RAILWAY USE CASE

INTERNATIONAL INDUSTRIAL SPRING SCHOOL 2024 - HUMAN-AI TEAMING - A HUMAN SYSTEMS INTEGRATION APPROACH

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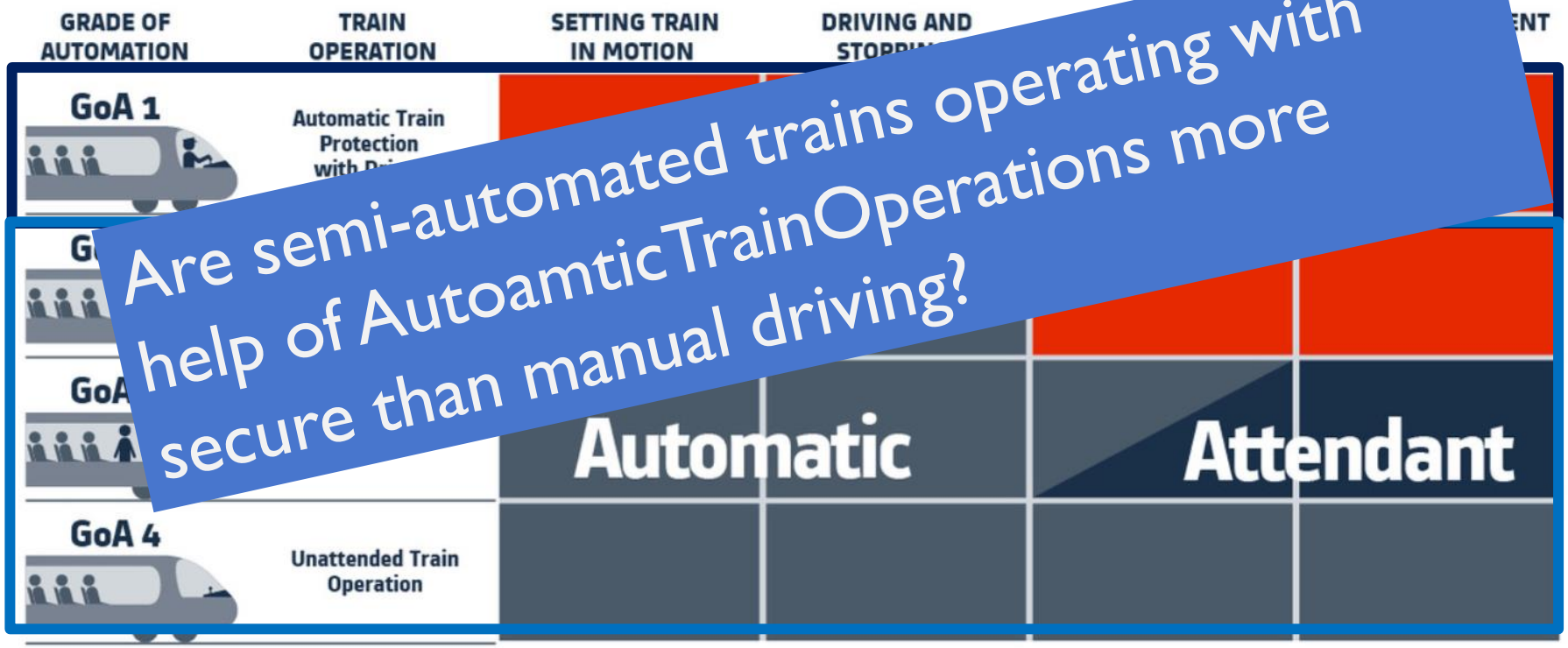
WORKSHOP 1

