

Overview activities PIARC TC 4.4 “Tunnels” (cycle 2019-2023)

Ronald Mante

Chair of Working Group 2 “Safety and Resilience”

Webinar PIARC library on road tunnel operations,

Kennisplatform Tunnelveiligheid, February 23, 2022

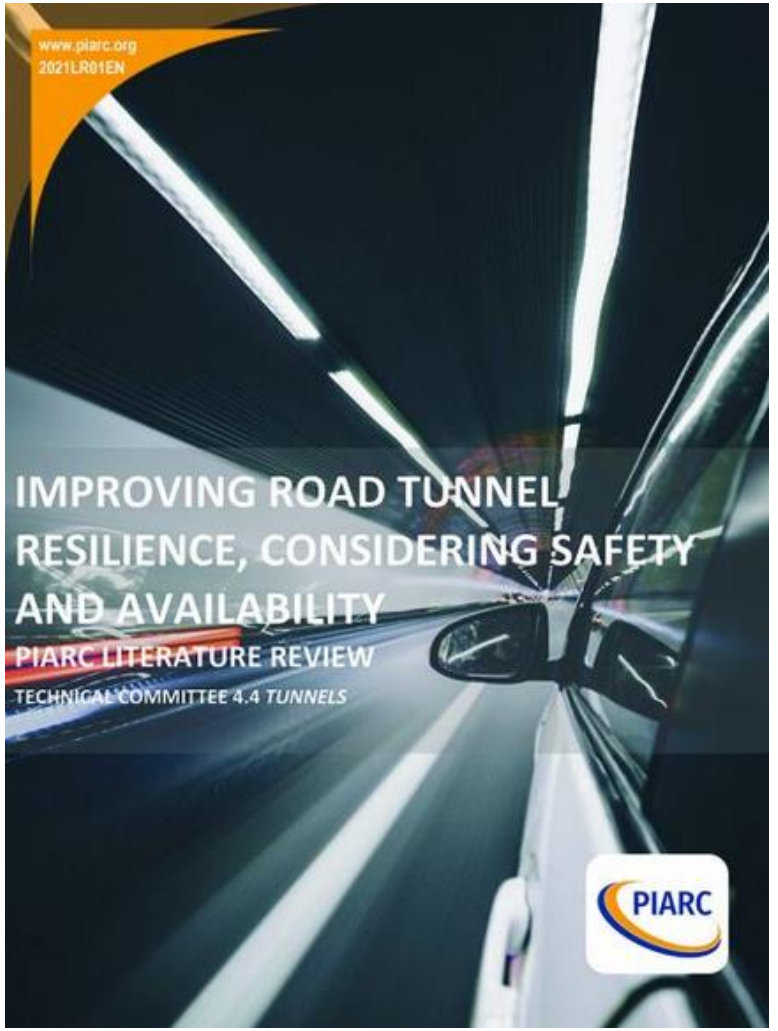
TC 4.4 Tunnels

- 150 members
- 37 Countries around the world represented
- Work is organized in TC meetings and 7 working groups and task forces

Activities in the current work cycle 2020 - 2023

1. Measures for increasing resilience of tunnels
(WG2, chair Ronald Mante, co-chair Bernhard Kohl)

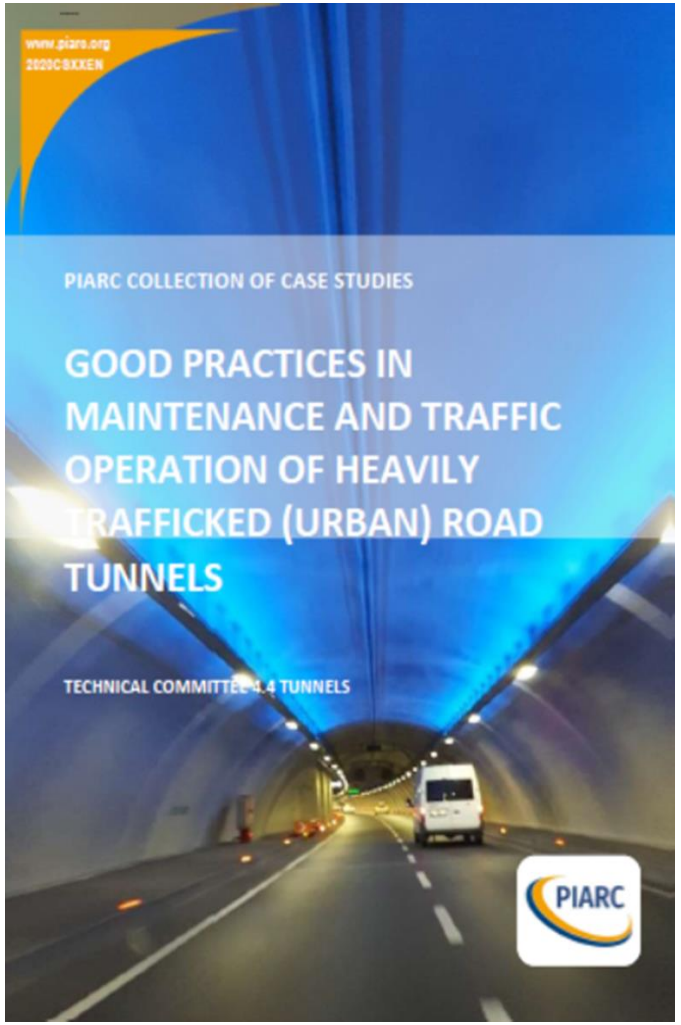
- Literature Review Report (2021, published)
  - More details on content later on
- Briefing note with case studies (2022)
- Full Technical report (2023)



