Rapid incident detection in tunnels through acoustic monitoring – operating experiences in Austrian road tunnels

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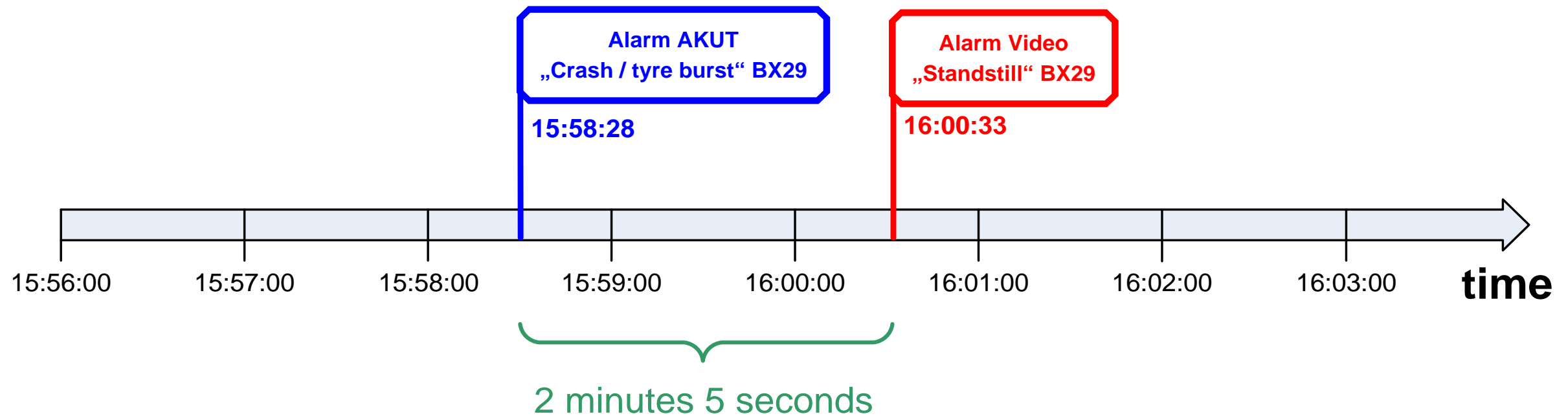Martin Gruber – ASFINAG BAU MANAGEMENT GMBH

