Event-B for Safety Analysis of Critical Systems

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Systerel, Aix-en-Provence

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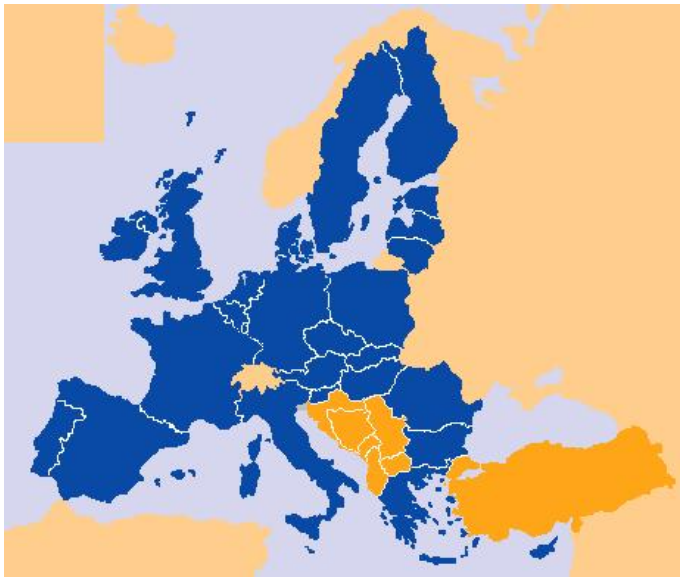
Contents



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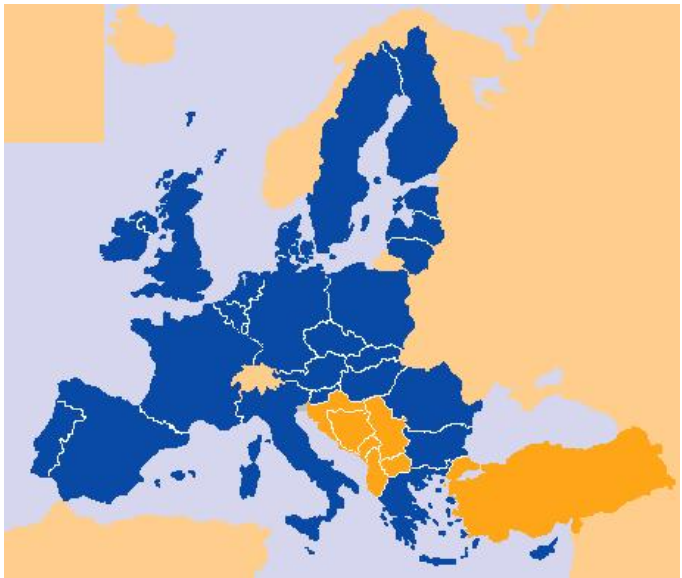

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European Train Control System (ETCS) Specification (ERA)

- Facilitation of Cross-Border Trains
- Data Transfer over Wireless Technique (GPRS)
- Goal : Homogenization of Train Signalling (up to $500\frac{km}{h}$)

Challenge : Informal Specification with room for interpretation. Very different detail level (requirements, implementation detail, notes etc.)

openETCS

Aims at providing a formal model, open proof and open source toolchain for ETCS.

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Overview

- Functional Model for Management of Radio Communication (MoRC)
- Safety Activities with Rodin
- Conclusion

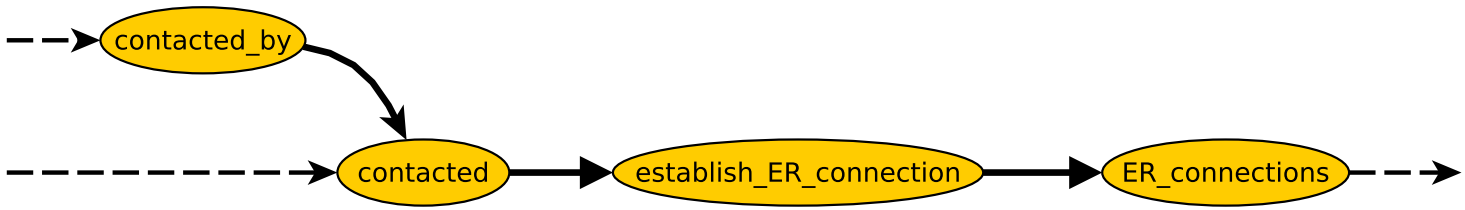
Contents

Management of Radio Communication

- Participants
  - On-Board Units (OBU)
  - Radio Infill Units (RIU)
  - Radio Block Centers (RBC)
- Section §3.5 of ETCS spec
  - Initiate, Maintain and Terminate Radio Communication
- Critical Function : Radio Communication for Movement Authority / Speed Limits

Event-B Model for MoRC

- Type *entities*
  - partitioned into set of OBU, RIU and RBC entities
- State of Communication
  - Communication direction (incoming, outgoing)
  - Protocol stage for each communication session



Event-B Machine Refinement

- Machine 0 - *Basic Communication*
- Machine 1 - *Directional Communication*
- Machine 2 - *Limit to OBU viewpoint*
- Machine 3 - *System Level Compatibility*
- Machine 4 - *Level Changes Support*
- Machine 5 - *Safe Radio Communication*

