



Workshop on Intelligent Vehicles for Logistics

Which Evolution for Intelligent Vehicle? An Automotive Perspective based on the European Projects Experience

CNR – Bologna, 16/04/2012

Fabio Tango



Outline

- Introduction and Context
- Two examples:
 - The Integrated Project INTERACTIVE
 - The Project ISI-PADAS
- Discussion and Conclusions



Outline

- Introduction and Context
- Two examples:
 - The Integrated Project INTERACTIVE
 - The Project ISI-PADAS
- Discussion and Conclusions



The Problem

- European Framework Programs (1996 - 2008) focus on singular in-vehicle systems for automated driver support in hazardous situations towards reducing fatalities on road
- Stand alone sensors not sufficient (physical limitations)
- In addition, Stand alone functions with dedicated set of sensors create redundancies, increase the cost
- New automotive technologies make intervention (active steering/braking) and interaction (seamless HMI) with the driver worth studying for both accident avoidance and mitigation



The Context #1

- Today's road vehicles already offer the driver a significant amount of different assistance systems to increase comfort and enhance road safety
- The era of ADAS and PADAS just seems to be beginning
- Next generation of Intelligent Vehicles (IVs) is ready to be developed, but which is their evolution?



The Context #2

- Necessary for the continued enhancement of road safety, further reduction of accidents and fatality rates, the driver remains the most essential actor also for the foreseeable future
- Driver must be able to control the vehicle, as well as to understand and accept the assistance and automation offered by PADAS.
- Technical systems and drivers have to be compatible



The Content #1

- Technical capabilities of IVs must take into account the characteristics of the driver, in order to achieve a high compatibility between these two agents such that the driver intuitively understands the offered assistance (Löper, 2008)
- In this context, a key concept is the Co-Drivers, which will be able to “understand” human drivers and to form symbiotic systems with them.



The Content #2

- The basic idea of the co–driver approach is to put a “virtual driver” in the car
- Based on the environment description, the “virtual driver” evaluates how a real human would drive, in the given situation, in order to fulfill a combination of safety, comfort and fuel reduction objectives



Accident Analysis

- All rear-end crashes take part for 73.3% of analyzed accidents and 22.81% of the severe accidents
- Many studies showed the benefits of FCW in reducing the number and severity of collisions
- Other studies investigated the benefits of ACC in limited traffic flows or heavy – but not congested – traffic
- Moreover, ACC reduces the workload and stress associated with tasks where drivers have to adapt their distance to the vehicle ahead



Outline

- Introduction and Context
- Two examples:
 - The Integrated Project INTERACTIVE
 - The Project ISI-PADAS
- Data Analysis and main Results
- Discussion and Conclusions

