

OPERATIONAL TRIAL OF DISTRIBUTED ACOUSTIC SENSING

COPEX 2022, GÜNTER BULAU

19.10.2022



Agenda

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- RMR's starting situation
- What is DAS?
- Performing the trial
- Results
- Conclusion

Starting situation

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- RMR has been affected by illegal hot tapping in the past



Starting situation

Typical detection of illegal hot taps

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1. Destruction of connected hoses (due to works)
2. Indication of magnetic scattering flux pig
3. Loss of monitored pressure (branch line)
4. USLD pig runs

You are always too late...

Starting situation

Trials made prior to DAS

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- ❑ **Cathodic corrosion protection based detection**
 - ❑ Principle: disturbance of el. current whilst working
 - ❑ Issues: high rate of false alarms, missing detection of tested events
 - ❑ Results: not applicable for RMR

- ❑ **Use of drones**
 - ❑ Principle: frequently inspection by drones
 - ❑ Issues: missing permissions for flights, technical problems (electric fields)
 - ❑ Results: not applicable for RMR

- ❑ **Pressure wave based system**
 - ❑ Principle: negative pressure wave when opening/closing a valve
 - ❑ Issues: disturbing influence of pigs, valve and pump operations, accuracy
 - ❑ Results: not reliable on main lines of RMR

Starting situation

Further improvements

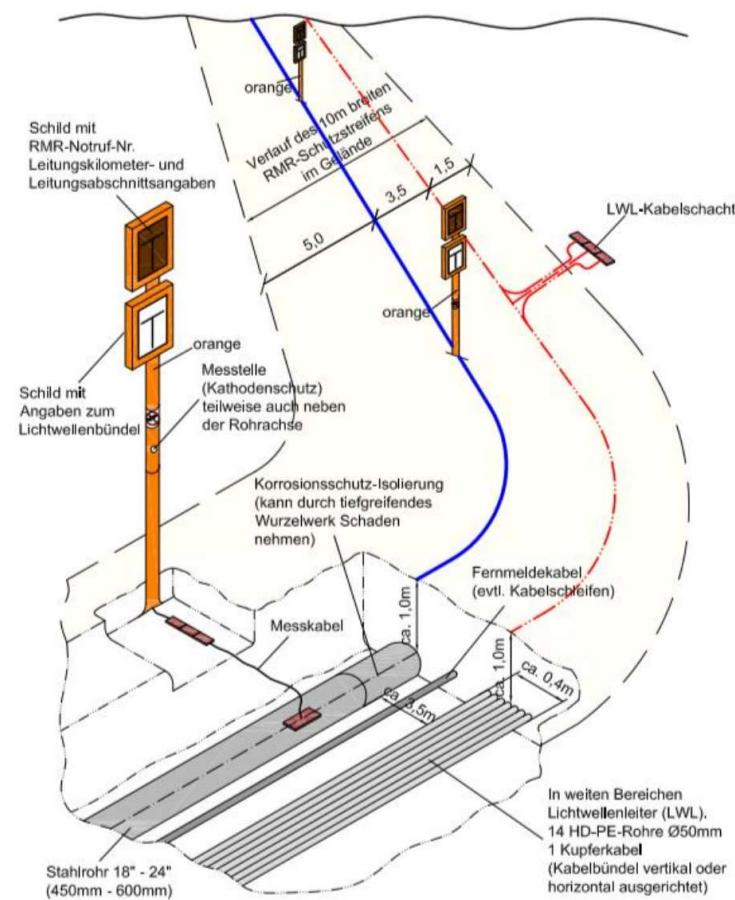
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- Identification of potential „high risk“ areas
 - ▣ Car park, hidden, short distance to motorway,...
- Frequent cuts of grass and vegetation (inspection)
- Frequent run of USLD-pig (ultrasonic leak detection)
- Frequent use of sniffer dogs in certain areas
- Helicopter flights on different weekdays

Starting situation

RMR, Protected strip

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What is DAS?

DAS - distributed acoustic sensing

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- Using a fiber as sensor („microphone“)
- Range up to 50 km (probably more)
- Resolution 1-10 m