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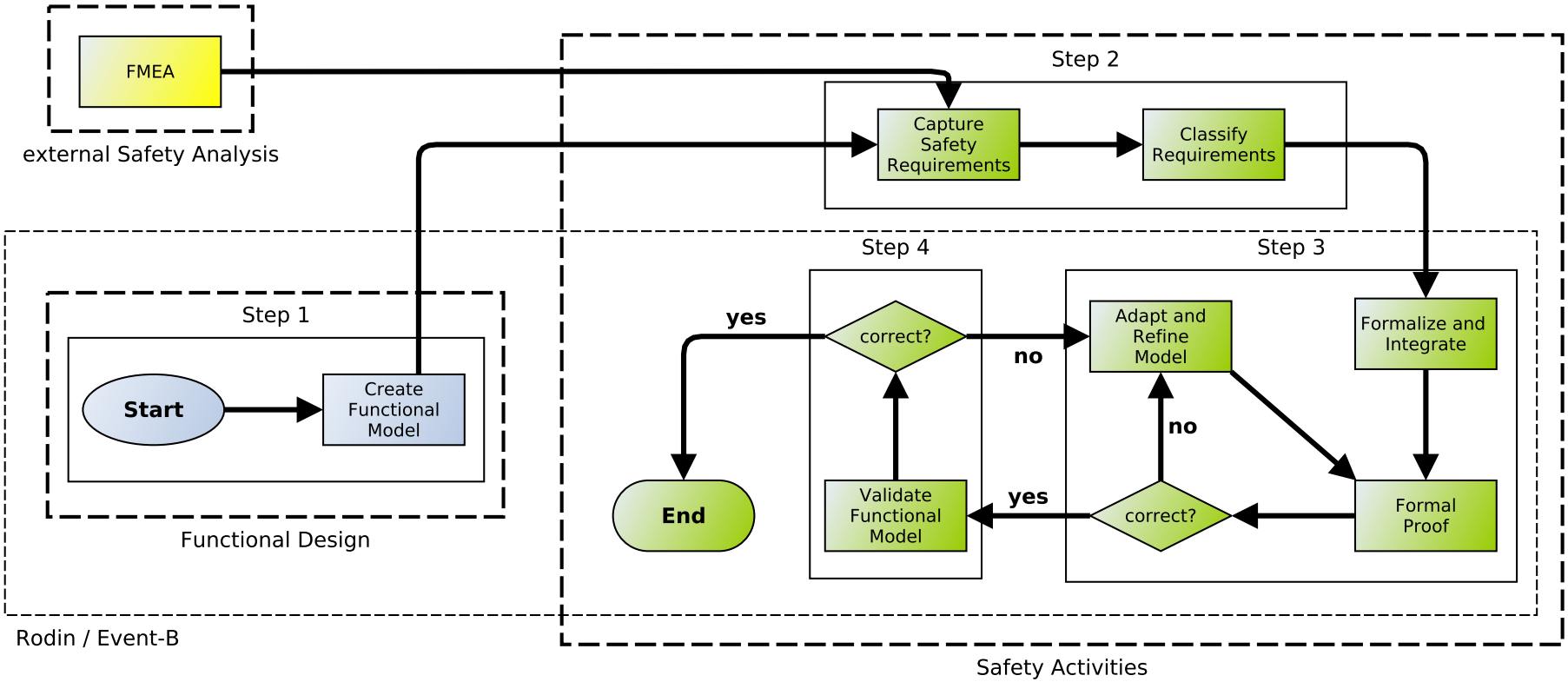
Safety Support with Event-B



Safety Requirements

Failure Modes and Effects Analysis (FMEA)

Hazard

"Exceeding the safe speed or distance as advised to ETCS."

- **REQ_FMEA_ID_005** If a communication with trackside equipment is active, set-up of safe radio connection with another trackside equipment mustn't beformed. Exception in case of handover with RBC.
- **REQ_FMEA_ID_007** Establishment of communication session shall be performed when no communication is active. Exception in case of handover with RBC.

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Integration into Model

- Machine 3
  - Establish additional connection only with RBC for hand-over
- Machine 6 - *Explicit hand-over RBC*
  - Refine set *establish_ER_connections* with one variable
  - Refine set *ER_connections* with two variables
  - Invariants to show size limitations and correct hand-over with RBC

Validation

- Establish communication with on-track equipment
- Establish hand-over with two RBCs
- Terminate and re-establish a communication session