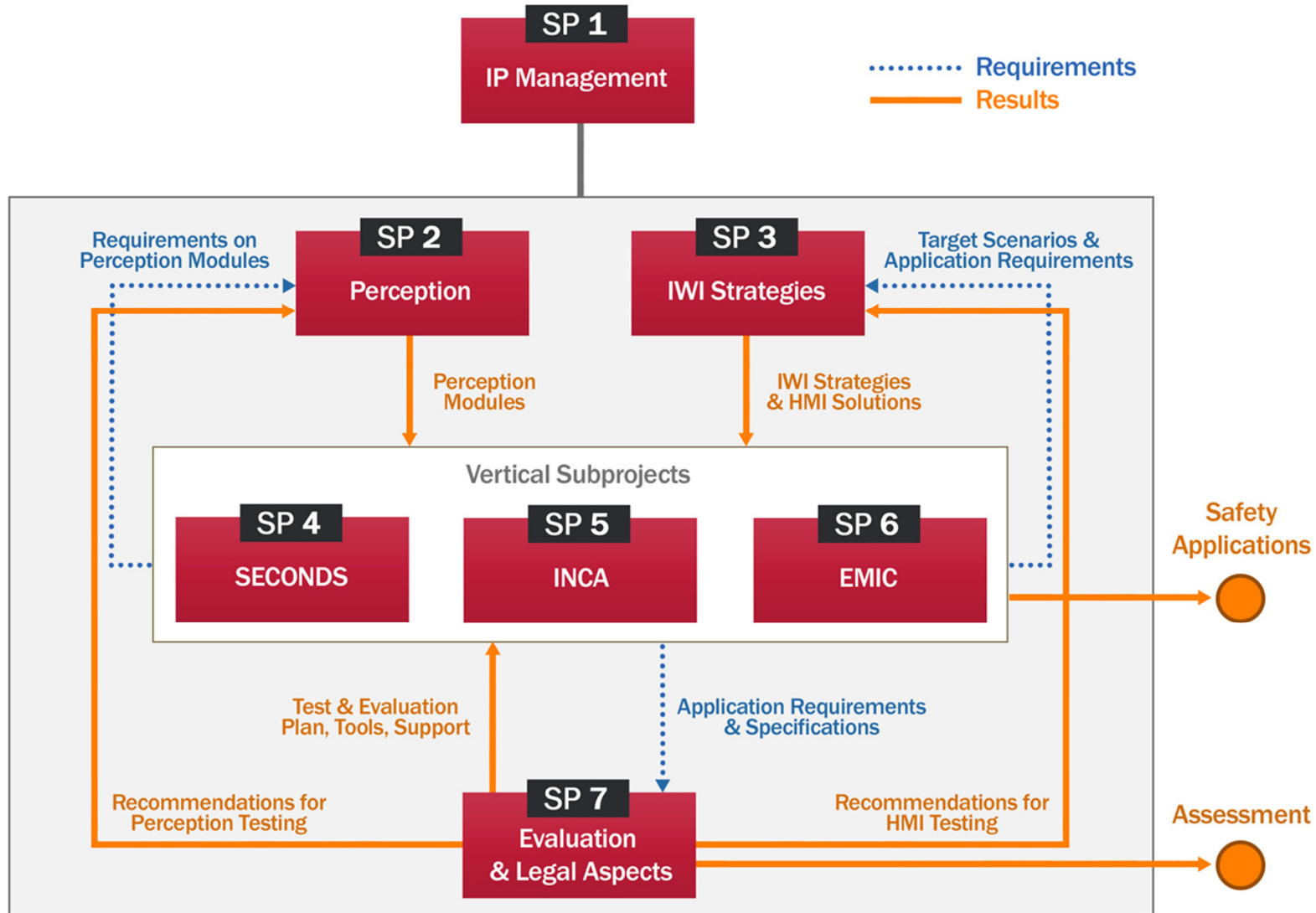


Key-elements

- InteractIVe develops the technology for next-generation safety system on Intelligent Vehicles
- Advanced sensor networks will continuously support the driver and can intervene if the driver is unable to react sufficiently in emergency situations (the driver is continuously supported but keeping him/her in the loop as far as possible)
- **The interactIVe vision:** Accident-free traffic realised by active safety systems in all vehicles