Graz, 2018/06/13
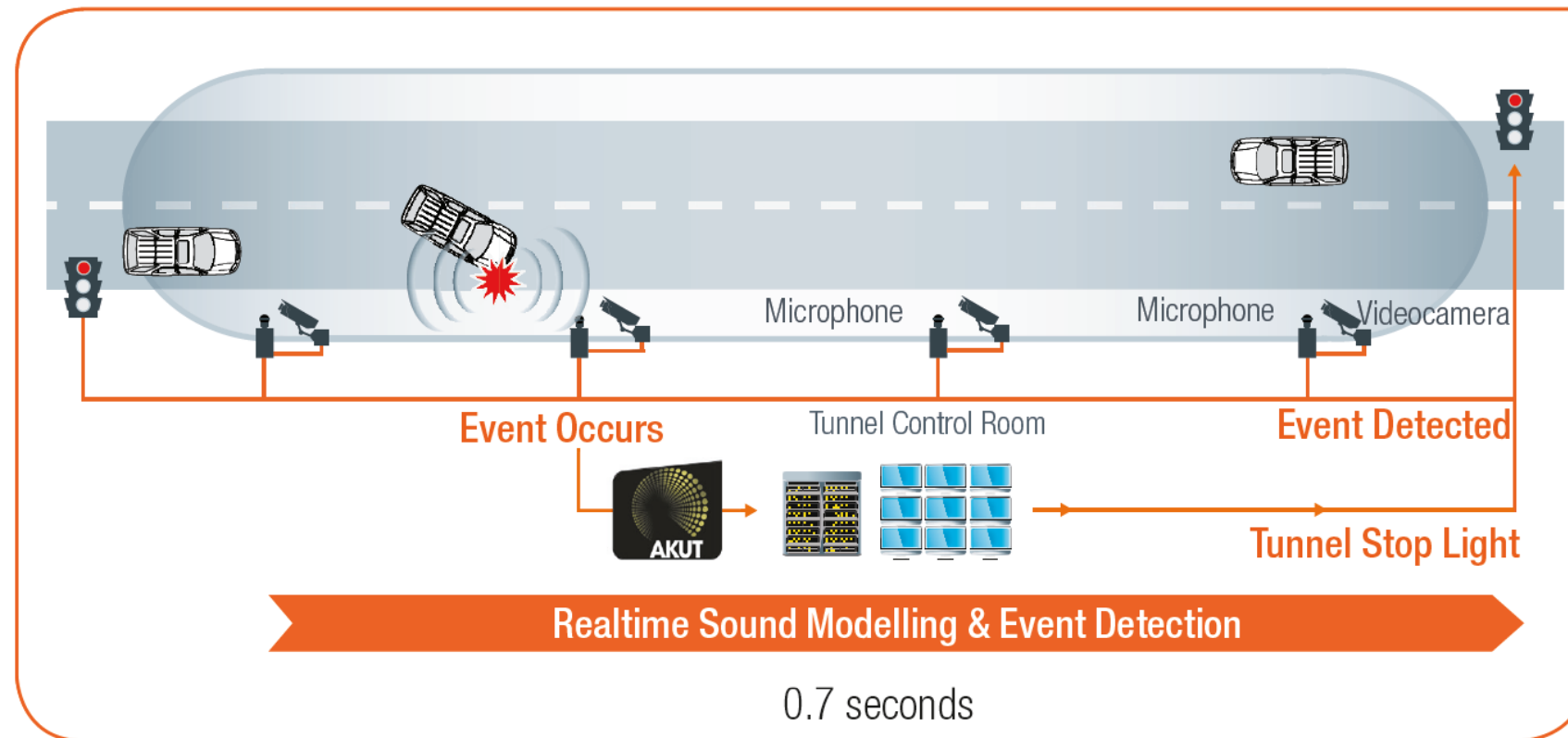
Acoustic Tunnel Monitoring - AKUT™

- Detection of abnormal sounds in in tunnels

- Incident detection in **less than 1 second**!

Acoustic Tunnel Monitoring – Benefits

- Very fast incident detection

- Tunnel **stop lights** can be **immediately activated**

- **Fewer** tunnel occupants require **evacuation**

- Even with **poor visibility** due to smoke the operator can **hear people in the tunnel** – and is able to locate them

