Warsaw, 6-8.02.2023

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MOSTY

"PIARC collection of case studies maintenance and traffic operation of heavy trafficked road tunnels"

ARTHUR KABUYA

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BRUXELLES MOBILITÉ
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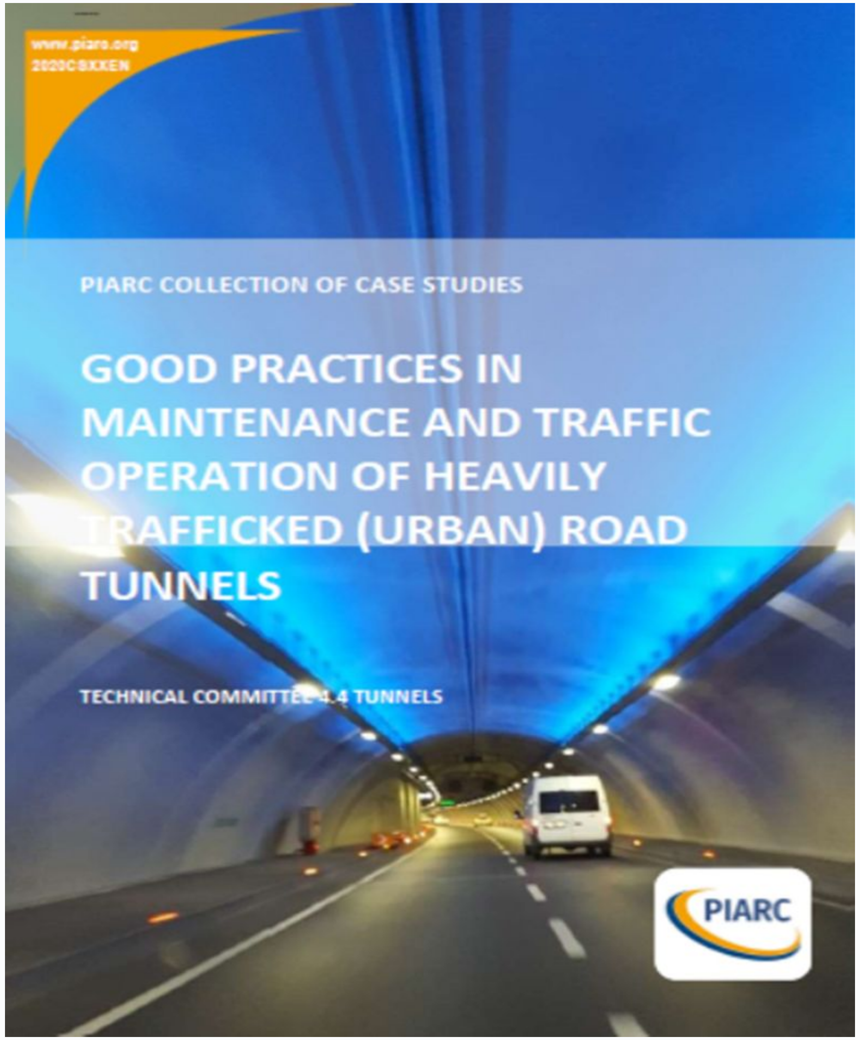
“PIARC collection of case studies maintenance and traffic operation of heavy trafficked road tunnels”



Arthur Kabuya

Leader of working Group 1 on Sustainable Operations and Maintenance of PIARC Technical Committee 4.4 on Tunnels.

COMPOSITION OF WORKING GROUP 1

18 members

16 corresponding members

5 reviewers

39 participants in total (from 16 countries)

Leader: Arthur Kabuya (Belgium)

Co-Leader: Urs Welte (Switzerland)

Europe: Austria , Belgium, Czech Republic , Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Switzerland, United Kingdom

Asia: Japan, Singapore , South Korea

Strategic Plan / Term of Reference)

Issue 4.4.2: Best practices in management (maintenance and traffic operation) particularly of urban and heavily trafficked tunnels	
Strategies / Objectives	**Outputs**
• **Identify best practices in management (maintenance and traffic operation), particularly of urban tunnels and tunnels with heavy traffic,** • Encourage coordination with other TCs and TFs, such as *T.C.2.1 – Mobility in Urban Areas, T.C.3.1 – Road Safety, T.C.3.3 – Asset Management, and T.F.3.1 – Road Infrastructure and Transport Security.*	**4.4.2 a:** **Briefing Note including Collection of Case Studies; Expected deadline October 2021** **4.4.2 b:** **Full Technical Report; Expected deadline November 2022**