Project Structure





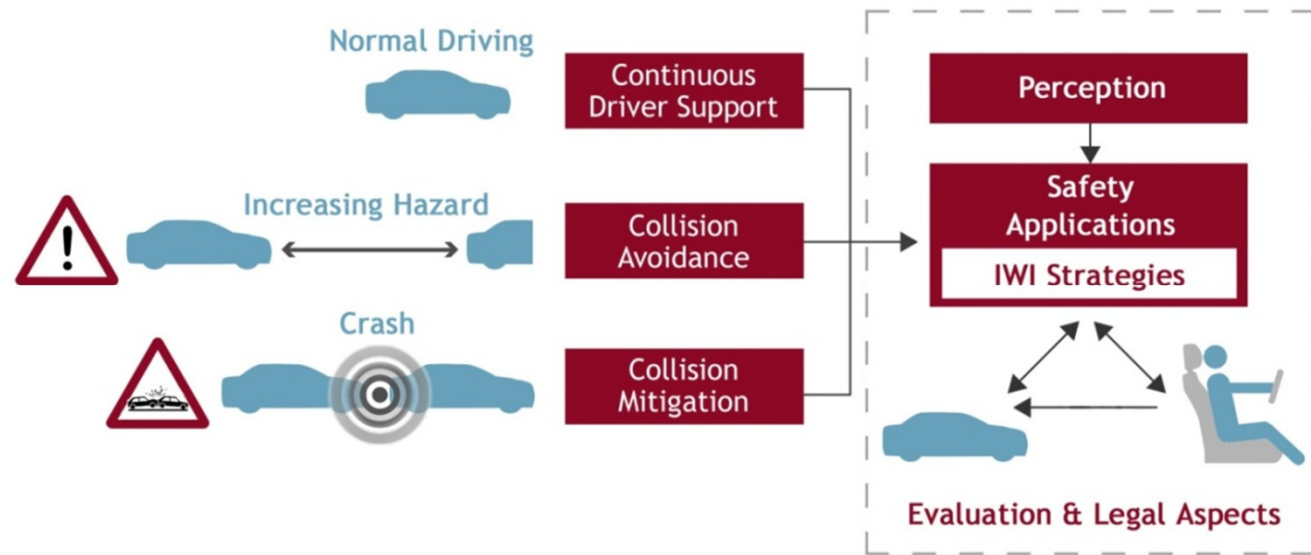
Main Objectives

- Create an innovative model and platform for enhancing the perception of the driving situation
- Extend range of possible scenarios and usability of ADAS by multiple integrated functions and active interventions
- Improve decision strategies for active safety and driver-vehicle-interaction
- Develop solutions for collision mitigation that can improve the market in-take within lower-class vehicle segments
- Further encourage the application of standard methodologies for the evaluation of ADAS



System Overview

- 3 major application functionalities perceived in a time-wise continuum
- Multi sensor data fusion approach (including digital map -ADASIS v2 + communication data)
- Study of human-automation-vehicle interaction strategies