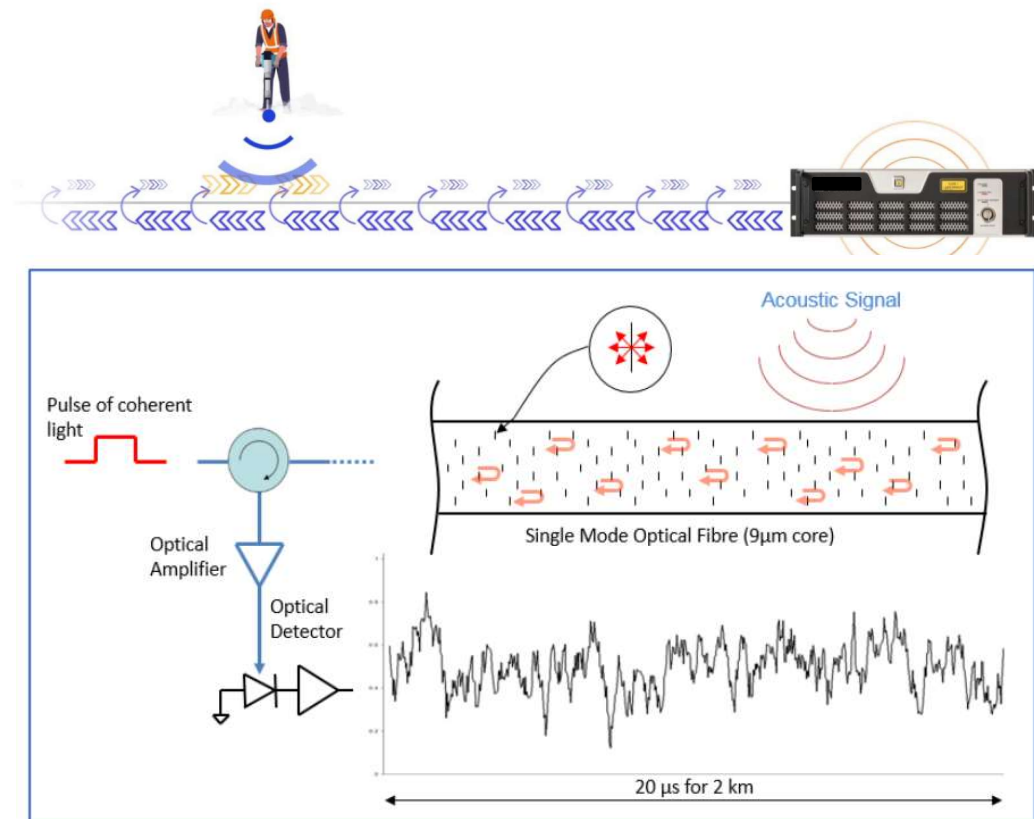
- Aims
 - Detection of external intrusion
 - by excavators
 - by hand shoveling
 - Reliability of the system
 - Minimum of false alarms

What is DAS?

Principle of DAS, detection

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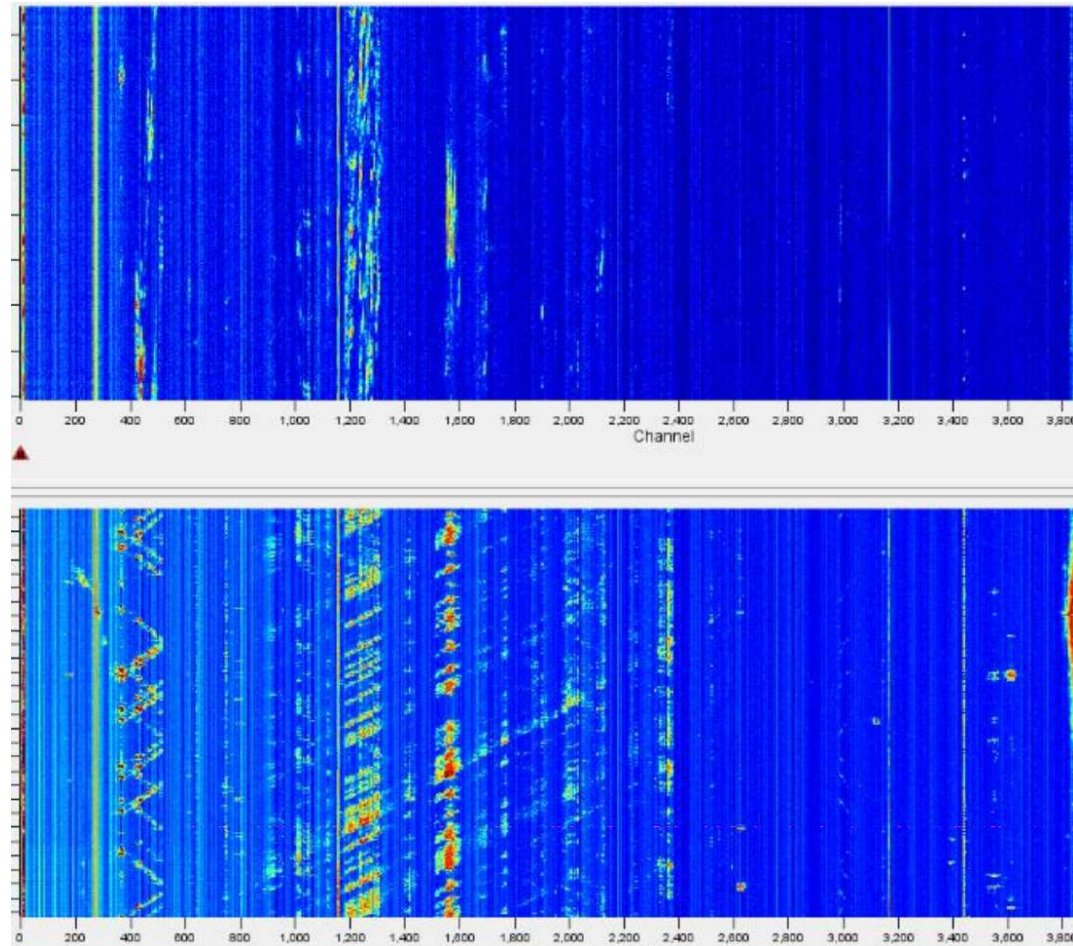
- Laser pulse (thousands per second) is fed into the fiber optic cable
- Microscopic fractures in the glass of fiber
- Backscattering (Rayleigh)
- Microscopic motion is enough to change the relative position of the fractures
- Changed reflection is analyzed and evaluated
- Algorithms decide whether an alarm should be displayed