Methodology and approach :

The information comes from experts of the working group WG1, which discussed and deepened these topics at the working group meetings.

in order to obtain a unified grid, a structure of information was given, which included the following chapters (whereas the format is used as a guideline):

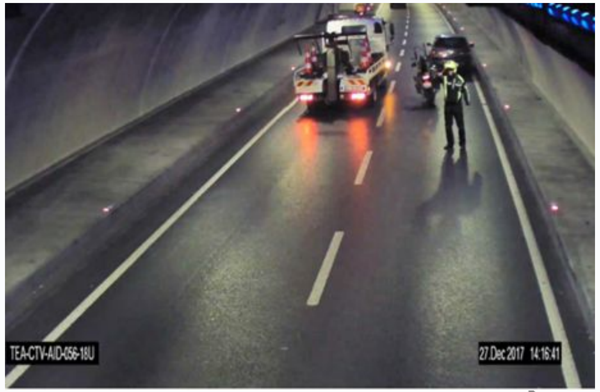
- Objectives
- Scope
- Requirements
- Technical challenges
- Non-technical challenges
- Lessons learned

11 case studies collected

Case Studies

Category	Author	Case Study
Implementation of the "quick responders" concept with different approaches	Charcellay (F)	Quick Responders in Eurasia Tunnel Istanbul
	Shiratory (JP)	Motor Cycle Squad in Yamate Tunnel Japan
	Kabuya (B)	Contribution of Patrolling in the Operation of Urban Tunnels of Brussels
	YEO and LOH (SG)	Fast response team in Marina Coastal Expressway (MCE) tunnel
Measures to organize work and to reduce nuisance to users during the renovation of tunnels	Kluge (D)	Safe Traffic Management during the Construction of Tunnels on a Hamburg Motorway
	Wierer (A)	Availability-optimization for traffic at tunnel Amras Austria
	Kabuya (B)	Renovation of the Hallepoort-tunnel in Brussels : a global and proactive traffic nuisance reduction programme
	Chiodini (N)	Traffic Management Measures during the Refurbishment of Tunnels in Oslo
New tools for maintenance and operation	Rakosnik (CZ)	CAFM and BIM to Maintenance in Czech Republic
	Welte (CH)	RAMS in Gotthard Rail Tunnel Project Switzerland
	Frei (CH)	Virtual Reality for Ventilation Systems

Example1 of Case studies



Quick responders in Eurasia Tunnel (Istanbul, Turkey)

Author: Pierre Charcellay, WG1 TC4.4 (France)

Objectives

The rapidity of the response to an incident in a tunnel is key for safety and asset protection, especially when a fire is declared or likely to.

Within Eurasia tunnel, allowing only light vehicles, fires will be small in power but might be difficult to attend due to congestion up stream the fire. The challenges are to purchase and equip motorbikes to tackle fires

Type of incident (in tunnel)	Average intervention time
Accident	1 min 47 sec
Animal	2 min
Breakdown Vehicle	2 min 37 sec
Claustrophobia	40 sec
Debris	2 min 20 sec
Fire	30 sec
Pedestrian / Cyclist	40 sec
Stopped Vehicle	23 sec
Wrong Direction Vehicle	2 min 22 sec

Eurasia Tunnel is 5.4 km single tube tunnel connecting the 2 sides of Istanbul by passing under the Bosphorus. Located in the heart of the city with more than 18 million inhabitants and many visitors, the tunnel handles more than 50,000 vehicles every day.

Example2 of Case studies

Motorcycle squad in Yamate tunnel

Author : Akira SHIRATORI, WG1 TC4.4 (Japan)

The Yamate tunnel, located in the center of Tokyo, is the longest urban road tunnel in Japan. The tunnel is 18.2km long and the traffic volume is approximately 80,000 vehicles/day.

Objectives :

Motorcycle squad has been introduced for speedy response to incidents/ abnormalities in long tunnels with narrow shoulder

Especially in case of tunnel fire, the squad arrives at the site, blocks up and conducts traffic regulation at early stage to prevent secondary disaster.

Vehicle Type / Case	Motorcycle Squad（motorcycle）		Traffic Patrol Vehicle（four wheels）	
	Number of cases	Arriving time (ave.)	Number of cases	Arriving time (ave.)
Accident	277	12.5min	9,587	16.4min
Broken Vehicle	296	12.6min	8,425	17.3min
Total	573	12.55min	20,216	16.8min

The response time of the motorcycle corps is the time from receiving the incident and starting the engine at the base to arriving at the site.
For traffic patrol vehicles, excluding the number of vehicles that are without emergency dispatch.