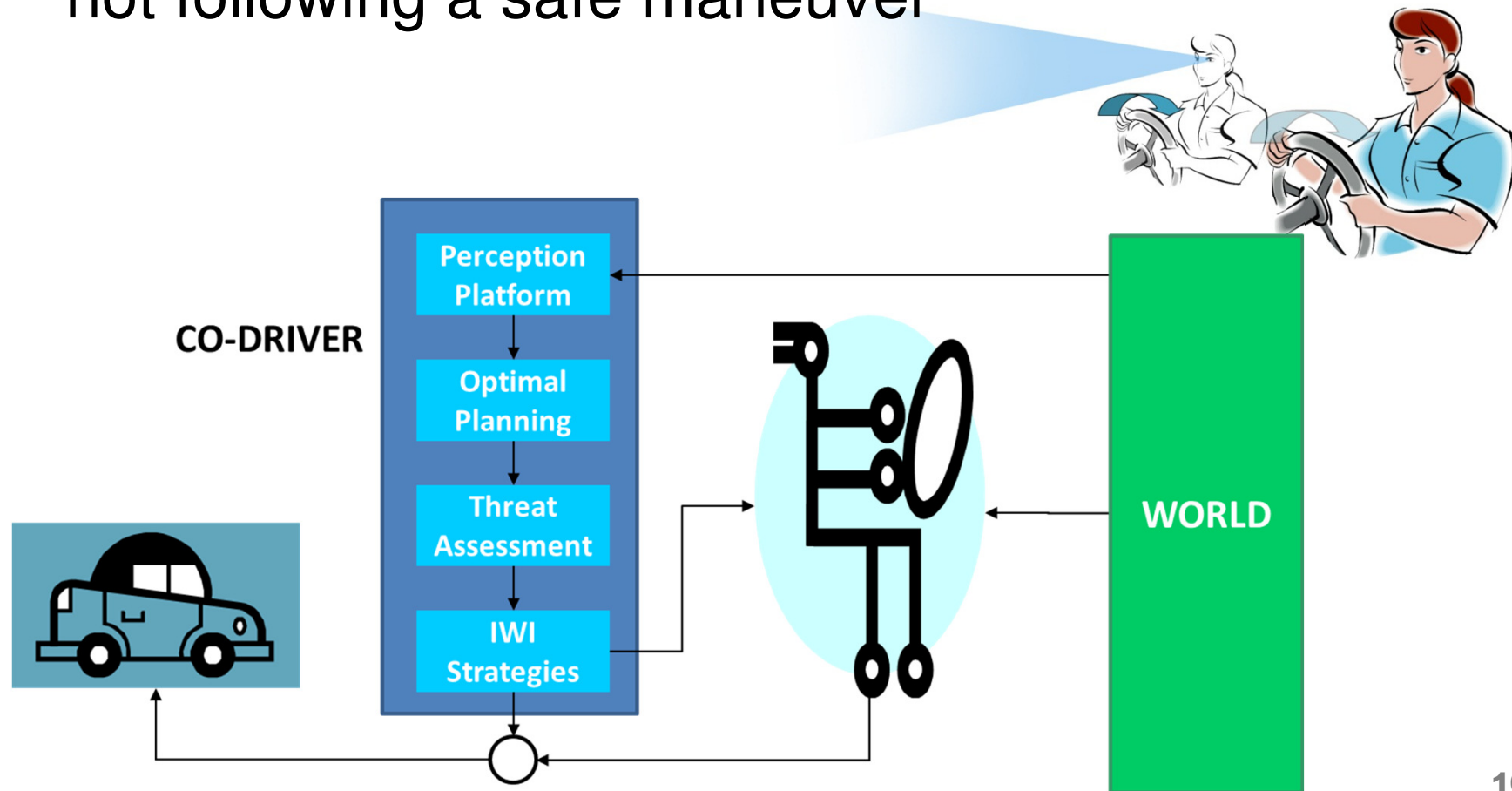
Demonstrators





SP4: SECONDS

- Driver Assistance system conceived as a co-driver, who gives active advices when the driver is not following a safe maneuver