15:30-17:30: **USE-CASE SESSION 1 - PROBLEM STATING**

BACKGROUD IN RAILWAY: AUTONOMOUS TRAINS



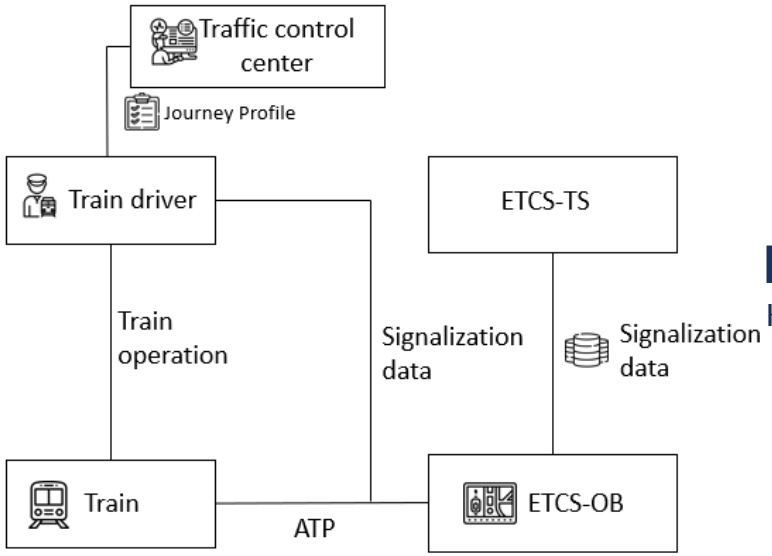
Are semi-automated trains operating with help of AutoamticTrainOperations more secure than manual driving?

EUROPEAN RAIL TRAFFIC MANAGEMENT SYSTEMS (ERTMS)/ AUTOMATED TRAIN OPERATION (ATO)

- **ETCS** (European Train Control System)
  - A signalisation system under surveillance of ATP(Automatic Train Protection)
  - To replace the different signalisation system in all EU contries
- **ATO** (Automated train operation) **over ETCS**
  - The autopilot respects the timtable assigned to it
  - ATO recieves information by Journey Profiles which include information about:
    - The theoretical route : where to go and the road profile (radiant; distance etc.)
    - The stations to serve
    - The particular restrictions (low adhesion zone, work in progress for the tail etc.)