Example3 of Case studies

Fast response team in Marina Coastal Expressway (MCE) tunnel

Author: Se Lay YEO WG3 TC4.4 (Singapore) & Alfred LOH

Objectives

- Swift response to tunnel incidents and recovery.
- Ensure safe tunnel operations.

The MCE is a 5km-long dual 5-lane expressway, of which 3.6km is an underground tunnel. The remaining 1.4km comprises of surface roads, depressed roads and viaduct structures. A 420m stretch of the tunnel runs under the seabed.

This case study discusses the importance of ground resources deployed to provide timely incident recovery, ensure tunnel safety and traffic connectivity.

LTA Traffic Marshal and EMAS Vehicle Recovery Tow Trucks.

Since the opening of MCE Tunnel in 2013, the ground resources have fulfilled their KPI in ensuring attendance and clearance of incidents within 8+8mins (respond and clearance)

Example4 of Case study

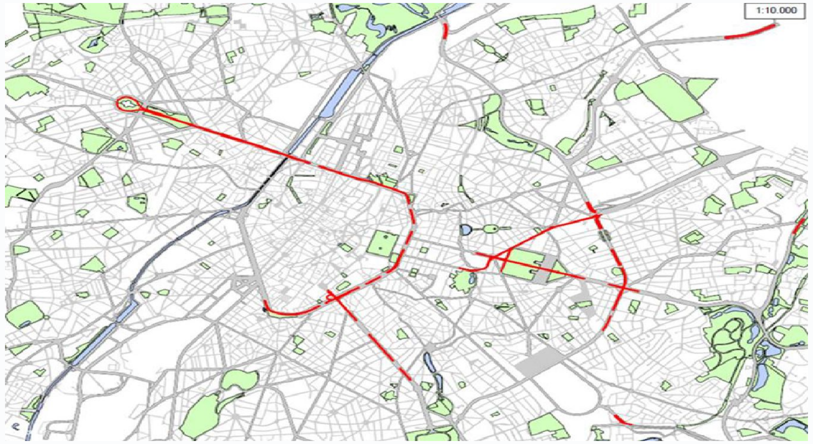
Contribution of Patrolling in the Operation of Urban Tunnels of Brussels.

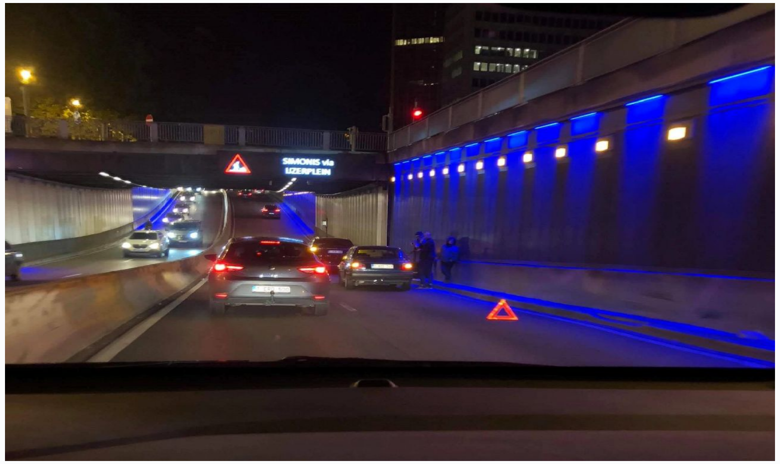
Authors:
Damien Tillet, Arthur Kabuya (Belgium)

In the operation of urban tunnels, incident management is of utmost importance. In the region of Brussels, the management of minor incidents is still unsatisfactory. To face this situation and in order to improve tunnel availability, it was decided that a call for tender for frequent patrolling of the tunnels and outer roadways would be issued.

The main objectives of patrolling are as follows:

- Ensuring frequent rounds.
- Ensuring tunnel availability and viability of the outer roadways.
- Intervening at the very start of a traffic incident so as to ensure the efficient protection of tunnels users and to avoid the propagation of a significant event (i.e. intervention by the first responders in case of the start of a fire).
- Intervening as quickly as possible in the case of a technical issue in a tunnel so as to reduce the impact on traffic.
- Preventing risks of potential malfunctions (mainly technical) by means of a visual control, or limiting their impact.