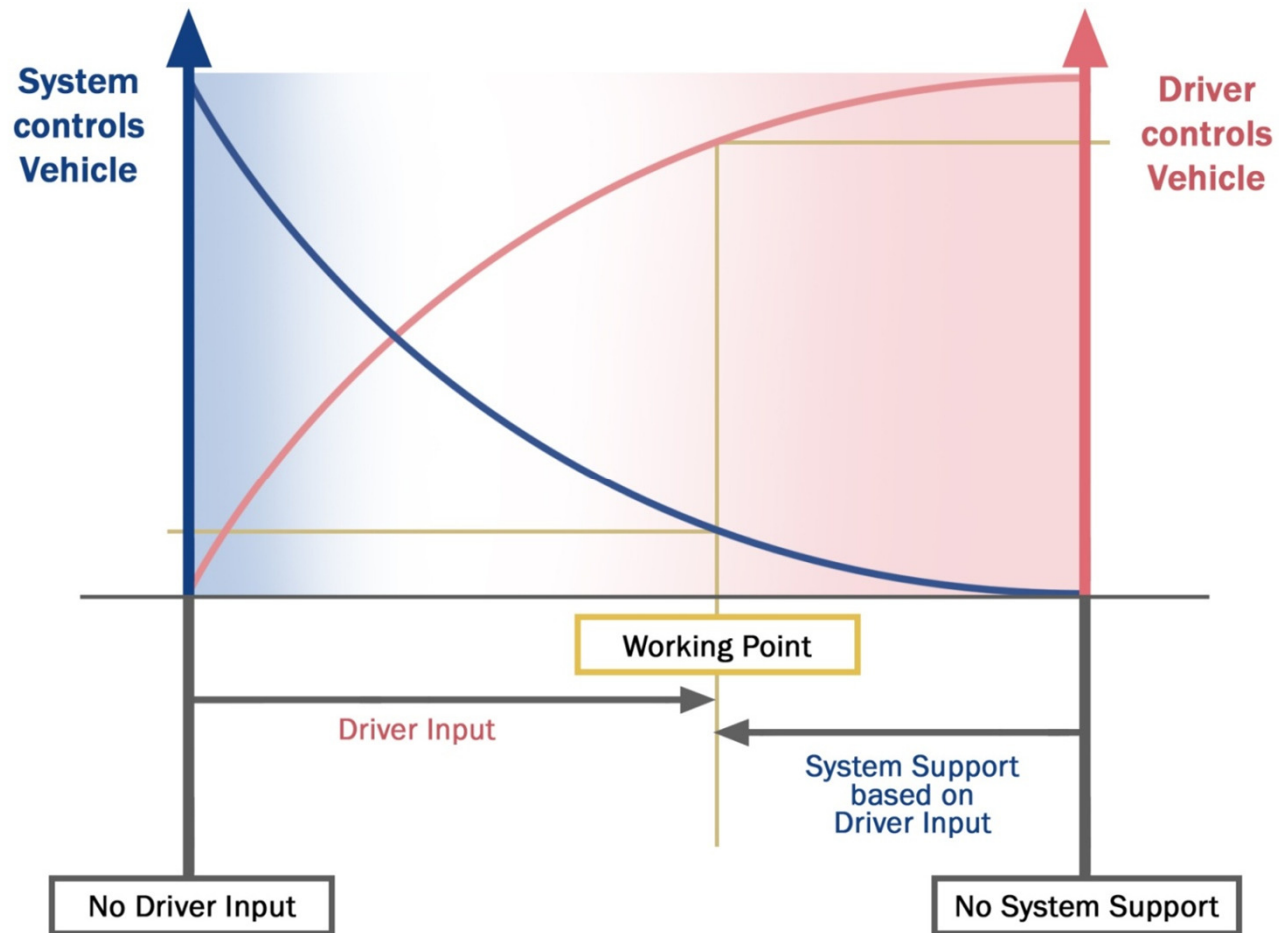


Objectives

- Conceive, develop, and test continuous support functions
- Functions: continuous support (integrated longitudinal and lateral support), curve speed control, enhanced dynamic pass predictor, safe cruise
- Innovative concept for splitting the driving task (amount of control) between driver and vehicle