Activities in the current work cycle 2020 - 2023

2. Best practices in management in urban and heavily trafficked tunnels (WG1, chair Arthur Kabuya, co-chair Urs Welte)

- **Case Studies (2022)**
  - Implementation of the "quick responders" concept with different approaches,
  - Measures to organize work and to reduce nuisance to users during the renovation of tunnels,
  - New tools for maintenance and operation.
- **Full Technical Report (2022)**
  - Recommendations on traffic, operation, maintenance, equipment, refurbishment strategies



Activities in the current work cycle 2020 - 2023

3. Impact of new propulsion technologies on road tunnel operations and safety (WG4, chair Peter Sturm, co-chair Martin Kelly)

- **Joint Workshop PIARC, ITA COSUF & KPT: Webinar 20./21. October 2021**,
  - successful event with more than 200 participants,
  - report & presentations available www.ita-cosuf.org
- **Collection of Case Studies Report (2022)**:
  - results of recent research projects and
  - some limited information about accidents and fires in road tunnels involving NEC vehicles.
- **Full Technical Report (2023)**

Activities in the current work cycle 2020 - 2023

4. Intelligent Transportation Systems in tunnels (WG3, chair Henric Modig, co-chair Gary Clark)

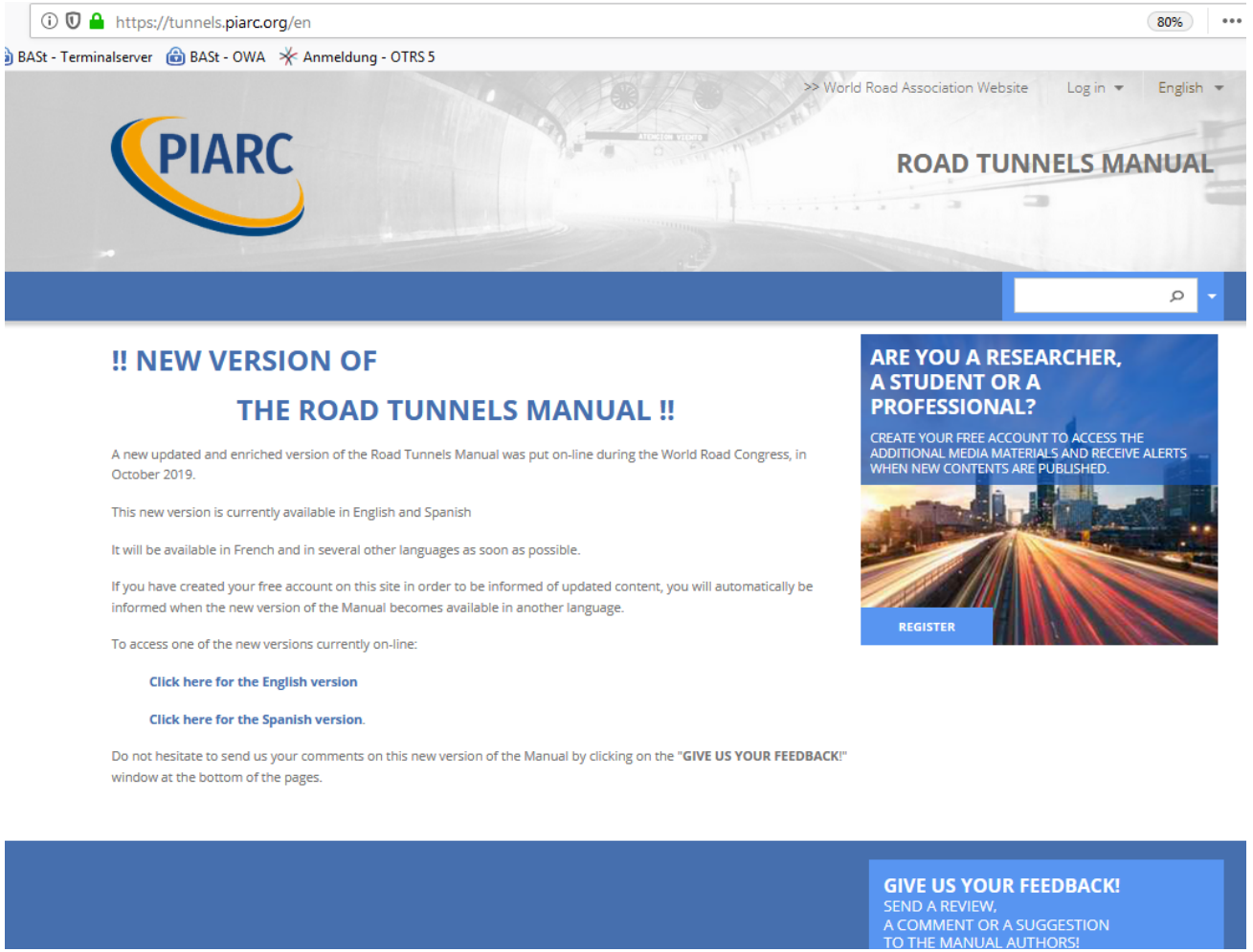
- **Full Technical Report (2022)**
  - Identification of technological advances in ITS and their impact on road tunnel operation and user safety
  - Highlight of the main expectations of the tunnel community regarding these systems
  - Current topics: Platooning, GPS pilot in Stockholm Southern link, UN regulation No. 157 for ALKS (automated lane keeping systems) – SAE Level 3

