PhD Program in Computer Science and Systems Engineering
XXX Cycle 2015-17
DIBRIS, University of Genova

Proposal of Research Theme

Proposer: Roberto Sacile

Research area: System Engineering, Safety Engineering, Transport and Logistics Systems

Description  Railway Signalling System Reliability Assessment Model

Railway signalling is a system used to control railway traffic safely, essentially to prevent trains from colliding. The main international standard for train control and command systems is the European Rail Traffic Management System (ERTMS). ERTMS has three levels. ERTMS Level 1 and ERTMS Level 2 are already widely applied in Europe. ERTMS Level 3 is currently under development. In ERTMS Level 1, the train position is detected from track circuits and transmitted to the train via balises, which are electronic devices placed between the rails at regular intervals. In ERTMS Level 2, the train position is obtained via track circuits. Balises are used here only as position markers, transmitting fixed data to initialise or to recalibrate the train's odometer. A continuous stream of data informs the driver of line-specific data and signals status on the route ahead, allowing the train to reach its maximum or optimal speed but still maintaining a safe braking distance factor. Still in its conceptual phase, ERTMS Level 3 introduces a “moving block” technology. Accurate and continuous position data is directly supplied to the control centre by the train. As the train continuously monitors its own position, in ERTMS Level 3, there is no need for “fixed blocks” as the circuit tracks are – rather the train itself is considered as a moving block.

The aim of this work is to develop a methodology to evaluate quantitatively the railway signalling system performances, in particular taking into account the ERTMS level 2, as well as future developments of ERTMS level 3, modelling them as a system of systems (SoS). The related SoS performance will be evaluated in terms of dependability parameters and average time spent in each state (working state, degraded state and failed state). The originality lies in the approach to consider ERTMS level 2 as a SoS and seeks to evaluate its dependability parameters by considering the failure and so the unavailability of whole SoS as an emergent property. The proposal consists in modelling the ERTMS level 2 using the Universal Modelling Language (UML) Statechart for formal verification of security properties and the Bayesian Networks for dependability evaluation. Other control approaches will be also taken into account. The PHD research will investigate the following aspects:

• Explain how to elicit (extract) failure probabilities or interval failure probabilities (imprecise probabilities in general) form real reliability data and experts’ opinions.
• Explain how to propagate uncertainty form of reliability data at the components level to the railway system level.
• To take into account maintenance policies (which are not cited in the standards related to ERTMS) in dependability studies.
• To use the proposed methodology in order to evaluate quantitatively the likelihood of near accidents in railway systems.

1 An additional level 0 can be defined, that is when an ETCS vehicle is used on a non-ETCS route.
The research will involve leading industrial companies in railway signaling systems. A possible cotutoring with UTC, the Technologic University of Compiègne (France), will be also offered as an agreement between University of Genova and UTC.

Reference