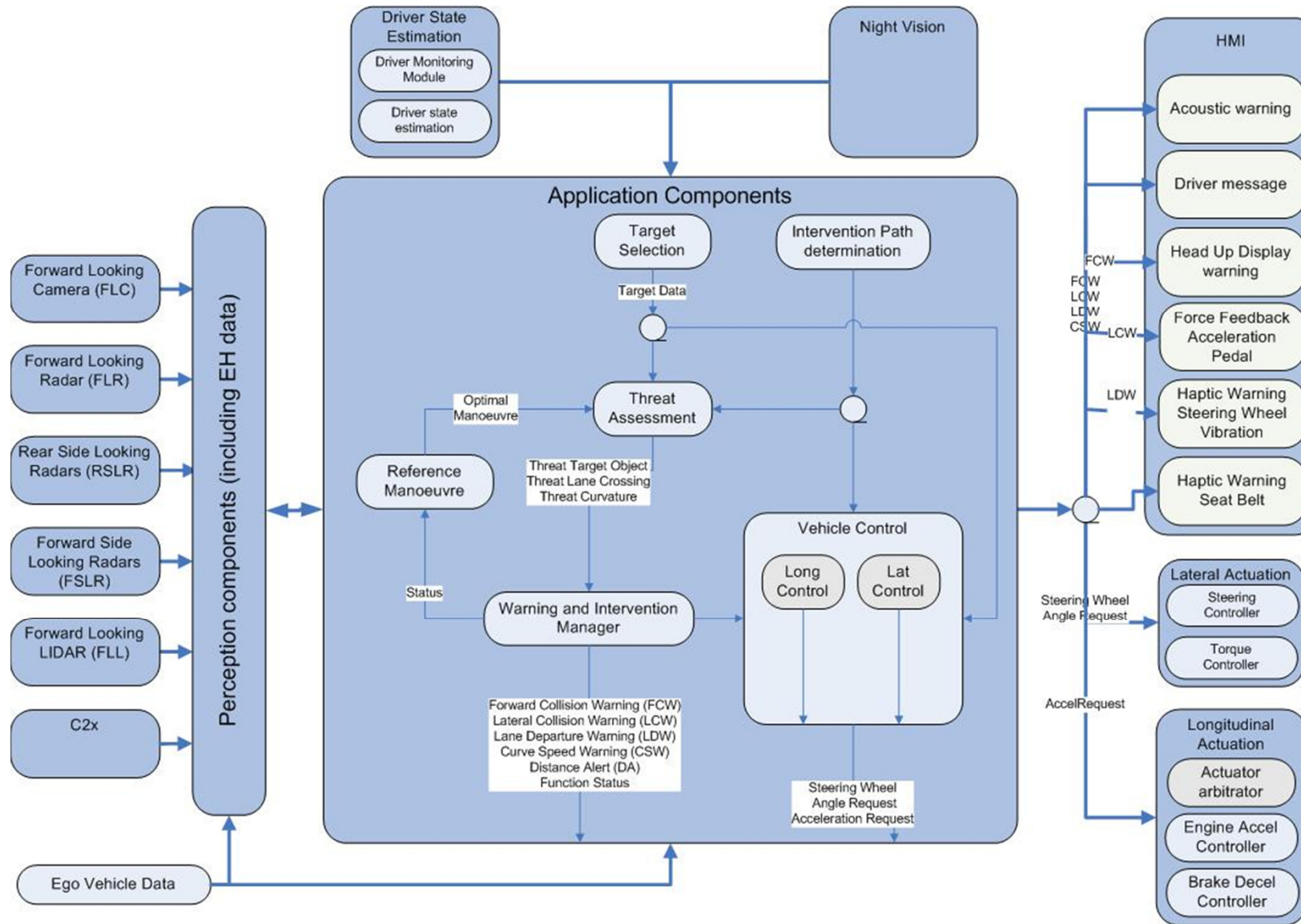


Splitting driving task





System Architecture





Outline

- Introduction and Context
- Two examples:
 - The Integrated Project INTERACTIVE
 - The Project ISI-PADAS
- Discussion and Conclusions



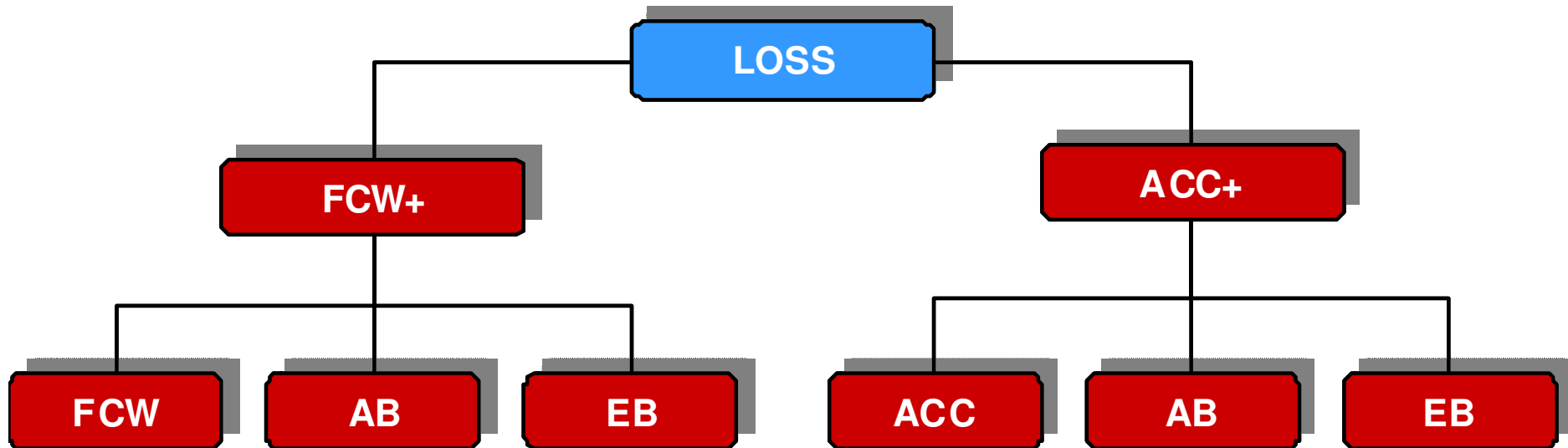
The ISI-PADAS Project

- Co-funded by EC in the FP7: **Integrated Human Modelling and Simulation to support Human Error Risk Analysis of Partially Autonomous Driver Assistance Systems**
- The main goals of ISI-PADAS are:
 - implementation of a human error risk approach for designing advanced control systems (PADAS)
 - innovative driver's model development, for predicting correct and erroneous driver behaviors
 - development of a joint DVE-Simulation Platform to integrate driver models
 - new knowledge about driver behavior including errors



The Concept

- PADAS means *Partially Autonomous Driver Assistance Systems*



- LOSS = Longitudinal Supporting System



Functioning

- FCW+ goes from warning / information to the driver (too short headway or too fast with respect obstacle speed) up to automatic system intervention (emergency situations or minimisation of the impact consequences), through a cooperative action (assisted braking) ⇒ **driver in the loop**
- ACC+ is more focused on automatic control: it moves from ACC function to emergency braking, through assisted braking ⇒ **driver outside the loop**