Activities in the current work cycle 2020 - 2023

5. Update of the Tunnels Manual

- Ongoing revision of the Road Tunnels Manual:
  NEW version available (English and Spanish, French to be added soon)
- New pages on civil works in preparation
- Recent content will be added (e.g. hyperlinks to new reports)

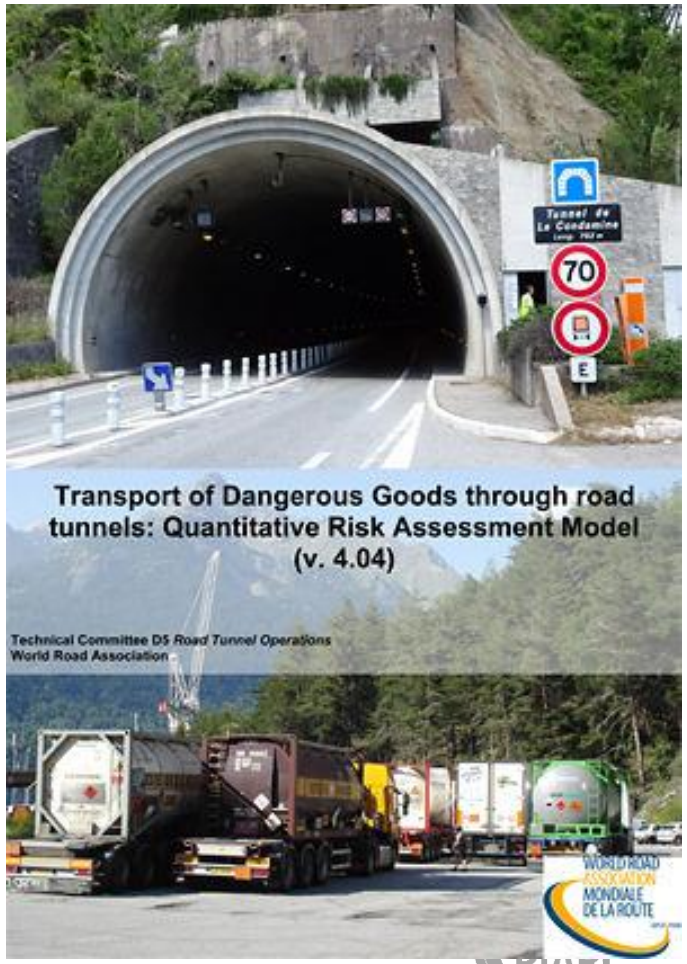
https://tunnels.piarc.org/en



Activities in the current work cycle 2020 - 2023

6. Support for updating and improving of DG-QRAM Software

- Update phase 2 of the software is in progress
- New Software Version: DG-QRAM license V 4.04 (phase 1) could be ordered at PIARC (www.piarc.org). Discount if you are already a user of the software
- Video and presentations from the QRAM webinar available at www.piarc.org



Conferences (2020 – 2023)

- World Winter Service and Road Resilience Congress
  8-11 February 2022 – Online

- 2nd PIARC International Conference on Road Tunnel Operations and Safety,
  25-28 October 2022 – Granada (Spain)
  (https://www.piarc-tunnels-spain2022.org/)

- 27th World Road Congress
  2-6 October 2023, Prague (Czech Republic)



Improving Road Tunnel Resilience, Considering Safety & Availability – PIARC Literature Review

Ronald Mante

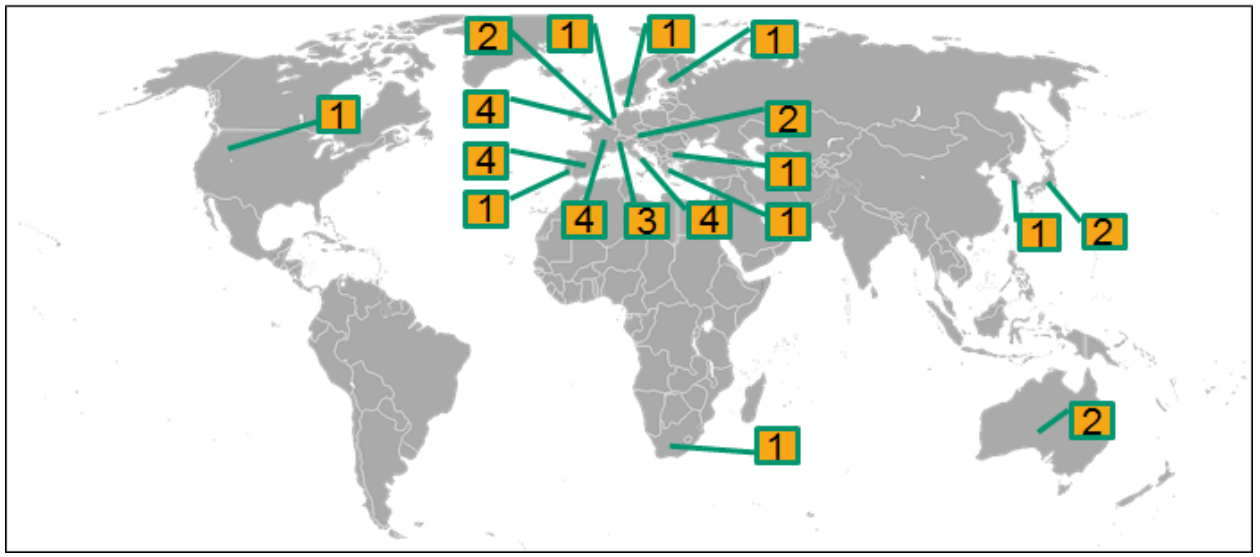
Chair of Working Group 2 “Safety and Resilience”

