Monorailex 2021
An Overview of Norms and Standards for Monorail Systems

2021-09-25 / 2021-09-27

TÜVRheinland®
Genau. Richtig.

Content

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Content

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Introduction

An Overview of Norms and Standards for Monorail Systems

Current status of standardization in monorails:

- Monorail systems are experiencing a relevant market trend
- No monorail specific international standards or norms are available
- Lack of a dedicated standardization is a limit to acceptance and diffusion of monorail systems
- Lack of standardization has impact can result in an inconsistent or incomplete normative framework
- Inconsistent and incomplete normative framework might negatively effect system acceptance

TÜVRheinland®
Genau. Richtig.

Introduction

An Overview of Norms and Standards for Monorail Systems

Content of the paper:

- Analysis of relevant railway, urban transport and people mover standards that could be used in monorail projects
- The standards are analyzed in regards of their applicability to the monorail systems and not in their detailed technical content.
- Focus on:
  - Safety
  - Overall system integration
  - Automatic Train Control
  - Rolling Stock
- Exclusions:
  - Guidance beam
  - Civil works

TÜVRheinland®
Genau. Richtig.

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Safety Standards

An Overview of Norms and Standards for Monorail Systems

Analyzed standards

- EN 50126
- EN 50128 and EN 50129
- EN 50657
- IEC / EN 62267

TÜVRheinland®
Genau. Richtig.

Safety Standards - EN 50126

An Overview of Norms and Standards for Monorail Systems

EN 50126-1 / -2, 2017

Railway Applications – The Specification and Demonstration of Re-liability, Availability, Maintainability and Safety (RAMS) – Part 1: Generic RAMS Process and Part 2: Systems Approach to Safety

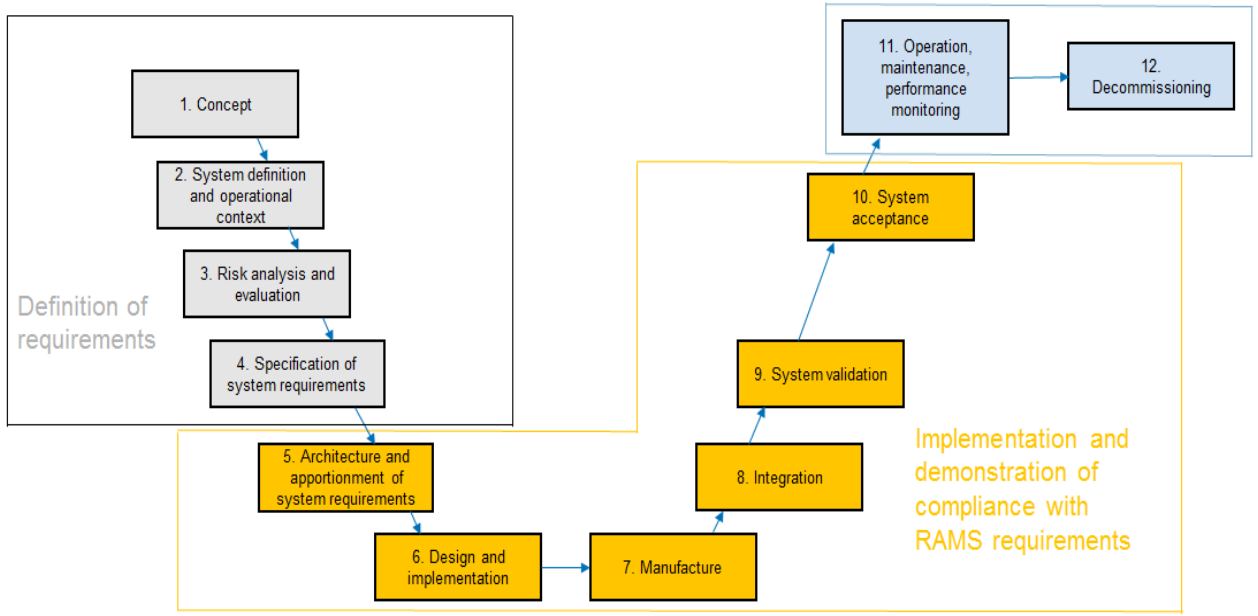
- It is a European Standard, widely accepted worldwide
- In detail EN 50126-1 provides a safety management process, supported by guidance and methods described in EN 50126-2.