AS-IS & TO-BE ANALYSIS

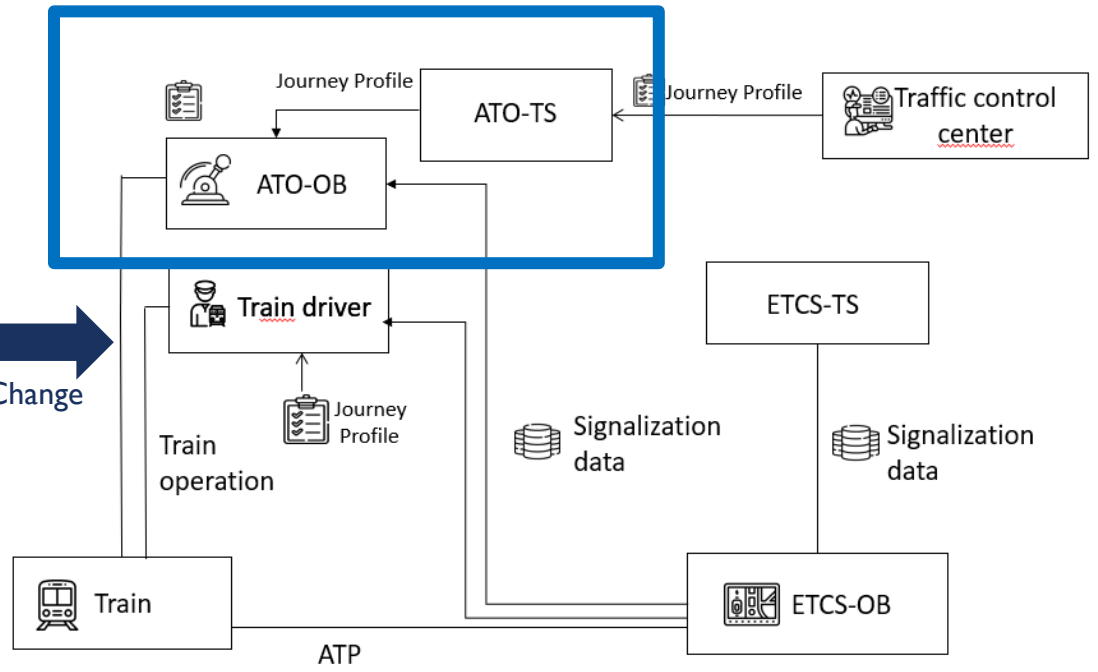
GoA1 Manual Driving



Gap

Key Factors for Change

GoA2 Semi-automated Driving



AS-IS & TO-BE ANALYSIS

Driver Machine Interface (DMI) in the cabin

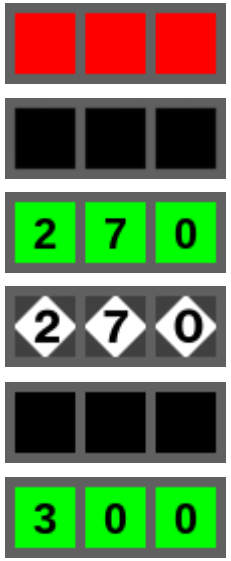
GoA1 Manual Driving

Driver Machine Interface (DMI) in the cabin

GoA2 Semi-automated driving

From the incident analysis results, the signalization system dysfunction is a safety-critical component to add to our simulation scenarios.

Trackside signals



TVM display in cabin

After discussion with train drivers, we identified two safety-critical components from experience: **obstacles on the rail** and **weather**

Obstacles on the rail

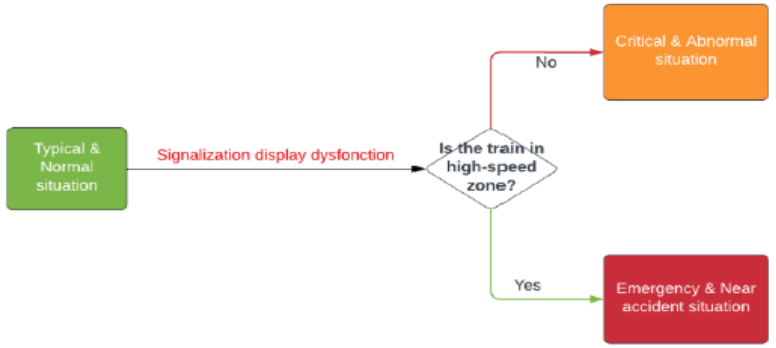
Bad weather

FROM INCIDENT ANALYSES TO SCENARIO CONSTRUCTION AND MODELING

Source: https://www.sncf.com/fr/groupe/coulisses/signalisation-ferroviaire; https://fr.wikipedia.org/wiki/Transmission_voie-machine

SCENARIO IN DIFFERENT SITUATIONS

- There are three types of situations the train driver can potentially encounter during a mission:
  1. **Normal or typical situation**: The mission goes as expected, and the train arrives at its destination smoothly.
  2. **Degraded or abnormal situation**: An unexpected event or technical system degradation occurs during the journey, but the situation can be managed and returned to normal by following procedures.
  3. **Emergency:** An unexpected event or technical system degradation occurs during the journey, with limited options to resolve the situation.



Take the example of signalization system dysfunction, on GoA1, before entering the high-speed zone, train driver can restart the signalization display in case of dysfunction. But during the high-speed driving, this becomes an emergency

EXEMPLE SCENARIOS

- Scenario I : Drive the train from Point A to Point B smoothly
- Scenario II: Signalization system out of order during the mission: the train driver has the possibility to restart the system manually
- Scenario III: Obstacle on the rail: the train driver needs to identify and decide the object type and respond accrodingly