Acoustic Tunnel Monitoring – Features

- Localization of the incident

- Switch on correct cameras

- Discrimination of different danger categories
  - Crash / tyre burst
  - Tyre squeal
  - Door slam
  - Honking
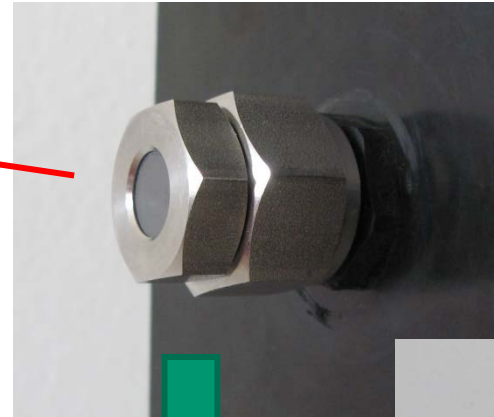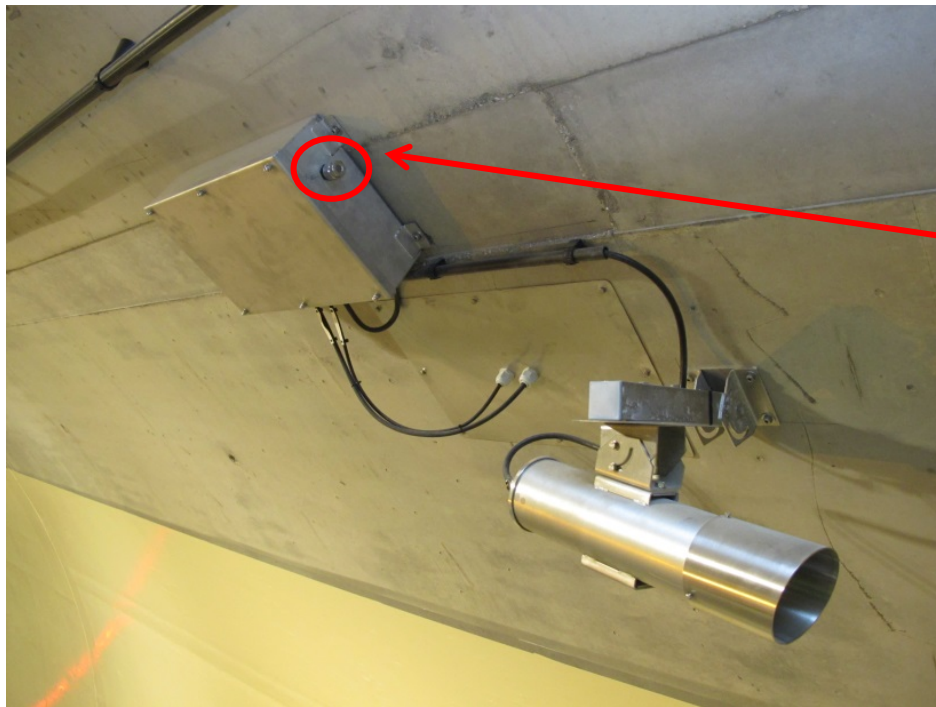 - Voices/shouting (Voice Scan)

Voice Scan

Voice Scan

Tunnel microphone

Operational experience
Analysed tunnels

■ Systems analysed using the ASFINAG incident database

Tunnel	Length in m	Number of bores	Number of microphones	Average Daily Traffic Volume
Bosruck, A9	5,505	2	122	17,470
Ehrentalerberg, A2	3,345	2	75	30,623
Falkenberg, A2	1,090	2	26	30,623
Lendorf, A2	800	2	20	30,623
Trettnig, A2	450	2	12	30,623
Götschka, S10	4,435	2	86	37,298
Neumarkt, S10	1,970	2	38	37,298
Pernau, S10	245	2	4	37,298
Lest, S10	545	2	12	37,298
∑ 9 Tunnel	∑ 36.77 km bore length		∑ 395	

Longterm analysis of incidents

- Analysed period of time: **July 2016 – February 2018**

- ASFINAG incident database contained **28 incidents** in the analysed tunnels

- 9 incidents are not included in analysis
  - 6 incidents outside of tunnel (no microphones installed)
  - 1 underfloor fire of a passenger car
  - 1 car rolled onto the traffic lane – without damage
  - 1 dataset was incomplete and not useable

Longterm analysis of incidents

- 19 relevant incidents in 9 tunnels from 07/2016 – 02/2018

- Classification of the relevant incidents

| Incident type	
Rear-end collision	5
Collision of 2 vehicles	4
Collision of a vehicle with the infrastructure	10
Total	**19**