TÜVRheinland®
Genau. Richtig.

Safety Standards - EN 50126

An Overview of Norms and Standards for Monorail Systems

The standard provides a methodological approach to RAMS management, having as pillar the lifecycle model (so-called “V-model”):

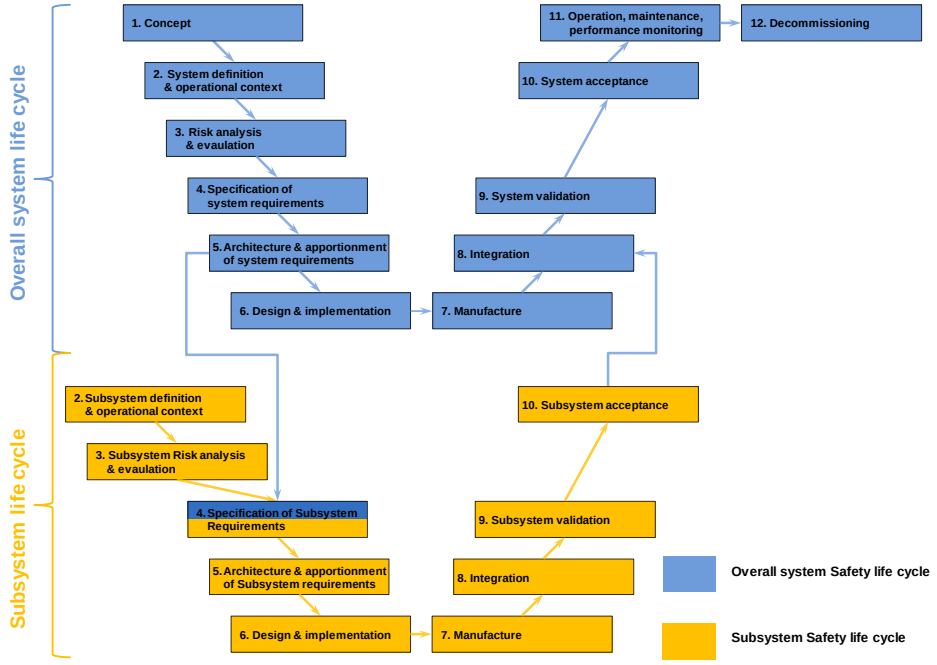


TÜVRheinland®
Genau. Richtig.

Safety Standards - EN 50126

An Overview of Norms and Standards for Monorail Systems

The EN 50126-1/-2 constitutes also the tool, by which technical standards can be defined as requirements for the technical safety of a system / subsystem / equipment or component involved in a safety function.



TÜVRheinland®
Genau. Richtig.

Safety Standards - EN 50126

An Overview of Norms and Standards for Monorail Systems

- The methodological approach to RAMS adopted by the EN 50126-1/-2 lifecycle approach makes this standard virtually applicable to all type of urban guided transport system and related subsystems.

- Applicability to monorail based urban guided transport systems and related subsystems is therefore given without limitations.

TÜVRheinland®
Genau. Richtig.

Safety Standards - EN 50128 / EN50129 / EN50657

An Overview of Norms and Standards for Monorail Systems

- The standards EN 50128 / EN50129 / EN50657 are to be read in conjunction with the EN 50126:

EN 50128:2011, Railway applications - Communication, signalling and processing systems - Software for railway control and protection systems

EN 50129:2018, Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling

EN 50657:2017, Railways Applications - Rolling stock applications - Software on Board Rolling Stock

- As per their scope, the standards do not define a limited applicability to a certain guiding technology