Webinar PIARC library on road tunnel operations, Kennisplatform Tunnelveiligheid, February 23, 2022

Introduction PIARC TC 4.4 Working Group 2

- 38 members / participants from 18 countries
- Leader: Ronald Mante (The Netherlands)
- Co-Leader: Bernhard Kohl (Austria)

Group picture, taken during meeting in Vienna (Austria), October 14, 2021

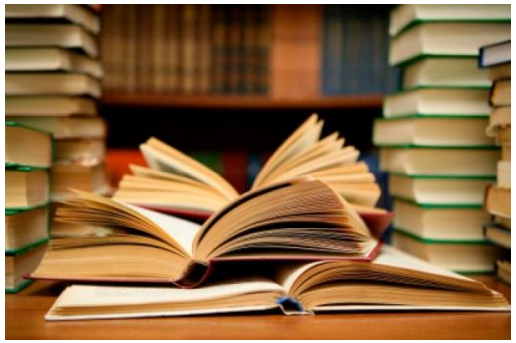


Number of members per country

PIARC cycle 2019-2023

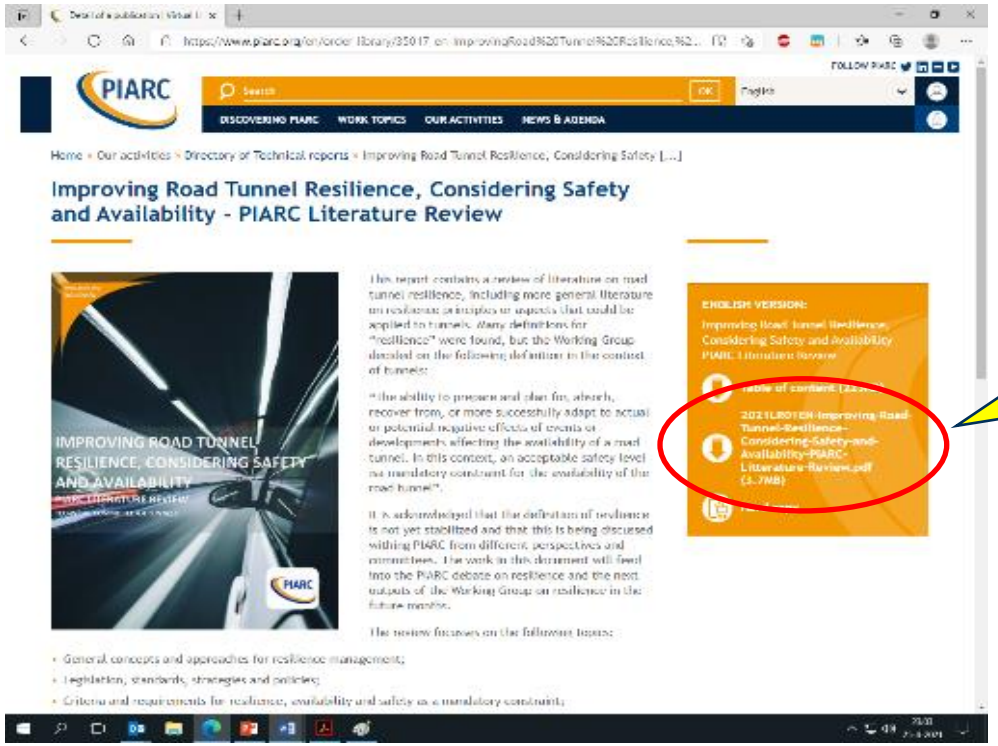
- Focus of TC 4.4 Working Group 2 is a study on measures for increasing resilience of road tunnels
- First step was a review of existing literature on methods and measures
- More than 100 literature sources were reviewed and the results were synthesized in the report:

"Improving road tunnel resilience, considering safety and availability, PIARC literature review"



Publication literature review report

- The report was **published** on the PIARC website on March 17th, 2021.