What is DAS?

Waterfall Diagram (raw version)

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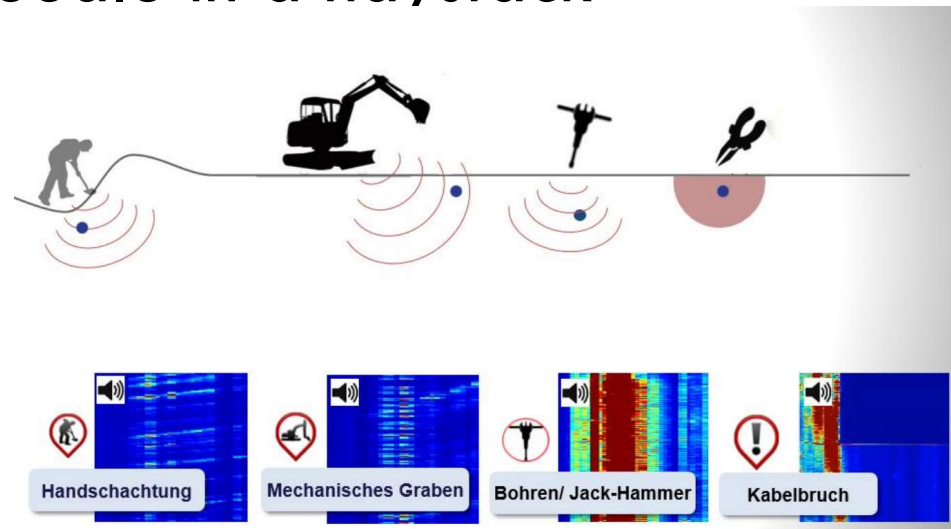


What is DAS?