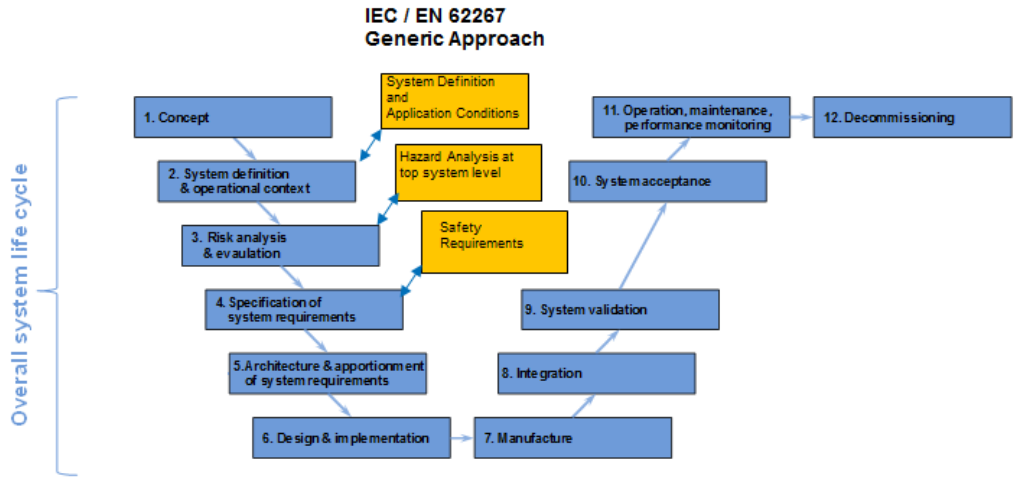
- The applicability of both standards to monorail projects is therefore possible without restrictions

TÜVRheinland®
Genau. Richtig.

Safety Standards - IEC / EN 62267

An Overview of Norms and Standards for Monorail Systems

- The IEC / EN 62267 provides requirements to safety for automated urban guided transport, focused on the functions that are automated and no more conducted by the train driver
- Guidance / requirements for risk analysis and subsequent phases
- Project specific approach → no restriction in applicability



TÜVRheinland®
Genau. Richtig.

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Overall system standards

An Overview of Norms and Standards for Monorail Systems

ASCE 21-13

- Automated People Mover Standard widely used worldwide, also recommended by the International Monorail Association.
- Several monorail projects around the world have adopted ASCE 21-13 as overall design guidance and standard reference.
- The standard can therefore be adopted as overall reference for system integration.
- A project specific detailed analysis of the applicability should however always be conducted.

TÜVRheinland®
Genau. Richtig.

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Automatic Train Control standards

An Overview of Norms and Standards for Monorail Systems

IEC / EN 62290

Railway applications - Urban guided transport management and command/control systems

- The standard is covering all kind of urban guided transport systems, and has found application in a number of monorail projects.
- The management, command and control systems of urban guided transport systems are defined by the standard as Urban Guided Transport Management and Command/Control Systems (UGTMS).
- The standard defines basic functions that shall be conducted by the UGTMS (refer e.g. section 6.2.2).
- The identified functions are applicable also to monorail systems.

TÜVRheinland®
Genau. Richtig.

Automatic Train Control standards

An Overview of Norms and Standards for Monorail Systems

IEEE 1474

The standard IEEE 1474 is a US standard standard for Communications-Based Train Control (CBTC) .

- IEEE1474 is referred by the ASCE 21-13 as the applicable standard for CBTC to Automated People Mover systems.

The standard provides:

- An overview of relevant system parameters / reference quantitative performances for CBTC systems that are also applicable to monorail systems.
- Overall functional safety requirements on the CBTC systems, also applicable to monorail systems.
- A typical safe braking model, applicable also to rubber based systems as monorails.

TÜVRheinland®
Genau. Richtig.

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

Rolling stock standards

An Overview of Norms and Standards for Monorail Systems

Covered rolling stock areas:

- Different bogie design, no rigid rail/wheel contact, different weight distribution (aprons vs undercarriage/roof located equipment), carbody dimensions can be defined as the major differencies between conventional and monorail rolling stock
- Standards for brake, bogie and carbody are therefore analyzed.
- Further monorail rolling stock subsystems can virtually be identical to the respective ones adopted e.g. in tramways or metros. Their related specific standards are therefore not analyzed in this paper.
- Also environmental requirements are analyzed

TÜVRheinland®
Genau. Richtig.