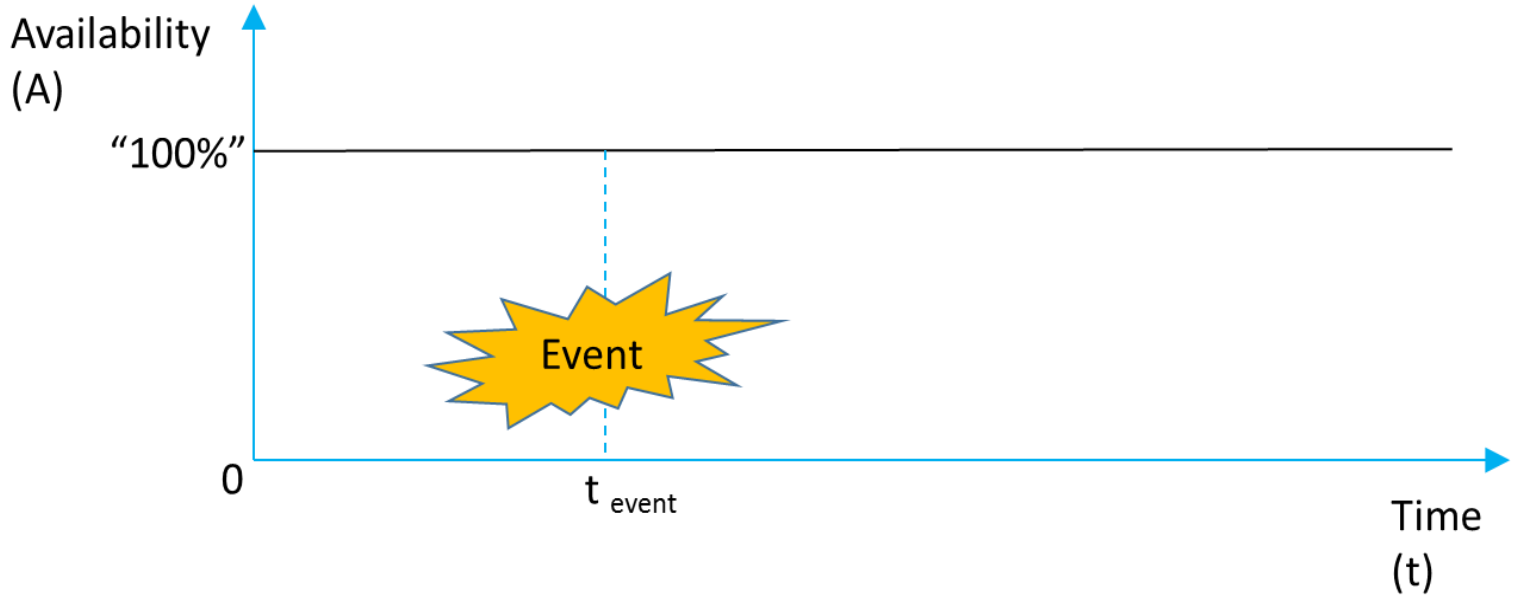


The report can be downloaded for free (like all other PIARC reports) from the PIARC website: www.piarc.org

Definition “road tunnel resilience”

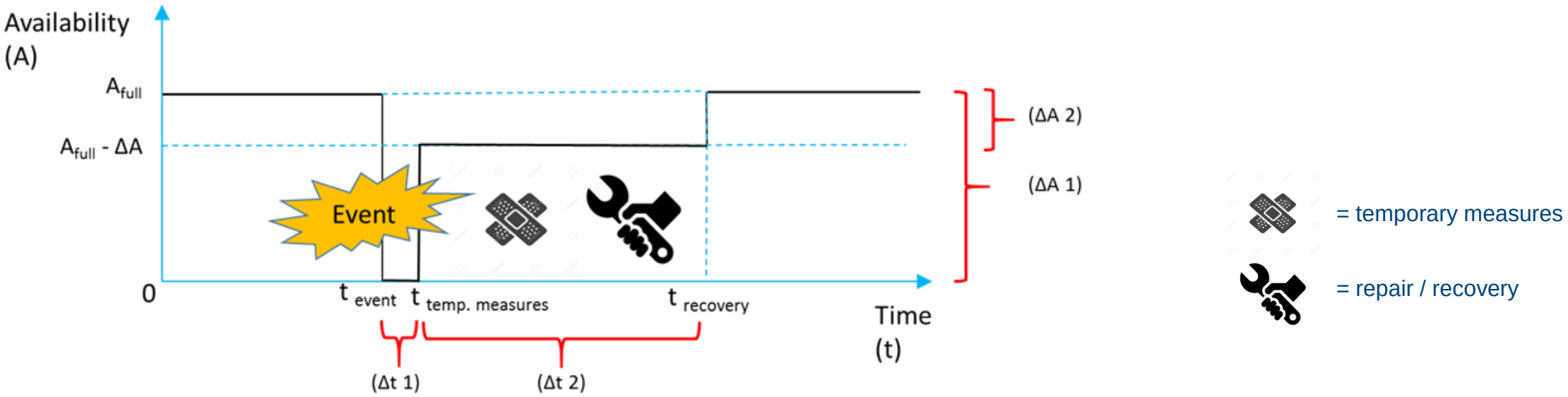
- “The ability to keep the tunnel open for traffic under safe conditions as much as possible (or to safely re-open it as quickly as possible) when potentially disruptive events occur”
- Or, more formally: “The ability of the tunnel system to prepare, plan for, resist, absorb, recover from, more successfully adapt to actual or potential negative effects of events or developments affecting the availability of a road tunnel in a timely and efficient way. In this context, an acceptable safety level is a mandatory constraint for the availability of the road tunnel.”
- Thus, resilience requires prevention, recovery (mitigation) and improvement (adaptation).

