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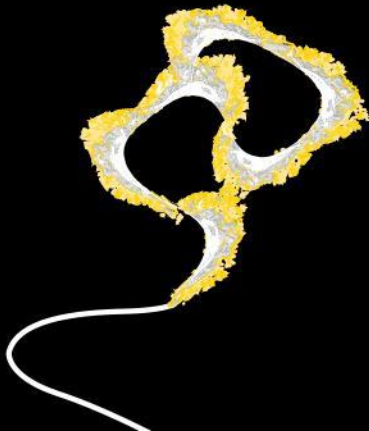
# Safety of autonomous trains

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# Contents

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- What is the system?
- To what safety level?
- What are the hazards?
- How to control them?

# What is the system?

## Grade of Automation

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- GoA0 - Manual
- GoA1 - Manual with ATP
- GoA2 - Semi-ATO + full ATP
- GoA3 - Driverless, full ATO + full ATP
- GoA4 - Unattended, full ATO + full ATP



# What is the system?

## Grade of Automation

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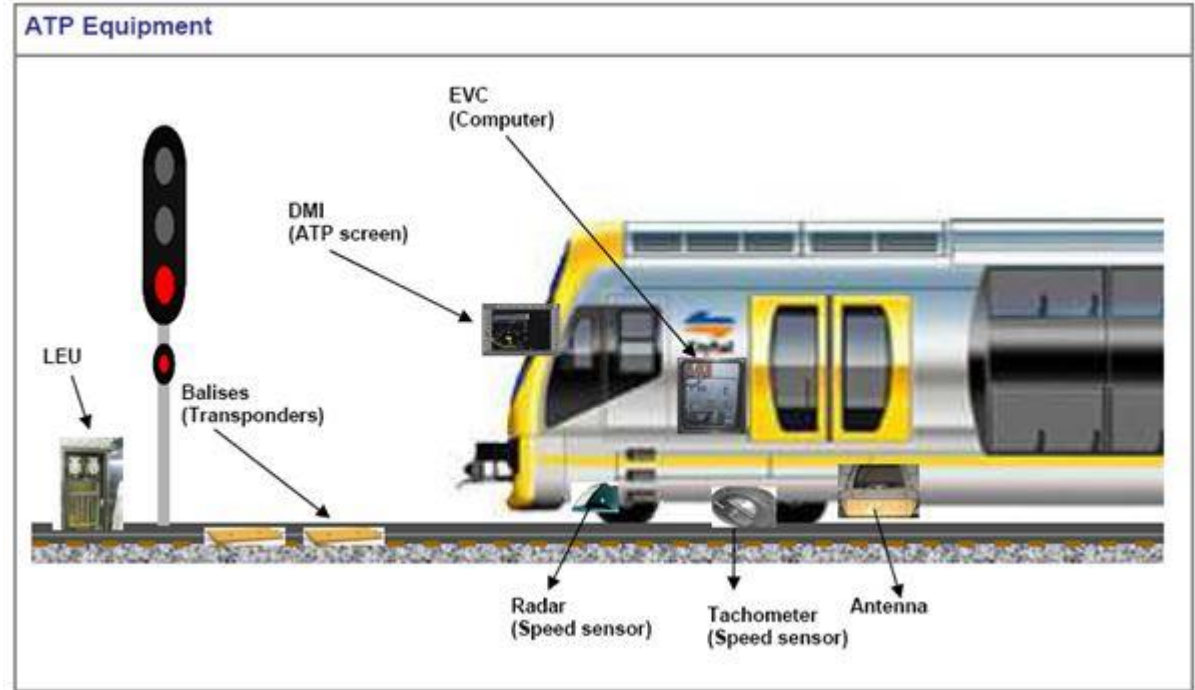
- GoA0 - Manual
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Disadvantage: separated infra and transport