Rolling stock standards - brakes

An Overview of Norms and Standards for Monorail Systems

EN 13452

EN 13452-1:2003, Railway applications — Braking — Mass transit brake systems — Part 1: Performance requirements and Part 2: Methods of test

- The standard applies among other to vehicles operating metros on rubber tyred wheels. Straddled type monorails only might be included in this category.
- Suspended monorails are explicitly excluded by the standard
- The standard can be fully applied also to brake systems for monorail vehicles.
- The choice of operational conditions should however be analyzed if representative of the monorail project in object.

TÜVRheinland®
Genau. Richtig.

Rolling stock standards - bogies

An Overview of Norms and Standards for Monorail Systems

EN 15827 – EN 13749

EN 15827:2011, Railway applications - Requirements for bogies and running gears

EN 13749:2011, Railway applications — Wheelsets and bogies — Methods of specifying structural requirements of bogie frames

Major design differences between monorail and traditional rolling stock bogies:

- Asymmetrical design
- No wheelsets, but cantilevered independent wheels on axle shafts (traction/support wheels)
- Vertical arms for guiding wheels stressing the bogie frame

TÜVRheinland®
Genau. Richtig.

Rolling stock standards - bogies

An Overview of Norms and Standards for Monorail Systems

EN 15827 – EN 13749

- The approach and methodology proposed by the standards is partially compatible with a monorail bogie, e.g. in the definition of the load cases and fatigue cycles.

- Adoption of the EN 15827 and EN 13749 as normative framework for monorail bogie design might therefore be approached, after a due analysis of applicability and necessary adaptation

TÜVRheinland®
Genau. Richtig.

Rolling stock standards - carbody

An Overview of Norms and Standards for Monorail Systems

Requirements for carbody strength and crash worthiness are defined in ASCE 21-13, EN 12663 – EN 15227

Overall applicability of ASCE 21-13 has already been analyzed

Focus on EN 12663 – EN 15227

EN 12663-1:2010+A1:2014, Railway applications – Structural requirements of railway vehicle bodies – Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons)

EN 15227:2020, Railway applications – Crashworthiness requirements for rail vehicles.

TÜVRheinland®
Genau. Richtig.

Rolling stock standards - carbody

An Overview of Norms and Standards for Monorail Systems

EN 12663 – EN 15227

- EN 15663 generically states its applicability to rail vehicles. The standard is of generic nature so application to monorail-type rolling stock is not to be excluded in advance.
- Monorails might be included in category C-II of EN 15227, so vehicles design for operating exclusively in a segregated network, without level crossing and interfaces with other means of transport.
- However, system specific collision scenarios shall be specified, that are due to the peculiarity of the system. This could be e.g. collision with a service vehicle or with obstacle on the guideway.
- The standards EN 15663 and EN 15227 might therefore be adopted for a monorail project after a due analysis of applicability and necessary adaptatiomn.

TÜVRheinland®
Genau. Richtig.

Rolling stock standards – environmental standards

An Overview of Norms and Standards for Monorail Systems

EN 50125 / EN 50121 / EN 50155 / EN 61373

EN 50125-1:2014, Railway applications — Environmental conditions for equipment Part 1: Equipment on board rolling stock

EN 50121:2017, Parts -1 to -5, Railway applications. Electromagnetic compatibility

EN 50155:2017, Railway applications - Rolling stock - Electronic equipment

EN 61373:2010, Railway applications - Rolling stock equipment - Shock and vibration tests

- The standards provide guidelines related to environmental factors such as e.g. altitude, temperature, humidity, rain, snow and hail, ice, solar radiation and resistance to pollution, dust, and electro-magnetic influences, as well as resistance to shock and vibrations.
- They are widely adopted in international urban guided transport projects and due to their generic approach can be fully applied in monorail vehicles

TÜVRheinland®
Genau. Richtig.

An Overview of Norms and Standards for Monorail Systems

1. Introduction
2. Safety standards
3. Overall system standards
4. Automatic Train Control standards
5. Rolling stock standards
6. Conclusions

TÜVRheinland®
Genau. Richtig.

