 - ▷ Example: ACC/ FCW
- ♂ Procedure for refining hypotheses (Results from FOT-NET workshop in Ams, Feb/09) was followed by OEMs (since functions are OEM specific)

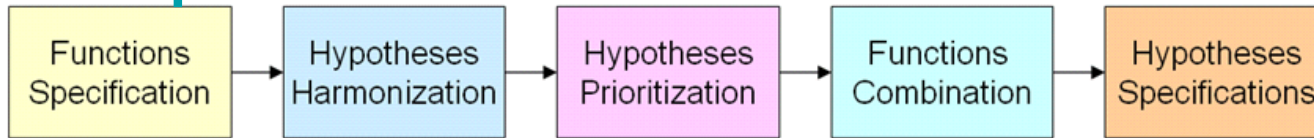
Step 5: Hypotheses Specification



- ⌚ Factors influencing hypotheses have been specified for each hypothesis.
 - ▷ Controlled Factors
 - ▷ Variable Factors
- ⌚ These factors should be taken into account by SP3, SP4, and SP6.
 - ▷ Example: Heavy rain
 - ▷ SP 3: measure "rain" (wipers)
 - ▷ SP 6: same "rain" distribution in control/ exp group.

Step 5: Final Hypotheses Specification

Example: factors for ACC



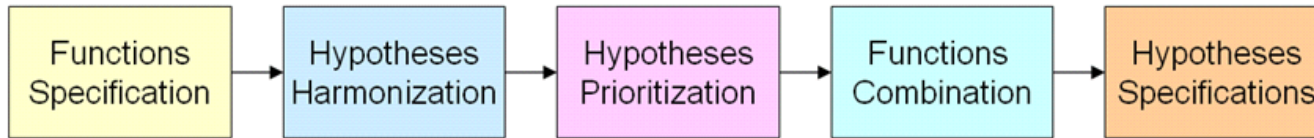
Controlled Factors

- A - ACC activation
- B - Driver identity
- C - Driver Age/Experience
- D - Speed range
- E - Intensity of braking
- ...
- N - ACC settings
- O - Overriding of the ACC systems

Variable Factors

- a - Trailer load
- b - Road Type
- c - Time of the day/week
- d - Level of sensation seek
- ...
- o - Type of tires
- p - How familiar is the driver with the road
- q - Time of the day (night/day)

Conclusions



- ⌘ Specifying testable hypotheses from system specifications and research questions is not trivial, but the necessary foundation work for a successful FOT
- ⌘ A limited set of hypotheses is necessary to focus data collection and analysis

8 Functionalities, 28 Partners, 1000 Vehicles

1 Field Operational Test, 8 Functionalities

28 Partners, 1000 Vehicles, 1 Field Operational Test

8 Functionalities, 28 Partners, 1000 Vehicles

1 Field Operational Test, 8 Functionalities

28 Partners, 1000 Vehicles, 1 Field Operational Test

8 Functionalities, 28 Partners, 1000 Vehicles

1 Field Operational Test