Example
Data Analysis from Traffic Management System

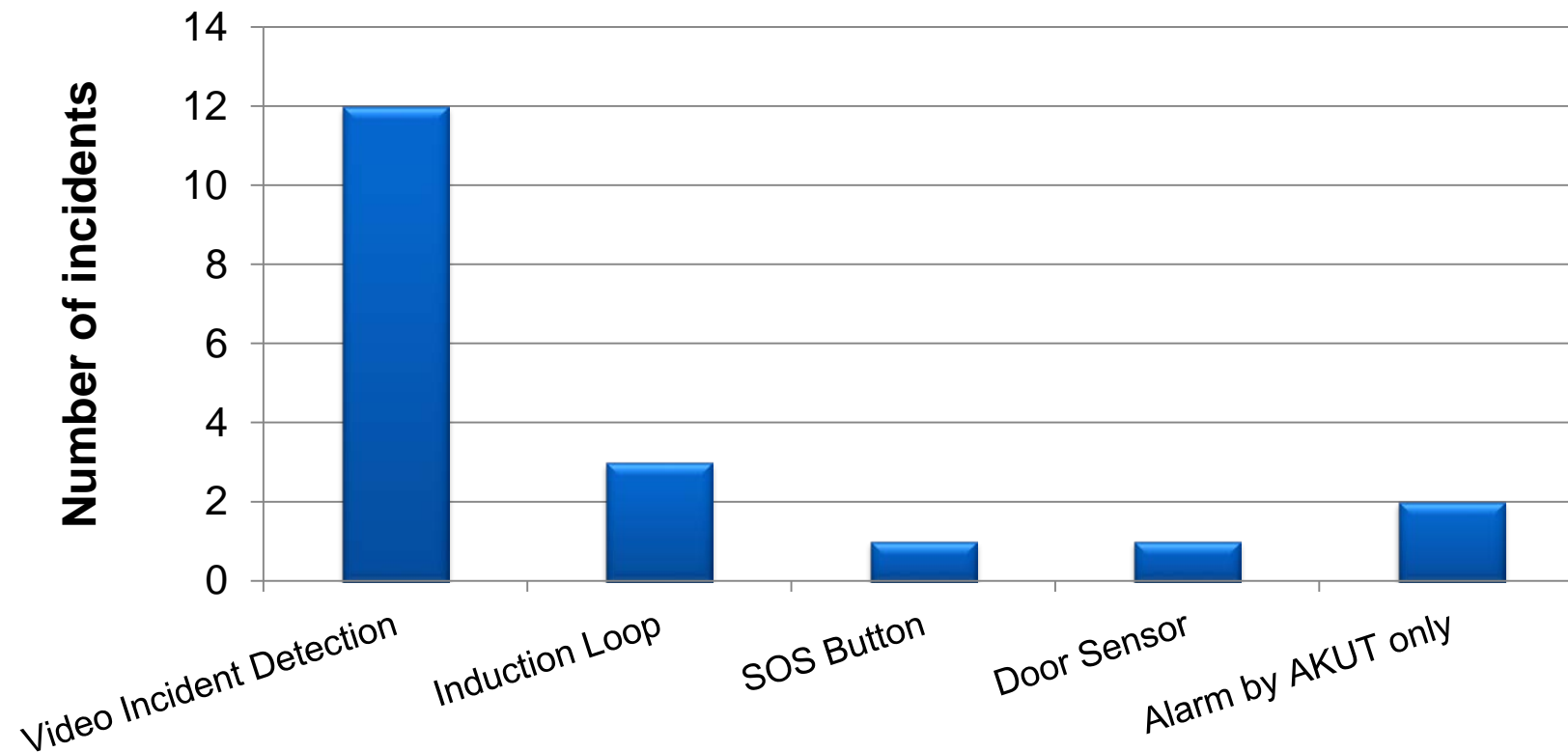| Zeitstempel	Instanzbeschreibung	Variablenbeschreibung	Wert	Benutzer	Quelle	Alarm ID
18.07.2017 16:42:34.	S10Go RFB Prag VK WVZ007 - Wechselverkehrszeichen 2	Ausschalten	1	Global\sperrer	Operato	
18.07.2017 16:46:16.	S10Go RFB Prag Betriebsart Innenstreckenbeleuchtung	Ereignis Quittieren	1	Global\kickinge	Operato	
18.07.2017 16:46:17.	S10Go RFB Linz Betriebsart Innenstreckenbeleuchtung	Ereignis Quittieren	1	Global\kickinge	Operato	
1. 18.07.2017 16:46:52.	S10Go RFB Prag AKUT - Mikrofon 006_4	Aufprall / Knall / Reifenplatzer a	Aktiv	Alarm Server	Alarms	1556334
18.07.2017 16:46:55.	S10Go RFB Prag AKUT - Mikrofon 006_4	Aufprall / Knall / Reifenplatzer a	Gegange	Alarm Server	Alarms	1556334
2. 18.07.2017 16:47:11.	S10Go RFB Prag VK DZS 201 - DZS 1	Langsamfahrer	Aktiv	Alarm Server	Alarms	1556336
18.07.2017 16:47:11.	S10Go RFB Prag VK DZS 201 - DZS 2	Langsamfahrer	Aktiv	Alarm Server	Alarms	1556335