The Approach

- Modeling FCW+ and ACC+ as **Markovian Decision Process** and using **Reinforcement Learning** to construct optimal WIS \Rightarrow artificial CODRIVER that behaves like a sort of trip-mate in driving (idea of horse, not of mother-in-law!)
- Artificial agent learns to interact optimally with a stochastic dynamic system through interactions: goal is to learn an optimal interaction policy \Rightarrow motion planner that makes trajectories similar to humans



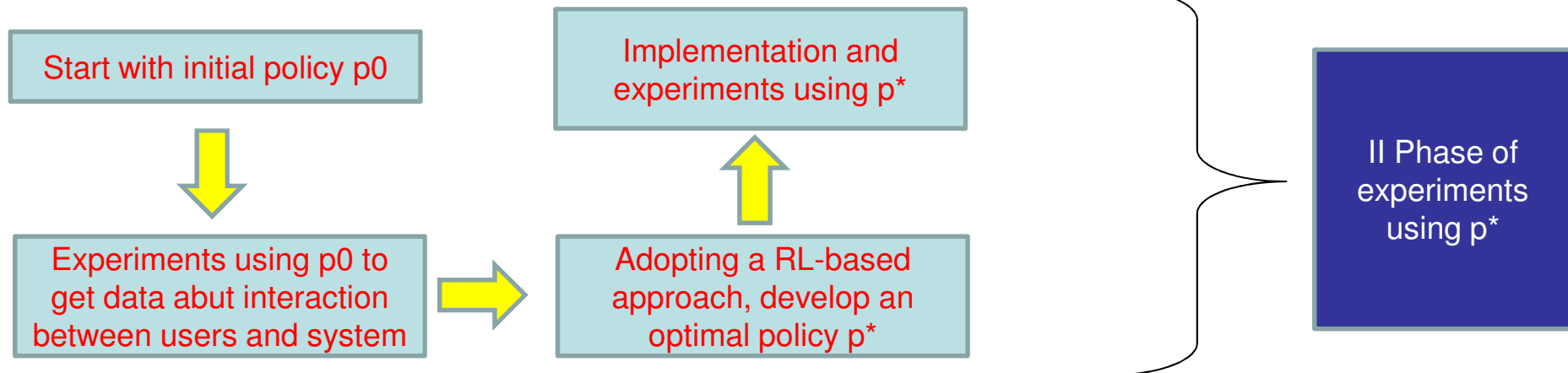
Method to solve MDP

- There are two computational impediments in solving this MDP exactly:
 - sets of states and actions of the corresponding MDP are very large.
 - dynamics of the MDP are unknown and difficult to model since the driver's reaction to the presence of PADAS on board is not deterministic and may vary from one driver to the other.
- RL algorithms will be used to learn an approximate optimal policy for the MDP directly from observed data



MDP Modelling

- Objective: taking an action, minimizing the cost \Rightarrow a policy is used to take decision



- Possible Integration with a driver's state classifier



Experimental Set-up

- A dedicated experiment has been conducted by “University of Modena and Reggio Emilia”, using the static OKTAL driving simulator
- For information: www.oktal.fr