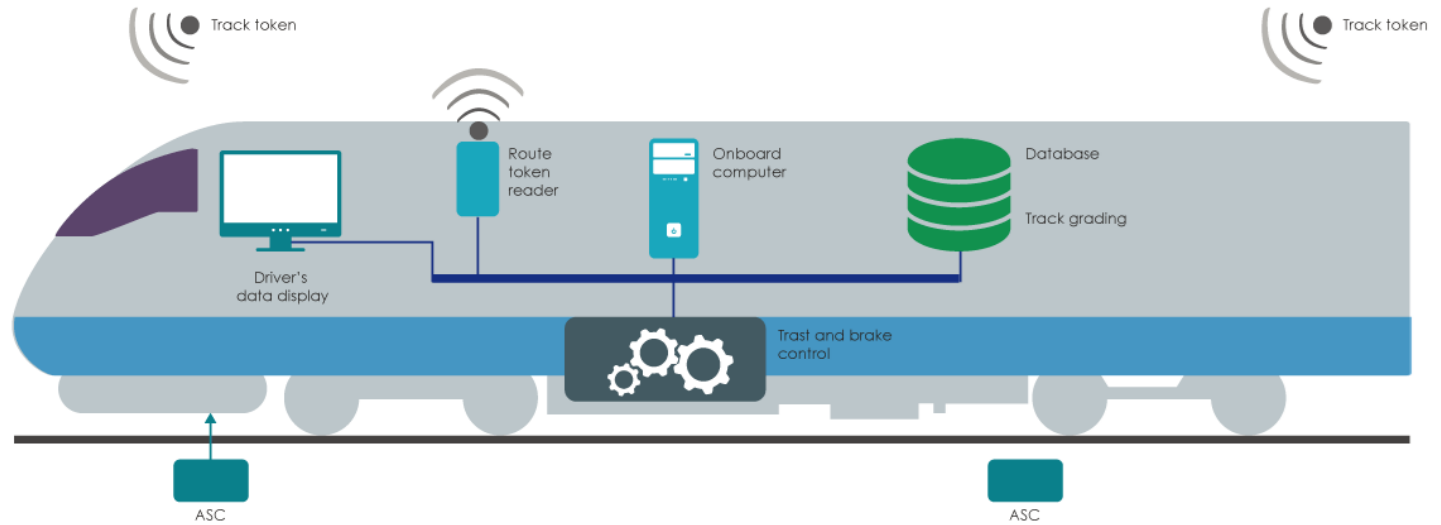


# ATP

- ECTS
- ERTMS



# ATO





# Safety Regulations

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Different types of safety regulations:

- Type A - Basic safety standards: basic concepts, principles for design and general aspects.
  - Example: ISO 12100 - design standards for all machinery
- Type B - Generic safety standards: one safety aspect
  - Example: NTA 9065:2012 - air quality
- Type C - Machine safety standards: detailed requirements



# Safety Regulations

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## ISO12100

- **Type A - Basic safety standards: basic concepts, principles for design and general aspects**
- Type B - Generic safety standards: individual safety aspect
- Type C - Machine safety standards: detailed requirements

System safety level: Catastrophic



# Incident: Driverless Train in Yokohama

- June 1, 2019
- GoA3 train
- Dozen of people injured
- Cause of Accident:  
Signal controlling  
direction by ATO devices  
on train



Demo of Autonomous Train moving backwards



# Identified Hazards

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- Failure of Onboard systems
- Failure of ATP system due to weak signal strength
- Absence of barriers in the road crossings
- No proper warning signals at the level crossing
- Lack of warning signs for poor visibility on the track due to bad weather conditions like fog
- Lack of luminescent warning signs during night



# Identified Hazards

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# Control of Hazard

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1. Redesign
2. Safety devices
3. Warning devices
4. Special procedures + training





# What to control?

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- Desired: low or medium risk
- Reliability
- Cost-benefit

Example:

*Failure of onboard systems like ATO*

- Backup
- Double check system

# Safety Culture

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- Unpredictable human interaction
- Training
- Desired safety culture level: Optimized
  - Constant monitoring of safety standards and active support from managers is achieved.

**ALL** Staffed trains  
**aboard!** are  
safe trains



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# Questions?

