



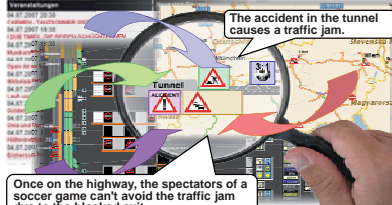
# BEWARE!

# An Ontology - Driven Framework for Situation Awareness Applications

## Problem

### Information Overload in Large-Scale Control Systems

- Large-scale control systems, like in the domain of road traffic management, typically deal with **dynamic environments**.
- They provide a **vast amount of information**, stemming from multiple heterogeneous sources, about a **large number of real-world objects anchored in time and space**.
- Human operators are at risk to **get lost in the induced information overload**.
- This endangers to **timely and correctly identify, resolve and pro-actively prevent critical situations** potentially causing serious impacts in the real world.

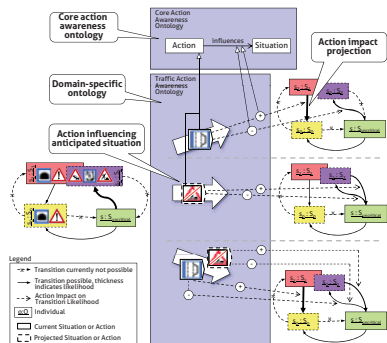
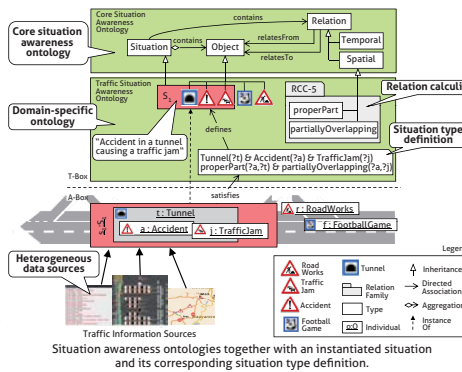


Manually identifying a critical situation.

## Approach

### Situation Awareness

- A **core situation awareness ontology** unifies concepts, such as **Situation, Object, and Relation** from various domains.
- Domain-specific ontologies**, like a traffic situation awareness ontology, extend the core situation awareness ontology to provide representations for heterogeneous data sources.
- Well-known calculi**, such as Region Connection Calculus (RCC), Oriented Point Relations Algebra, Allen's Time Intervals Algebra, and Freksa's Temporal Semi-Intervals, extend the core situation awareness ontology to provide qualitative spatio-temporal relations.
- Situation types** describing relevant situations are defined on basis of objects and relations.
- The notion of **neighborhood of relations**, **generalized to neighborhood of situations** enables reasoning about similarity and evolution of situations.
- Reasoning shortcuts** foster efficient situation assessment by exploiting meta-information about relations.



### Action Awareness

- A **core action awareness ontology** is integrated with the core situation awareness ontology.
- Domain-specific ontologies** extend the core action awareness ontology to describe actions of particular domains, and to describe how actions influence likelihoods of transitions between situations.
- Actions influencing anticipated future situations** are proposed early in time.
- A priori knowledge of domain experts**, as well as **action impact analysis** of past actions facilitate projection of action impacts.

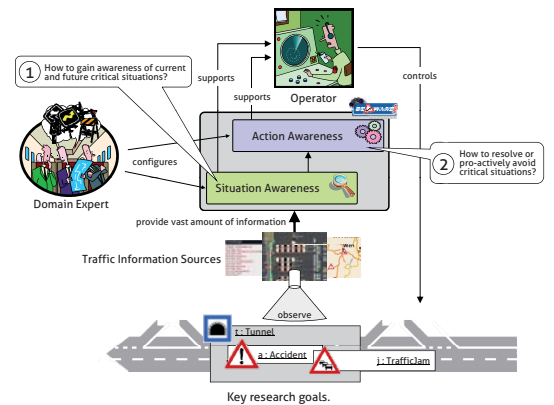
## Goals

Leverage **situation and action awareness** in large-scale control systems with **semantic-based methods**, thereby facilitating **information integration** as well as **situation assessment and exchange**.

### Situation Awareness

Gain awareness of **current and future critical situations**:

- Develop ontologies** for situation awareness as formal and semantically rich knowledge representation of situations.
- Incorporate qualitative spatio-temporal relations** describing real-world situations with physical objects distributed over time and space.
- Reason about the similarity and evolution of situations** to anticipate future critical situations.
- Facilitate efficient and robust situation assessment** with computationally tractable reasoning approaches fulfilling industry-strength robustness requirements.



### Action Awareness

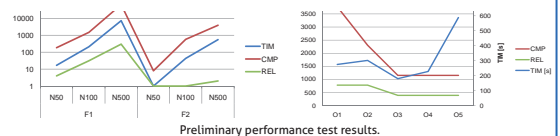
Propose actions to resolve or pro-actively avoid critical situations:

- Develop ontologies for action awareness** describing actions integrated with situation awareness ontologies.
- Elaborate on action assessment** for proposing viable sets of actions resolving current and preventing future critical situations.
- Project and reason on action impacts** enabling operators to be aware of the effects actions are likely to have.

## Evaluation

### Evaluation in the Domain of Road Traffic Management

- Functional and non-functional criteria** focusing on situation awareness and action awareness techniques are developed in accordance with industry partners.
- Test case design** is performed upon **real-world test data** (critical situations, viable actions), and **information extracted from printed operating procedures**.
- Tests are based on real-world information** stemming from the commercial road traffic management system GeoDyn 2 provided by Heusch/Boesefeldt.
- Simulation and offline evaluation** are employed as major evaluation techniques due to potentially negative impacts if testing in real time on real-world road traffic management systems.



### Preliminary Performance Test Results

- Focused situation types** being satisfied by a small number of object sets only increase performance in comparison to unfocused situation types (cf. F1 vs. F2).
- Reasoning shortcuts** exploiting characteristics of relations are promising to achieve performance increase (cf. O1 - O4).

## Prototype



## Project Facts

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