Example 1: full resilience by prevention



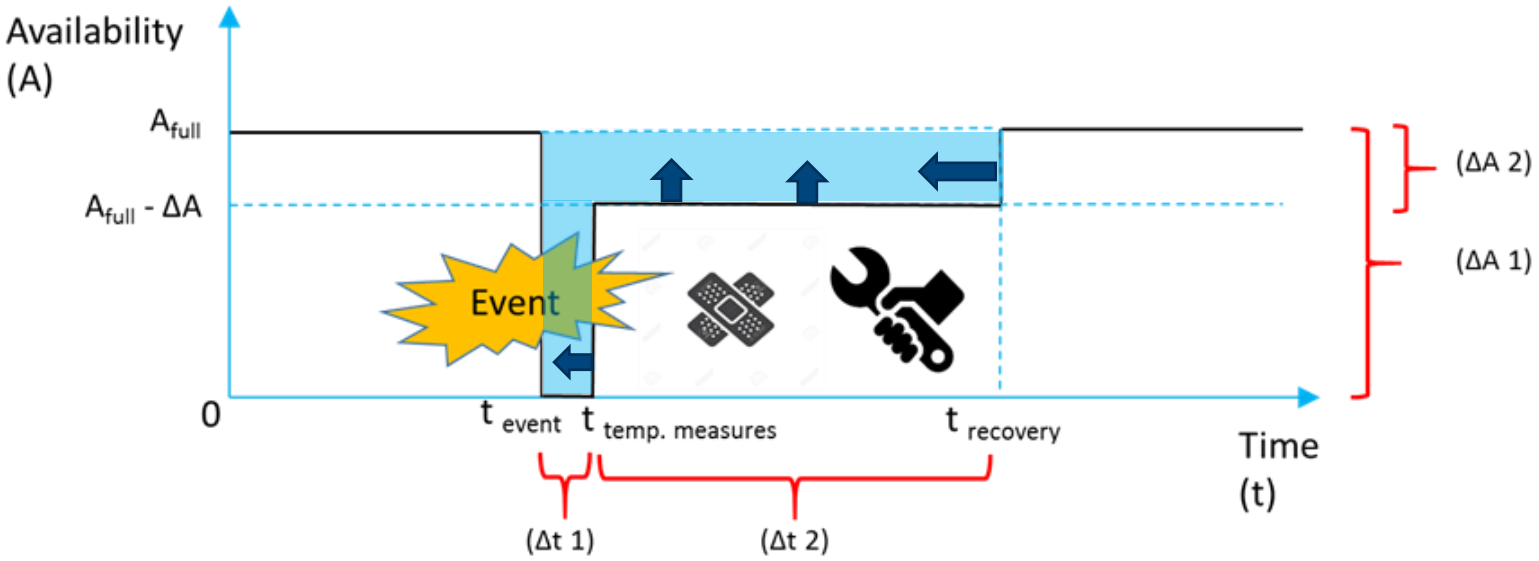
Imagine an event like a heavy rain shower; in this example loss of availability of the tunnel for traffic was prevented by a good design of the drainage & pumping system; therefore, the tunnel is fully resilient for this specific event.

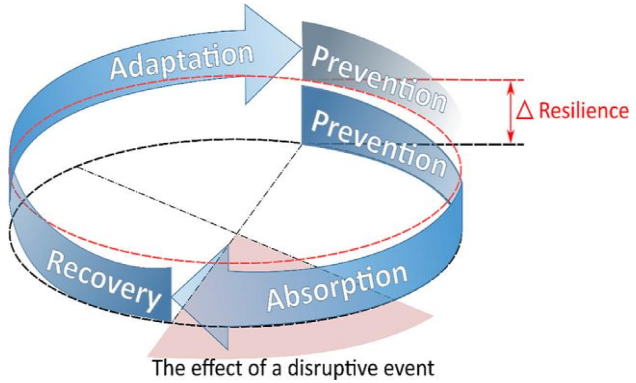
Example 2: resilience by mitigation



Imagine an event like the complete breakdown of the CCTV system, so that safe operation of the tunnel is not possible anymore. As a result, the tunnel is closed. Subsequently, traffic officers go on-site to observe the traffic and alarm the tunnel operator in case of an incident. Under these conditions, the tunnel can be re-opened, but maybe not fully, because one or more lanes might be kept closed to make the observation by traffic officers possible and to reduce the probability of an incident. In that case, this reduced availability would remain in service until the camera system is repaired and the tunnel can be fully opened again.