WORKSHOP II

15:30-17:30: **USE-CASE SESSION 2 - PROBLEM SOLVING - FOLLOWING UP ON CHOSEN USE CASES**

SNCF INCIDENT ANALYSES

- SNCF OPEN DATA

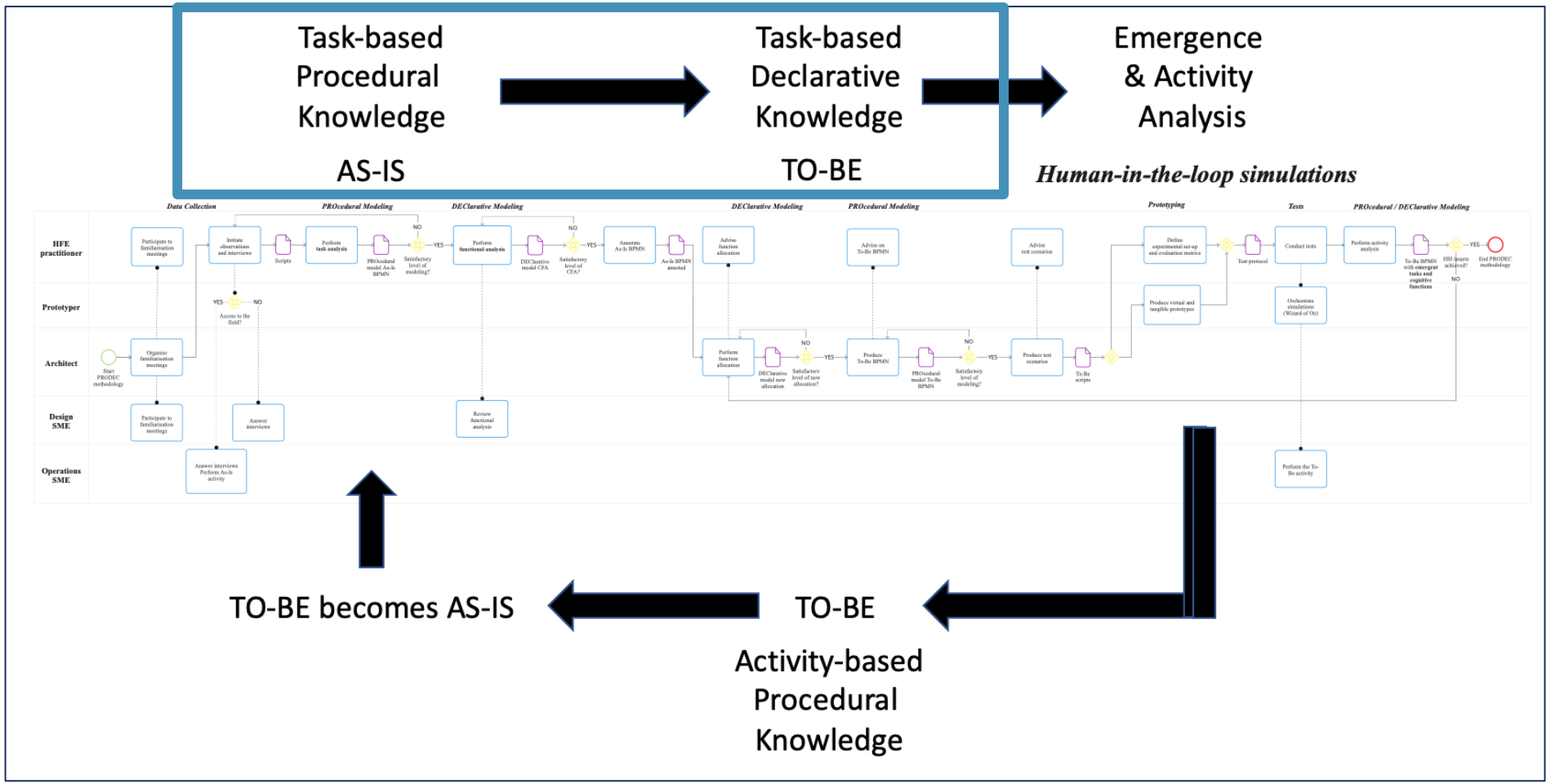
https://ressources.data.sncf.com/explore/dataset/incidents-securite/table/?sort=-niveau_gravite