26 tunnels, 19 are over 500m long with two being over 2km long with an average of 36,000 cars per day (in the range of 20,000 to 55,000).

On average: 1,141 traffic incidents per year

Example5 of Case studies

Safe Traffic Management during the Construction of Tunnels on the Motorway A7 / E45, Hamburg

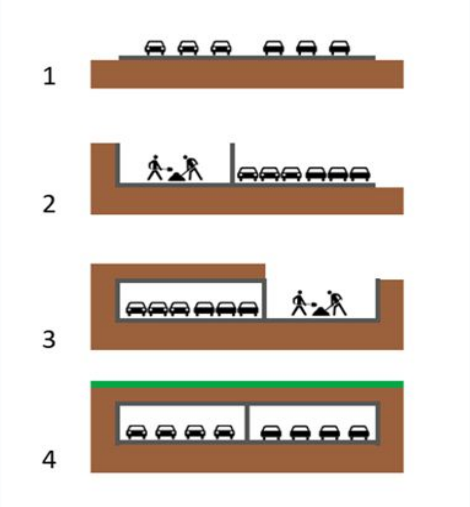
Author: Christina KLUGE, WG1 TC4.4 (Germany)

Objectives

The A7 / E45 is a cross-regional European north-south route and in the Hamburg metropolitan region (Germany) influenced by high volumes of commuters with up to 150,000 AADT over 2X3 lanes and short distances between the motorway exits / entries. To improve capacity an extension of the motorway with one additional lane per direction was required. The motorway passes through an urban populated area and therefore the need for adequate noise protection / reunification of urban quarters made it necessary to cover the motorway at three sections.

The resulting three motorway tunnels (appr. 0.5, 1 and 2 km long) north of the existing 3 km long Elbe Tunnel have to be built without substantially interrupting the traffic flow on the A7 / E45 and the surrounding urban network.

Each of the three new two-tube tunnels (Schnelsentunnel, Stellingentunnel and Altonatunnel) is to be constructed in the following major steps:



Various measures have been developed in order to meet the requirements on network availability without compromising tunnel safety during the construction period (being also beneficial for the final state). To assess the tunnel safety, quantitative risk analyses have been carried out.

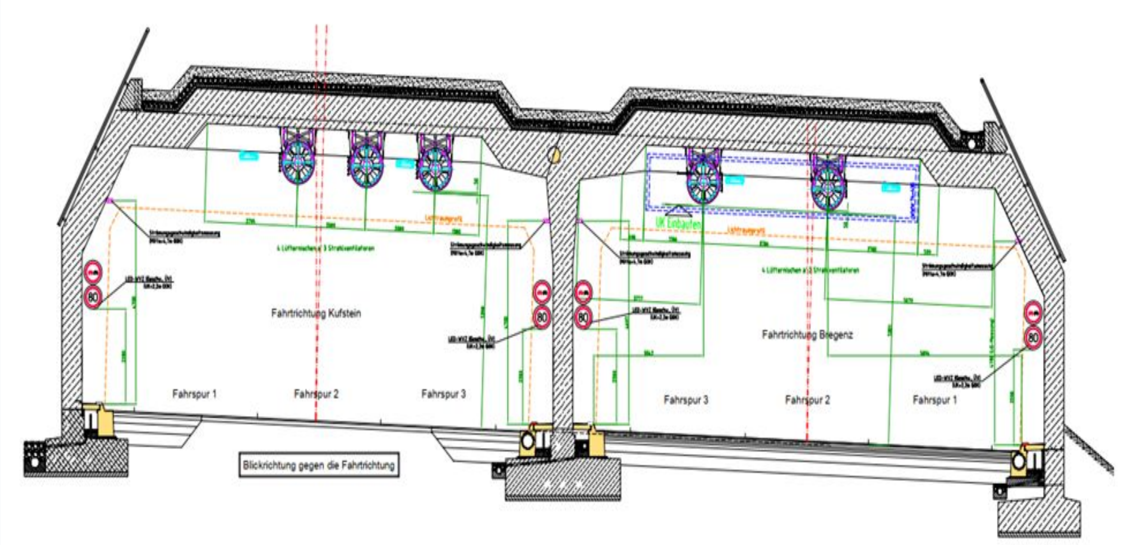
Example6 of Case studies

Availability-optimization for traffic at tunnel Amras

Author: Alexander Wierer (Austria)

Objectives

Discussion are normally held in the planning phase with regards to economic-technical decisions at the interface between construction and operation. In the Amras tunnel near Innsbruck, such a discussion was held and a decision was reached with respect to the necessity for vehicle height control. Instead of installing a vehicle height control system, the safety equipment in the tunnel was placed higher, so that the height control could be omitted.