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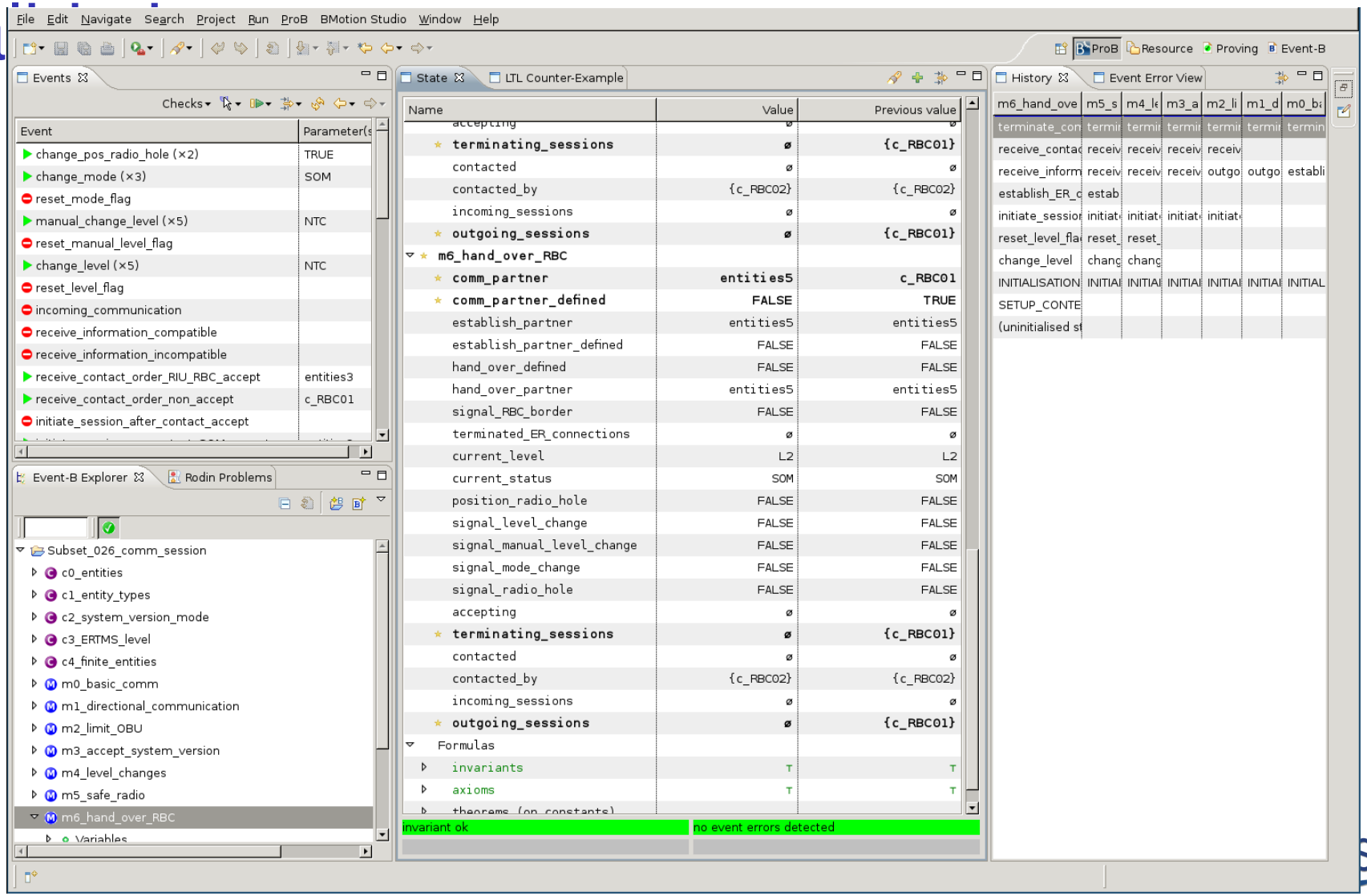
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Events
Checks
Event
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change_pos_radio_hole (×2)
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change_mode (×3)
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reset_mode_flag
manual_change_level (×5)
NTC
reset_manual_level_flag
change_level (×5)
NTC
reset_level_flag
incoming_communication
receive_information_compatible
receive_information_incompatible
receive_contact_order_RIU_RBC_accept
entities3
receive_contact_order_non_accept
c_RBC01
initiate_session_after_contact_accept
Event-B Explorer
Rodin Problems
Subset_026_comm_session
c0_entities
c1_entity_types
c2_system_version_mode
c3_ERTMS_level
c4_finite_entities
m0_basic_comm
m1_directional_communication
m2_limit_OBU
m3_accept_system_version
m4_level_changes
m5_safe_radio
m6_hand_over_RBC
Variables
State
LTL Counter-Example
Name
Value
Previous value
terminating_sessions
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{c_RBC01}
contacted
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{c_RBC02}
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establish_partner_defined
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hand_over_defined
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signal_RBC_border
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terminated_ER_connections
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History
Event Error View
m6_hand_ove
m5_s
m4_k
m3_a
m2_li
m1_d
m0_ba
terminate_con
receive_contac
receive_inform
establish_ER_c
initiate_sessio
reset_level_fla
change_level
INITIALISATION
SETUP_CONTE
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Contents

Conclusion

- Possibility to identify problems in the specification / requirements
- Provides strong link of the model to the specification
- Importance of Traceability of Requirements
- Possibility to validate the Intended Behavior (Functional and Risk Mitigation)

Questions

Collaboration / Diffs on models ?
Animation of decomposed models ?

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