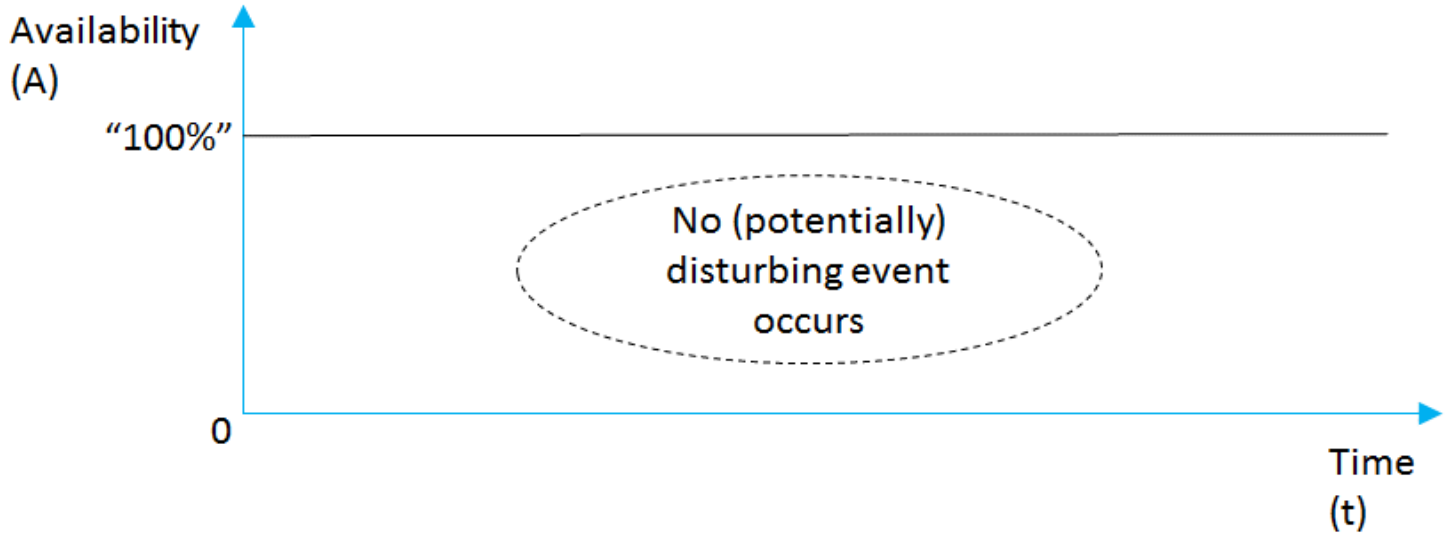
Example 3: resilience by adaptation / improvement





Concerning the previous example of the failure of the CCTV system, improvement / adaptation could be a quicker repair in the future, thus limiting the loss of availability the next time the CCTV fails: the smaller the blue area in the graph, the better the resilience.

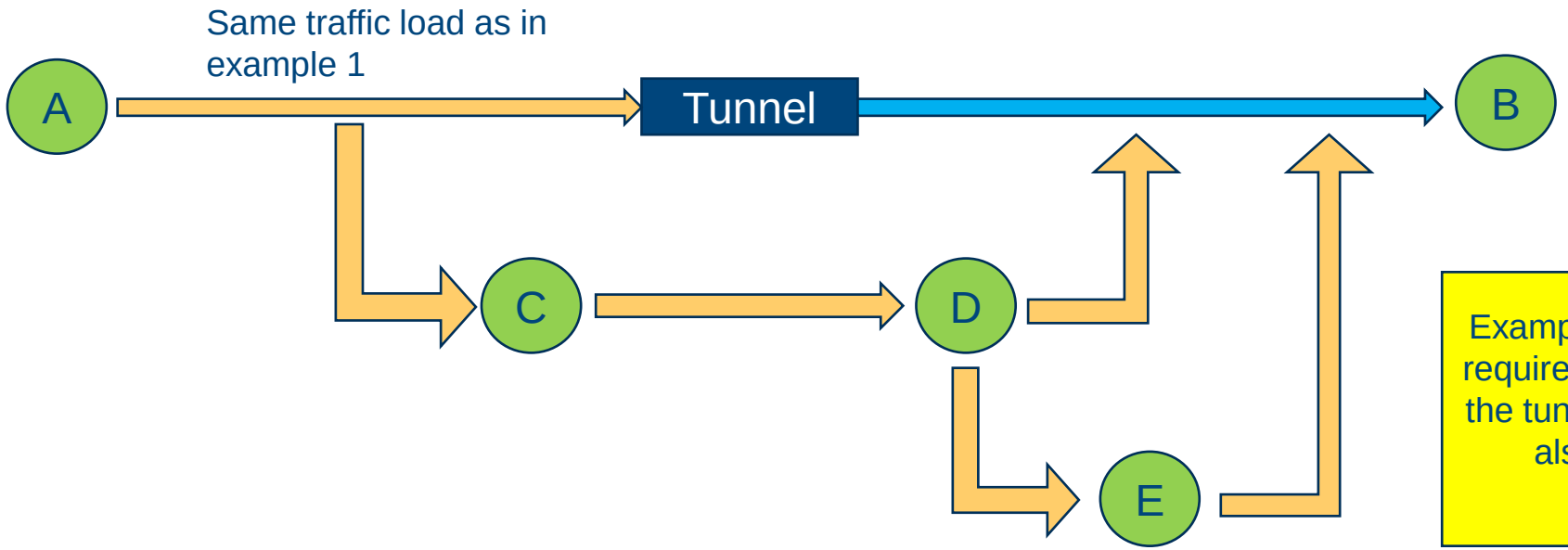
Example 4: resilience versus availability



A high availability does not necessarily equal high resilience, as this example shows. If no disturbing event occurs, the high availability is "pure luck", not the result of performed resilience. Also, when a tunnel is kept open despite the failure of critical safety systems, that could be more like "irresponsible" than "resilient".