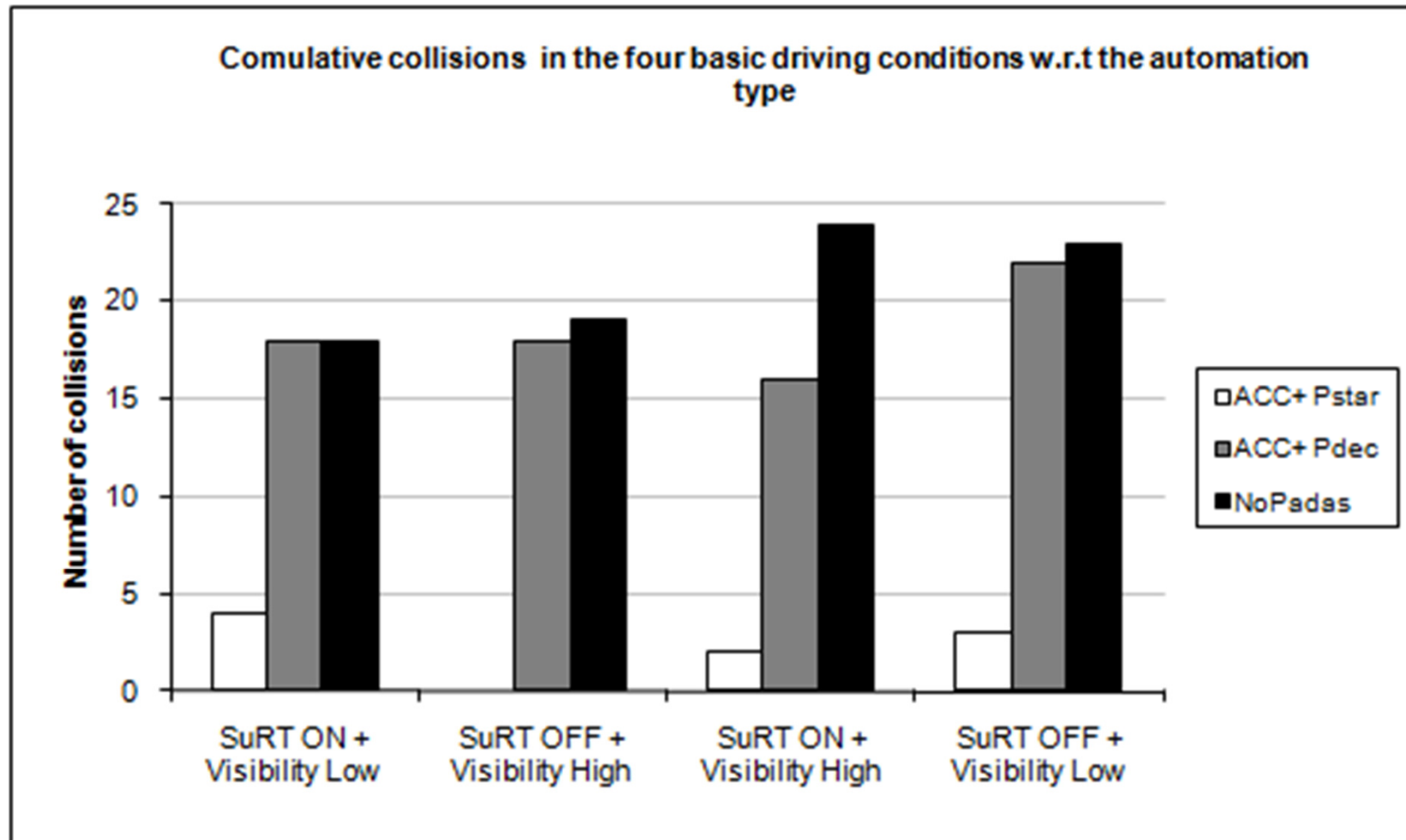


Data Analysis

- 3 different policies have been considered:
 - MDP + RL approach (p^* policy)
 - Reference policy ($pDec$), based on literature and currently used
 - No policy, users without any PADAS support (*No-PADAS*)
- Reference policy is based on the following idea:
which is the necessary deceleration for which the HV can reach the same speed of LV within a given distance (*safety distance*).
- Different Indexes used (e.g. number of collisions, TTC and $HD < Th$, Steering Entropy, etc.



Results #2





Outline

- Introduction and Context
- Two examples:
 - The Integrated Project INTERACTIVE
 - The Project ISI-PADAS
- Discussion and Conclusions



Conclusions #1

- We have presented two possible solutions for the implementation of the Co-Driver concept
- This Co-Drivers must be aware of human cognition, strategies and behavior.
- Moreover, it has to “understand the drivers”, identifying the intentions and classifying the states



Conclusions #2

- Driver and co-driver outputs are then compared (which in turn stresses the good quality of virtual user models).
- The most promising approach is to develop such a concept by means of a strong interaction between the driver model and the real-user
- To achieve that, an MDP approach with RL paradigm has been followed, which is quite new in automotive domain



Next Steps

- Comparison – if possible – with other Co-driver approaches available in literature
- Integration of PADAS strategies with driver's status classifier
- Integration with intention modeling (driver's maneuvers recognition)
- Long-term effects of IV on driver's behavior and workload
- Test on real-time and on-line data



Questions?

Thank a lot for your
kind Attention!





Main Contacts

- Fabio Tango (CRF) e-mail address = fabio.tango@crf.it
- Project web-site:
 - <http://www.isi-padas.eu>
 - <http://www.interactive-ip.eu/>