3. 18.07.2017 16:47:18.	S10Go RFB Prag TV - Kamera 006_4 - FS1 - stehendes KFZ	ausgelöst	Aktiv	Alarm Server	Alarms	1556337
18.07.2017 16:47:19.	RFB Prag Kurz Tunnelsperre	Vorschau ein	1	Global\sperrer	Operato	
18.07.2017 16:47:22.	RFB Prag Kurz Tunnelsperre	Vorschau ein	0	Global\sperrer	Operato	
18.07.2017 16:47:22.	RFB Prag Kurz Tunnelsperre	Manuell geschalten	1	Global\sperrer	Operato	
18.07.2017 16:47:22.	RFB Prag Kurz Tunnelsperre	Ausführung verwerfen	1	Global\sperrer	Operato	
18.07.2017 16:47:22.	RFB Prag Kurz Tunnelsperre	Programm Manuell bestätigt	1	Global\sperrer	Operato	
18.07.2017 16:47:27.	S10Go RFB Prag VK - Ampel SV203 BSGO01 - Ampel 2	Rotschaltung Aktiv	Aktiv	Alarm Server	Alarms	1556338
18.07.2017 16:47:27.	S10Go RFB Prag VK - Ampel SV203 BSGO01 - Ampel 3	Rotschaltung Aktiv	Aktiv	Alarm Server	Alarms	1556339
18.07.2017 16:47:27.	S10Go RFB Prag VK - Ampel SV203 BSGO01 - Ampel 1	Rotschaltung Aktiv	Aktiv	Alarm Server	Alarms	1556340
18.07.2017 16:47:27.	S10Go RFB Prag VK - Ampel SV202 AP_S10_02_545N - Am	Rotschaltung Aktiv	Aktiv	Alarm Server	Alarms	1556341