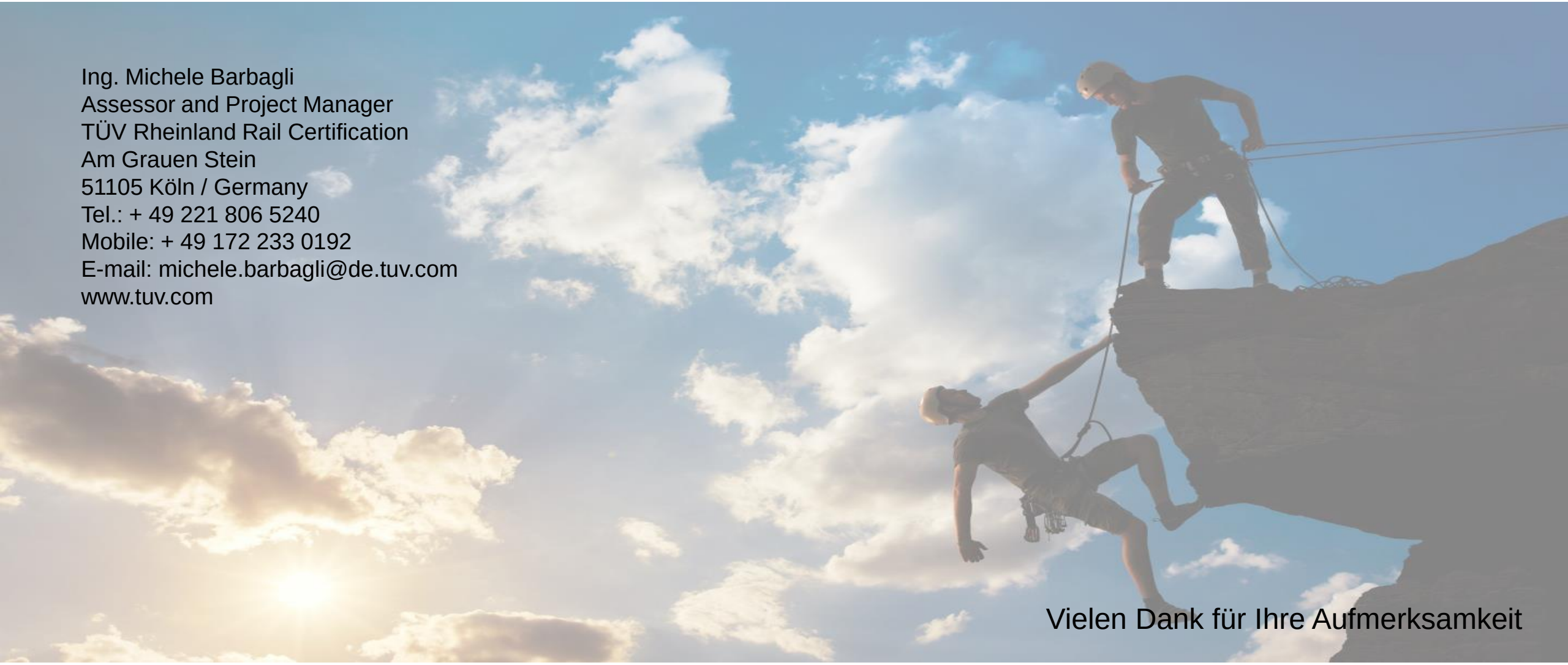
Conclusions

An Overview of Norms and Standards for Monorail Systems

- **Incomplete and inconsistent normative framework** negatively impacts system acceptance
- **Existing railway and urban transport standards** can be successfully applied to monorail projects and constitute a generic but consistent and complete normative framework.
- The **publication of a monorail specific guideline could be envisaged** by the interested actors in the future and would help formally defining a consistent and complete normative framework

TÜVRheinland®
Genau. Richtig.

Ing. Michele Barbagli
Assessor and Project Manager
TÜV Rheinland Rail Certification
Am Grauen Stein
51105 Köln / Germany
Tel.: + 49 221 806 5240
Mobile: + 49 172 233 0192
E-mail: michele.barbagli@de.tuv.com
www.tuv.com



Vielen Dank für Ihre Aufmerksamkeit

TÜVRheinland®
Genau. Richtig.