Required resilience depends on importance tunnel in total road network

Example 1



Example 2

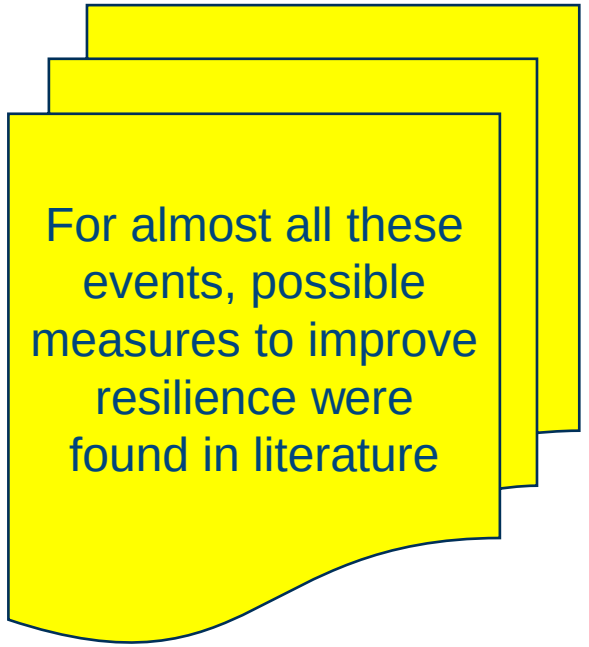
Example 2 would need less strict requirements for the availability of the tunnel than example 1; hence also less strict resilience requirements

Measures to improve resilience

- In accordance with studies by Bruneau et al., the literature report presents measures to improve resilience in the following categories:
  - Measures to prevent the negative effects on availability (reduced failure probabilities)
  - Measures to limit the degree of the negative effects on availability that are not prevented (reduced consequences from failure)
  - Measures to limit the duration of the negative effects on availability that are not prevented (reduced time to recovery)
- To manage these improvements, various resilience management approaches were found in literature
- In addition, Japanese studies (following the 2011 earthquake) highlight that a "just culture", in which people can act autonomously in an atmosphere of trust without being blamed, is also pivotal to show resilience in disaster situations when strict procedures do not work anymore

Possible events to be resilient for

- Extreme weather conditions, climate change and other natural hazards
- Traffic incidents
- Fires or release of dangerous goods
- Physical attacks or cyber-attacks (security issues)
- Failure of technical or operational safety measures or other parts of the tunnel system
- Tunnel maintenance and refurbishment works
- Technological and societal (long-term) developments



Some examples of measures that will improve resilience in general (for all event categories)

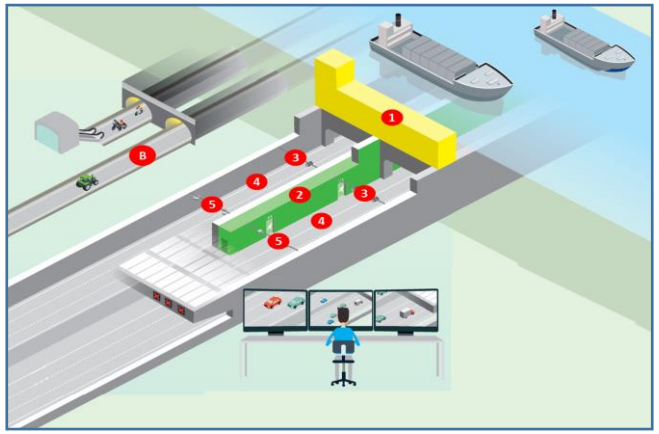
- Prevention of negative effects:
  - Tunnel system with sufficient capacity to withstand incidents: structural strength, fire resistance, road capacity, reliable equipment, staff size and capabilities, etc.
- Limitation of degree of negative effects:
  - Systems for early detection (to limit escalation), temporary bi-directional traffic in one tube, situational closure of lanes (instead of closing full tube in case of incident), more than one tube per driving direction, suitable alternative routes, etc.
- Limitation of duration of negative effects:
  - Incident management procedures and resources, service level agreements for emergency response, stocked spare parts for repair, in-house maintenance personnel, modular systems for quick replacement, etc.

To summarize: table of content report

CONTENTS

Next outputs during cycle 2019-2023

- Briefing Note including collection of case studies (expected early 2022):
  - 18 case studies collected from 13 countries world-wide
  - Including two contributions from NL:
    - Refurbishment Heinenoord Tunnel: trade-off to select approach to assure as much availability as possible
    - Method for a societal cost-benefit analysis (taking into account safety, availability and assets), to support decision to implement certain resilience measures (case A2 Leidsche Rijn Tunnel)
- Full technical report (expected early 2023):
  - Practical road map to manage and improve resilience;
  - “Measure sheets” with assessment of (cost-)effectiveness of various resilience measures, focusing on recovery



Thank you for your attention!

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Chair of TC 4.4 WG2

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