The tunnel Amras has a traffic load of about 90,000 vehicles per day.

Example7 of Case studies

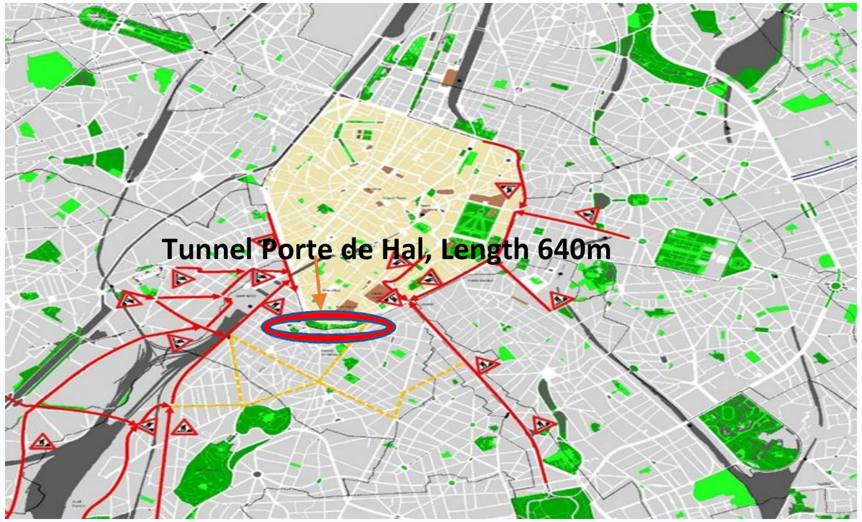
Renovation of the Hallepoort-tunnel:
a global and proactive traffic nuisance reduction programme

Authors: Inge Paemen, Arthur Kabuya (Belgium)

The Hallepoort-tunnel is an urban tunnel in the centre of Brussels (Belgium) through through which almost 40,000 vehicles pass every day

Objective

The main objective was to preserve the viability of the city by ensuring that the city did not become completely clogged up during the road works in the Hallepoort-tunnel. That is why a great deal of attention was paid to keeping the tunnel accessible when organisating the renovation of this important urban tunnel.



Example8 of Case studies

Traffic Management Measures during the Refurbishment of Tunnels in Oslo

Author: Corinne CHIODINI, WG1 TC4.4 (Norway),

Objectives

The Norwegian Public Roads Administration is completing this year the rehabilitation of the most tunnels in Oslo following minimum safety requirements from the EU-directive on tunnel safety. In addition, some structural elements (pavement) had to be repaired or improved, technical buildings in all the tunnels had to be extended, and systems for treatment of water from tunnel washing had to be put in place.

Traffic management measures

Various measures have been developed in order to meet the requirements on network availability without compromising tunnel safety during the working periods.

- Quick incident detection and localisation via automatic video detection (congestion, stopped vehicle, obstacles, …).
- Speed limit 50 km/h during bi-directional traffic (70 km/h in the final state).
- Variable message signs indicating congestion, alternative routes,
- Information signs with an incentive to late braiding for increasing the capacity
- Short term bus and taxi lane, and restrictions for the electrical vehicles in this lane (only vehicles with at least two persons were allowed to use the lane)

Road	Tunnel	AADT	Length	Opened	Working period	Closure
Ring 3	Smestad	46000	500m	1983	2015-2016	One tube 24/7
E6	Bryn	68000	300m	1969	2016-2017	One tube 24/7
Ring 3	Granfoss	45000	2300m	1992	2015-2017	One tube 24/7
Ring 3	Tåsen	59000	1300m	1999	2016-2018	Night work only
E6	Opera - Ekeberg/Svartdal	76000/ 11000	1580m/ 1300m	1993/ 2000	2017-2019	One tube 24/7 in few months, then night closing
E18	Opera – Festning/ramps	60000/ 14000	1800m/ 600m	1990/ 1996	2019-2020	Night closing
E6	Vålereng	68000	800m	1989	2020-2021	One tube 24/7 in few months, then night closing

Example9 of Case studies

CAFM and BIM to Maintenance in Czech Republic

Authors: Lukas RAKOSNIK, Ludvik SAJTAR, WG1 TC4.4 (Czechia)

Case Study and basic information on how CAFM with integrated BIM was implemented in an operated tunnel and is used during maintenance

Objectives

After commissioning (2015) the Blanka Tunnel Complex (BTC), the tunnel manager decided to additionally create the Computer-Aided Facility Management (CAFM) system including the Building Information Modelling (BIM) system. In addition to saving on administration, operation and maintenance costs, the tunnel manager expects optimization of maintenance processes and activities, simplification of control activities, and reduction of maintenance time.