Result of longterm analysis

- Result: **all 19 incidents were detected quickest by AKUT!!!**
- No missed incident!
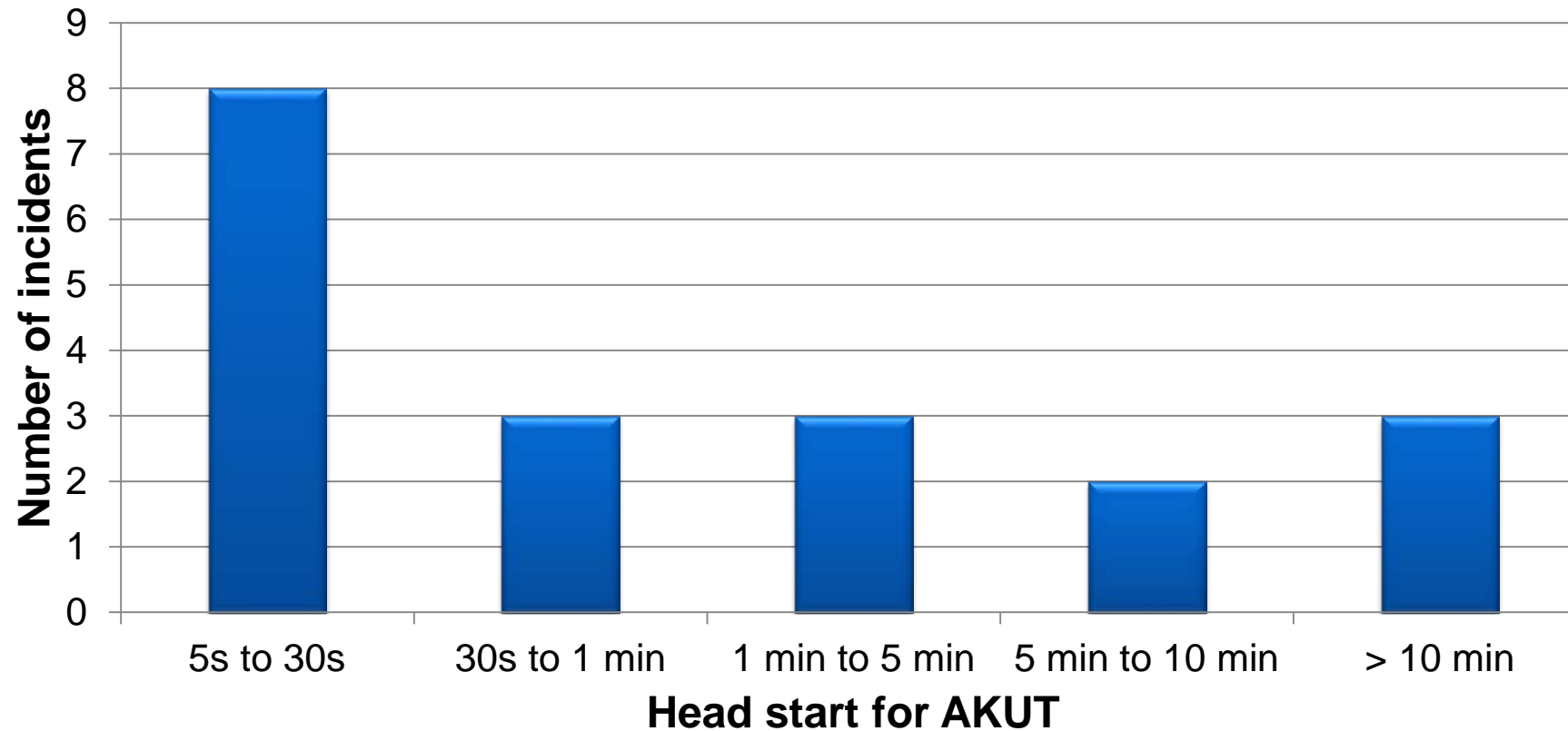
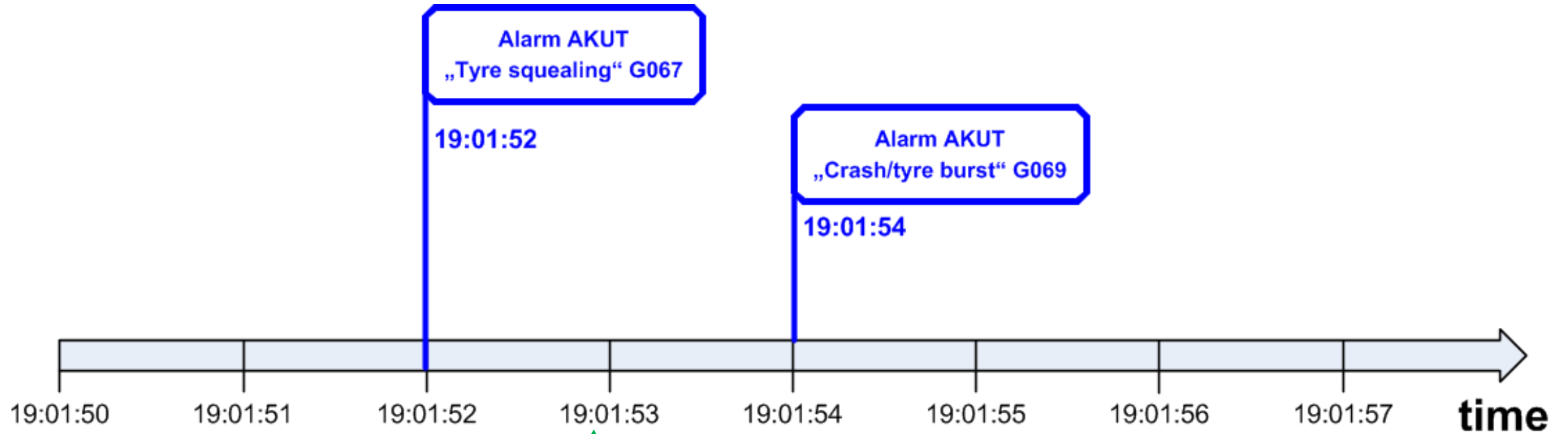# Result of longterm analysis

