Hypothesis Formulation

1 Introduction

One of the early stages in preparing an FOT is the stage at which broad research questions are formulated. This should precede the definition of the study design and of the performance indicators. Part of the formulation of research questions is the generation of hypotheses that translate those general research questions into more specific and testable hypotheses.

FESTA distinguished between more general and open *research questions* and more specific *hypotheses*. These terms and many others were defined in the project glossary. This glossary has been further developed in the current EuroFOT project and the EuroFOT definitions are used here. The definition of a research question is "a general question to be answered by compiling and testing related specific hypotheses". An example would be: "Does having a Forward Collision Warning system improve safety in driving?"

A hypothesis is here defined[1] as:

> "a specific statement linking a cause to an effect and based on a mechanism linking the two. It is applied to one or more functions and can be tested with statistical means by analysing specific performance indicators in specific scenarios. A hypothesis is expected to predict the direction of the expected change."

The term "function" is used because a particular system may have a number of distinct functions — for example, one system could provide both Adaptive Cruise Control and a Forward Collision Warning. It is also the case that one function can be provided by different systems. An example of a hypothesis might be: "Forward Collision Warning will have the direct effect of an increase in minimum Time to Collision (TTC)."

There is no process that can assure that all the "correct" hypotheses are formulated. To a large extent, creating hypotheses is an intuitive process, in which a combination of knowledge and judgement is applied. Nevertheless, a number of recommendations can be made about how this process should be conducted. These recommendations were tested in a FESTA workshop in February 2008 and modified based on the experience of and feedback from that workshop. Two complementary approaches are recommended:

- A top-down approach that considers six broad areas of system influence
- A bottom-up approach, applying use cases and situations to develop scenarios

[1] The definitions used here and below are from the glossary of the EuroFOT project.

2 Top-down: the 6 areas

The six areas of impact defined by FESTA are based on Draskóczy et al. (1998). Although this approach was originally designed for formulating hypotheses on traffic safety impacts, it is in fact equally applicable for efficiency and environmental impacts.

The FESTA six areas are:

1. Direct effects of a system on the user and driving
2. Indirect (behavioural adaptation) effects of the system on the user
3. Indirect (behavioural adaptation) effects of the system on the non-user (imitating effect)
4. Modification of interaction between users and non-users (including vulnerable road users)
5. Modifying accident consequences (e.g. by improving rescue, etc. — note that this can effect efficiency and environment as well as safety)
6. Effects of combination with other systems

It is not of particular importance to which of these areas a particular hypotheses is allocated. The six areas are instead to be used as a checklist to ensure consideration of multiple aspects of system impact.

In applying this procedure, it should be noted that:

- Area 1 includes the human-machine interaction aspects of system use
- The **driving task** (see Figure 1) can be defined, following Michon (1985) into the three levels of strategic, tactical (manoeuvring) and control aspects. All three levels need to be considered.

  The *Strategic Level* includes potential modifications to:

  - Mode choice
  - Route choice
  - Exposure (frequency and/or length of travel)

  The *Tactical Level* includes potential modifications to speed choice and the effects of such modification on manoeuvring and interaction with other road users.

  The *Control Level* also includes potential modifications to speed choice and the effects of such modification on vehicle control.

- Consideration should be given to such **mediating factors** as user/driver state, experience, journey purpose, etc.