	Numéro	Origine	Numéro ISIC	Type d'event	Date	Région	Lieu	Niveau de Gravité	Nature
1		Réseau		Incident grave de signalisation	20 janvier 2022	PACA	Beaulieu-sur-Mer (06)	4,0	Incident grave de signalisation entr...
2		Réseau		MISISN	20 janvier 2022	CVL	Joué les tours (37)	4,0	Refoulement d'un train travaux (GI ...
3		Cause Tiers Voyageur		Déraillement	24 février 2022	GE	Hochfelden (67)	6,0	Un train de Voyageurs heurte un ca...
4		Réseau		Défaillance voie	3 mars 2022	NAQ	Entre Silandes et Laluque (40)	3,0	Erreur de surclassement de défauts...
5		Réseau		Déraillement	9 mars 2022	HDF	Desvres (62)	3,0	Déraillement d'un train SNCF Fret ...
6		Réseau		Collision contre obst à un pass...	15 mars 2022	NAQ	St denis du pain (17)	4,0	Franchissement d'un passage à niv...
7		Voyageur		Dépassement sse limite d...	9 juin 2022	HDF	Entre Maurois et Cambrai (59)	4,0	Un conducteur respecte une LTV 6...
8		Réseau		Expédition d' train sans ordre éc...	9 juin 2022	GE	Thionville (57)	4,0	Franchissement sans restriction par...
9		Réseau		Incident g de signalisation I	15 juin 2022	HDF	Laon (02)	4,0	Détection de la suppression d'un e...
10		Voyageur		Dépa nt de la vitesse limite d...	24 juin 2022	NAQ	entre St-Léon-sur-l'Isle- et Neuvic (24)	4,0	Non-respect d'un ordre DERA avec...
11		Réseau		Expédition d'un train sans ordre éc...	28 juin 2022	PACA	Le Thor (84)	4,0	Expédition d'un train de l'EF SNCF...
12		Voyageur		AUTRE	1 juillet 2022	NAQ	Brive	4,0	Service Terminé transmis sans assur...
13		Voyageur		Défaut d'Immobilisation	9 juillet 2022	IDF	Paris Nord	3,0	Dérive à faible vitesse sur distance ...
14		Réseau		Défaillance voie	12 juillet 2022	IDF	Savigny sur orge (91)	4,0	Déformation de la voie principale, ...
15		Réseau		Expédition d'un train sans ordre éc...	11 août 2022	PN	Montigny Beauchamp (93)	4,0	Un AC (Agent Circulation) constate...
16		Réseau		Défaillance voie	30 août 2022	GE	Strasbourg	4,0	Découverte de défauts de géométr...

Event Type

Severity

POSITIONNEMENT OF THIS WORK IN PRODEC



Source: Guy A. BOY - The Role of People in Large Interconnected Systems (2022)

SNCF INCIDENT ANALYSES

The 10 **most frequent** incidents types in the French railway network 2015-2022.

Incident Type	Occurrence
Inadvertent crossing of a closed signal	174
Track failure	157
Exceeding speed limit (> 40 km/h)	132
Serious signaling incident	119
Dispatch without a written speed restriction order	116
Crosses level crossing with open gates	81
Open doors in passenger trains operations	78
Derailment	75
Fire on board a train	64
Damaged earthwork	57

The 10 **highest severity** incidents types in the French railway network 2015-2022.

Incident	Severity
Accident to person	4.89
Collision against end-of-track bumper	4.6
Collision between 2 trains rear-end	4.5
Collision against an obstacle at a level crossing	4.09
Authorization to pass a closed signal	4.0
Breakage of a piece of rolling stock	4.0
Collision against end-of-track bumper	4.0
Collision with parked or drifting vehicle	4.0
Damaged earthwork	4.0
Insufficient train brake power	4.0

Source: Sun, Yang, Marc Sango, Anne Barros, and Guy André Boy. 2023. “Preliminary Safety-Critical Scenario Analysis of Semi-Automated Train Operation.” 2023