■ Safety systems that reported alarms in **second place** after AKUT

Case 2: Accident of a passenger car

Alarm AKUT „Tyre squealing" G067

19:01:52

Alarm AKUT „Crash/tyre burst" G069

19:01:54

19:01:50   19:01:51   19:01:52   19:01:53   19:01:54   19:01:55   19:01:56   19:01:57   **time**

Video camera was automatically switched on the video wall

Detection of loose manhole covers

- Detection of abnormal noises beside defined noise classes

- Open manhole covers can cause serious accidents

- AKUT detected loose / open manhole covers
  - 21.07.2016 (Bosruck tunnel)
  - 14.01.2017 (Bosruck tunnel)

- **→Tunnel was immediately closed and heavy accidents were prevented!**

False alarms

- Main task is the detection of real incidents

- Each detection system has false alarms

- Number of false alarms is essential for operators

- No acceptance if number of false alarms to high

False alarms

- Tunnel analyzed: Bosruck

  bore length: 11,010 m

  # microphones: 122

  analyzed month: September 2016

Sound class	Number of false alarms per month	False alarms per km bore length and per 24 hrs
Accident / tyre burst	1	0.003
Tyre squeal	12	0.0363
Door slam	16	0.0484
Honking	0	0
TOTAL	29	0.0877

→ **Average of 0,96 false alarms per day at a 11 km bore length!**

False alarms

- Tunnel analyzed: Ehrentalerberg

  bore length: 6,690 m

  # microphones: 75

  analyzed month: March 2017

Sound class	Number of false alarms per month	False alarms per km bore length and per 24 hrs
Accident / tyre burst	6	0.0298
Tyre squeal	6	0.0298
Door slam	20	0.0996
Honking	1	0.0049
TOTAL	33	0.164

→ Average of 1 false alarm per day at a 6,7 km bore length!

False alarms

- Tunnel analyzed: Flirsch

  bore length: 2,252 m

  # microphones: 19

  analyzed month: January 2018

Sound class	Number of false alarms per month	False alarms per km bore length and per 24 hrs
Accident / tyre burst	0	0
Tyre squeal	0	0
Door slam	17	0.243
Honking	0	0
TOTAL	17	0.243

→ **Average of 0,54 false alarms per day at a 2,3 km bore length!**

Cleaning and maintenance

- **Pilot system in Kirchdorf tunnel in operation since 2010**
    - bore length: 5,614 m
    - # microphones: 49
    - DTV: 19,330 vehicles per day
- **Experience over the past 8 years**
    - No form of maintenance and repair work has been required
    - No form of extra cleaning work has been carried out
    - Not one microphone has failed since 2010
    - Server hard disks only had to be replaced twice as they were defective

Conclusion

- Sounds in the tunnel = new source of information

- Incidents are alerted after 0.7s to the operator → very fast

- Currently 22 installations with 1,250 microphones

- Analyses showed:
  - **all incidents** were **detected quickest** by AKUT
  - maximum time advantage: up to 12 minutes
  - **no missed incident**
  - **very low false alarm rate**

- No maintenance, cleaning work at pilot system since 2010

Many thanks to…

…for their great support!

More questions…?

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