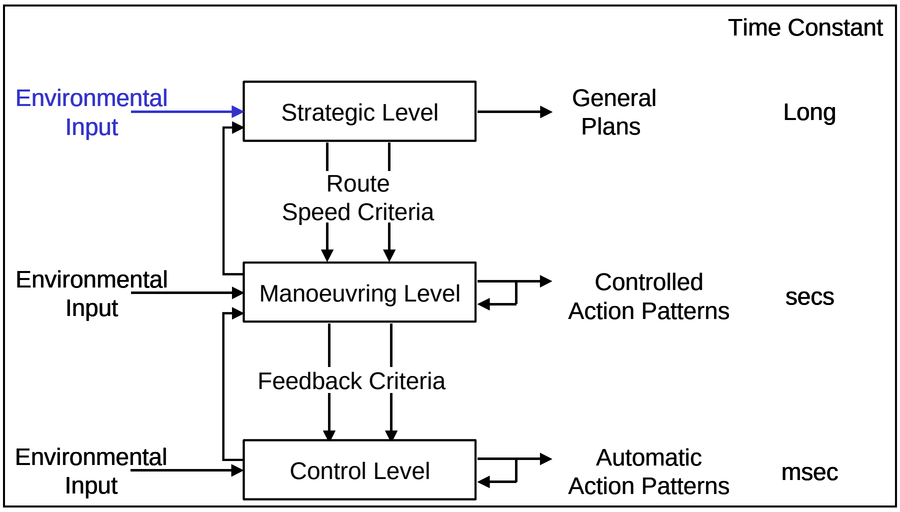

Figure 1: The three-level model of the driving task, based on Michon (1985)

It should also be noted that the **effects** of system use may be:

- Short-term or long-term in terms of *duration*
- Intended or unintended in terms of *system design*

A useful final checklist is to confirm that the following types of impact have been covered:

1. Safety
2. Efficiency
3. Environment
4. Mobility
5. Acceptance and trust
6. Usage
7. Adoption (making system use inherent in behaviour)
8. System penetration

3 Bottom-up: the use case approach

This process leads to the development of hypotheses concerning specific scenarios. These scenarios are derived from the combination of Use Cases and Situations (see Table 1). Scenarios should be covered systematically. It is recommended that a structured approach be used in scenario development and that an Excel spreadsheet is used as a record.

Table 1: Definitions

Subject	**Definition**	**Comment**	**Example**
Use Case	A specific event in which a system is expected to behave according to a specified function	A use case is a system and driver state, where "system" includes the road and traffic environment.	Car following
Situation	One specific level or a combination of specific levels of situational variables	Thus a situation is a specific state of the environment.	Rainy weather + darkness + motorway driving
Scenario	A use case in a specific situation	Use case + situation = scenario	Car following on the motorway in rainy weather and darkness

4 Prioritising the hypotheses

A complete list of the hypotheses that have been developed should be recorded. If it is considered that some are too trivial or too expensive to address in the subsequent study design and data collection, the reasons for not covering them should be recorded. It should also be noted that there are standardised techniques for observing driving behaviour with manual observers which may be less resource intensive than using dedicated data recording. Observations using such techniques can be carried out at various times during the study, preferably along a fixed route.

5 Summary

The basic set of recommendations are:

1. A structured approach should be applied linking a **top-down** approach at the global system level with a **bottom-up approach** which looks more at system states and what can arise from them. FESTA considers it mandatory to combine the two approaches.

2. A multidisciplinary team should *jointly* develop the hypotheses. A workshop at which participants can brainstorm and debate is recommended to achieve this. Participants in the process should include design engineers, traffic engineers and behavioural scientists, ideally including both behavioural psychologists and human factors experts.

3. The process should iterate between the top-down and bottom-up approaches. It is not particularly important which is performed first, but it is important to cross-check one approach by using the other.

4. An important output of the process is the initial selection of the **Performance Indicators** to be used in testing the hypotheses.

6 References

Draskóczy, M., Carsten, O. and Kulmala, R. (1998). Road safety guidelines. Deliverable B5.2 of CODE project (TR1103). Atkins Wootton Jeffreys, Birmingham, UK. Available at: http://cordis.europa.eu/telematics/tap_transport/library/code-b5-2.html.

Michon, J.A. (1985). A critical review of driver behaviour models. In Evans, L. and Schwing, R. G. (Eds.), Human Behavior and Traffic Safety. Plenum Press, New York, pp. 485-520.