RAILWAY ACCIDENT EXEMPLE

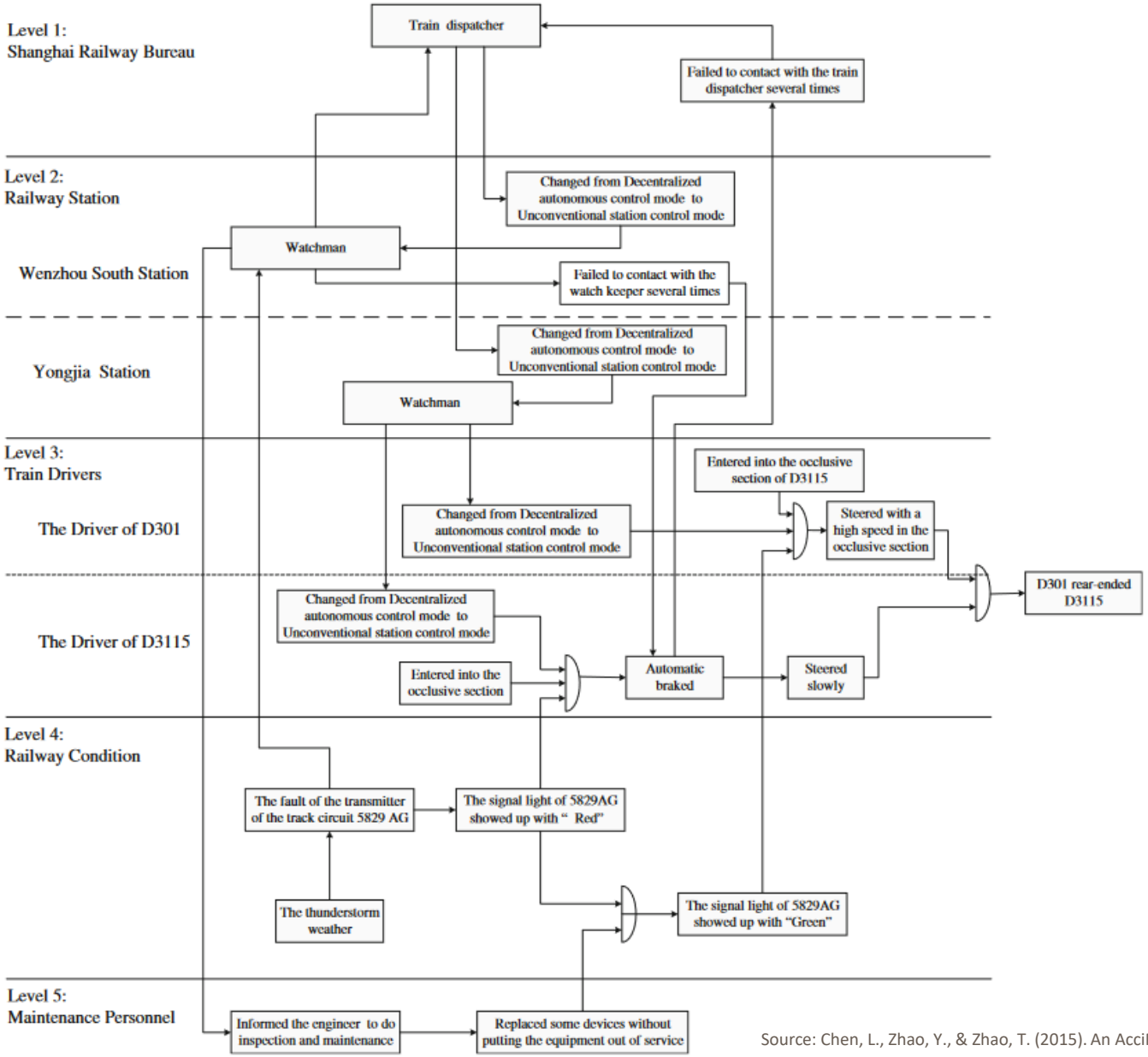
Accident	Country	Year	Fatalities/Injuries
Ladbroke Grove accident	UK	1999	31/400

A Turbo train that departed from Paddington failed to stop at a red signal and collided with a high-speed train (HST) approaching the station from the opposite direction on the same line.
The collision followed by derailment and fires.
The immediate "human error" that preceded this crash was a Signal Passed At Danger (SPAD).

RAILWAY ACCIDENT EXEMPLE

Accident	Country	Year	Fatalities/Injuries
Yong-Wen collision	China	2011	40/172

At a speed of 99 km/h, the China Railway Highspeed (CRH) train D301 rear-ended another CRH train, D3115. As a result of this collision, six cars derailed and two went off the bridge.
The signalling and train control system used on the accident line was the Chinese Train Control System (CTCS). Train D3115 was commanded to leave Yongjia station and was notified that the train may brake due to the ATP system in the flawed section of track and, once this occurs, the train must be restarted and continue to travel.
As expected, the train automatically stopped, but the train operator failed to restart the train. The train operator contacted the dispatcher and station operator and was called by them several times; however, all calls were lost. During this period, train D301 departed from Yongjia station as normal. Due to the track circuit breakdown, D301 neither received information about D3115 nor stopped automatically and the two trains then collided.



AcciMap of Yongwen railway accident

Source: Chen, L., Zhao, Y., & Zhao, T. (2015). An AcciMap analysis on the China-Yongwen railway accident. Lecture Notes in Mechanical Engineering, 19, 1247–1253.

WORKSHOP III

10:15-12:15: **USE-CASE SESSION 3 - EVALUATION AND VALIDATION**

MERCI

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