With its total length of 6,4 kilometers, the Blanka is the longest road tunnel in the Czech Republic

Example10 of Case studies

RAMS in Gotthard Rail Tunnel Project

Author: Urs WELTE, WG1 TC4.4 (Switzerland),

Objectives

Due to the length of the tunnel, an essential requirement was to reduce disruptions to operations to a minimum. For this reason, very high availabilities were required to ensure smooth and uninterrupted operation. The "RAMS" method was a measure to achieve this goal and to seamlessly follow the elements reliability, availability and maintainability under consideration of safety (RAMS) from design to commissioning.

The basic principle of reliability prediction and integration of single results of one subsystem into the complete tunnel system is necessary. This includes e.g: basic component data, RAM-interfaces, reliability calculations, disruption protocol. The big challenge is to be able to calculate these values or to obtain the data from manufacturers or other sources.

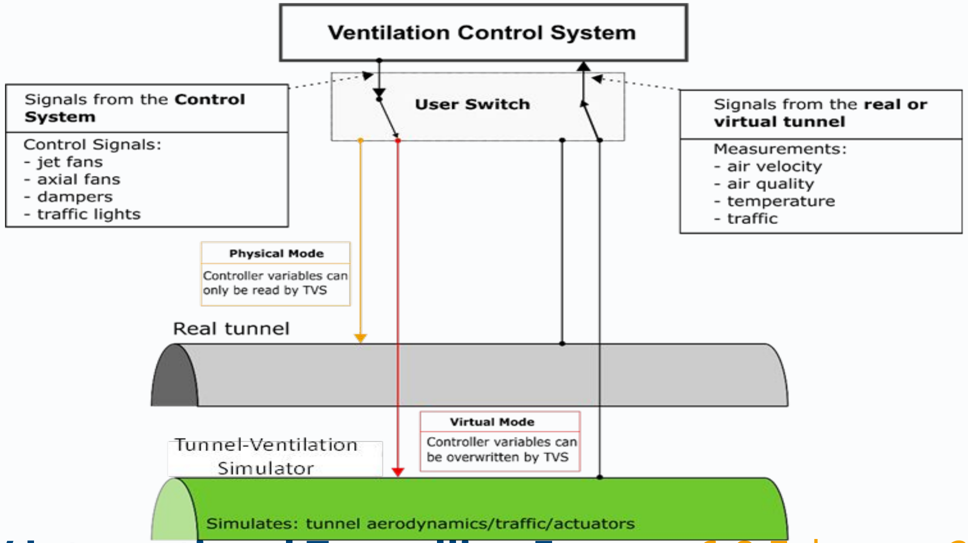
Example11 of Case study

Digital Twins for Tunnel Ventilation – A tool development, testing and commissioning

Author: Simon Frey (Switzerland)

Within the various safety equipment in a road tunnel, tunnel ventilation has by far the highest degree of complexity in terms of control systems (e.g. longitudinal airflow control for smoke management). Therefore, a big effort is required for implementing, testing, commissioning as well as maintaining the control system. Using conventional methods, it is difficult - if at all possible - to conduct all the required tests in the workshop or on site. By using a digital twin of the tunnels aerodynamics and ventilation equipment, the control system can be developed, tested, and commissioned in a more reliable and more efficient way.

The Tunnel-Ventilation-Simulator is such a virtual twin, able to simulate aero- and thermodynamics of an underground facility in real time and able to interact with the control system of the tunnel ventilation.



The project.
The Einhausung Schwamendingen (EHS) in the urban area of Zurich, Switzerland is a project extending an existing two bore tunnel (length: 800 m) by enclosing the existing road to a total covered length of about 1,800 m. The highway A1L is one of the primary axes leading to the city-centre with a daily traffic volume of about 100’000 vehicles per day.
In terms of the ventilation system, the project has some special features. The tunnel is equipped with 12 exhaust fans per tube instead of 2, as it is usually the case in a “standard” smoke extraction system.

THANK YOU FOR YOUR ATTENTION

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