Principle of DAS, classification

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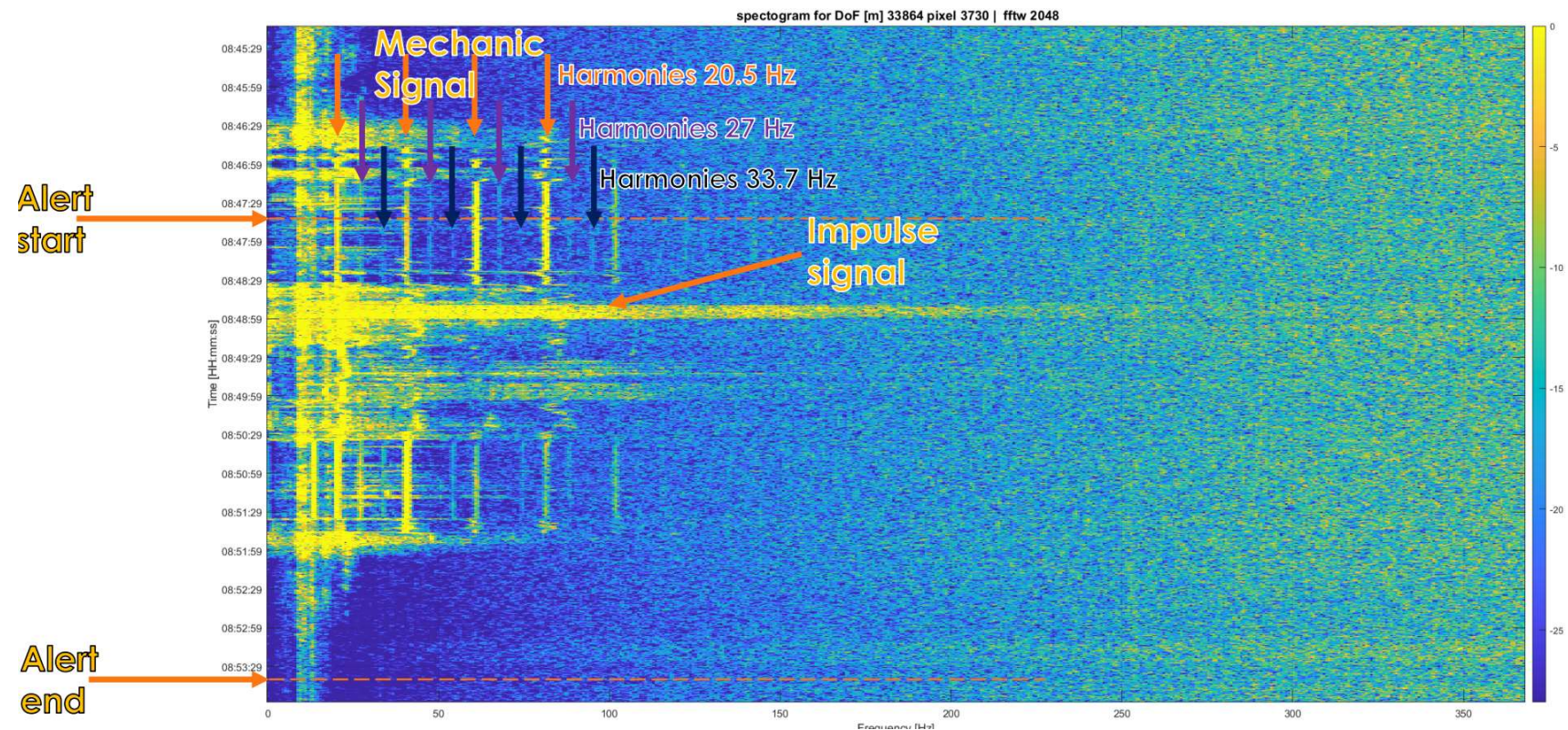
- Differentiation between relevant and non relevant signals
- Data, data, data $>$ patterns and time
- Like searching for a needle in a haystack



What is DAS?

Specialists view

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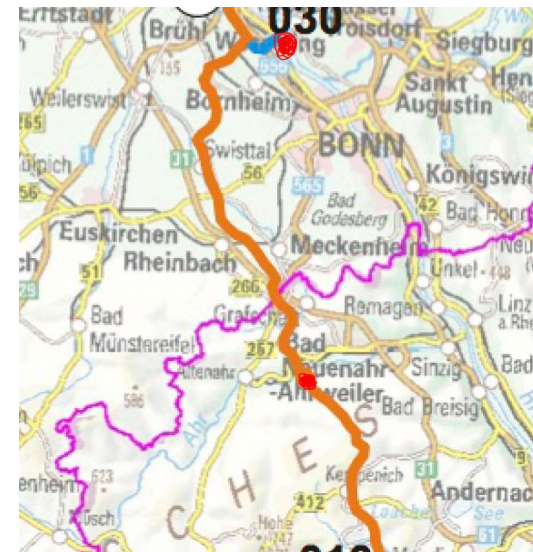


Performing the trial

Test setup

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- One section (about 50km)
- Two providers (parallel, scheduled for three months)



Performing the trial

Installation

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- ❑ Simple (plug and play)
- ❑ 19" rack (8u)
- ❑ Testing the optical link
- ❑ Synchronization
- ❑ Matching optical distance (fiber/pipeline)



Performing the trial

Calibration

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- First steps (started in July 2021)
 - Definition and checks of interesting (noisy) points, such as highway-/railcrossings
 - Consideration of various types of soil
 - Verifying of pipeline position
 - Verifying of pipeline depth
 - Beginning with penetrating scenarios

Performing the trial

Communication challenges

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- ☐ Loss of cellular internet connection
- ☐ UI bugs
- ☐ Loss of IP address
- ☐ Login issues
- ☐ Disappearing alerts
- ☐ ...

Performing the trial

Test: 2x excavator work for minimum 15 minutes

17

08:26-08:38 above fiber
08:41-08:59 above pipeline

provider 1 no detection provider 2 no detection
provider 1 no detection provider 2 no detection



Performing the trial

Test: 2x manual digging for minimum 15 minutes

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09:40-09:57 above fiber

provider 1 Detected, accuracy + 20m provider 2 no detection

10:03-10:18 above pipeline

provider 1 Detected, accuracy + 20m provider 2 no detection



Performing the trial

Test: 2x excavator work for minimum 15 minutes

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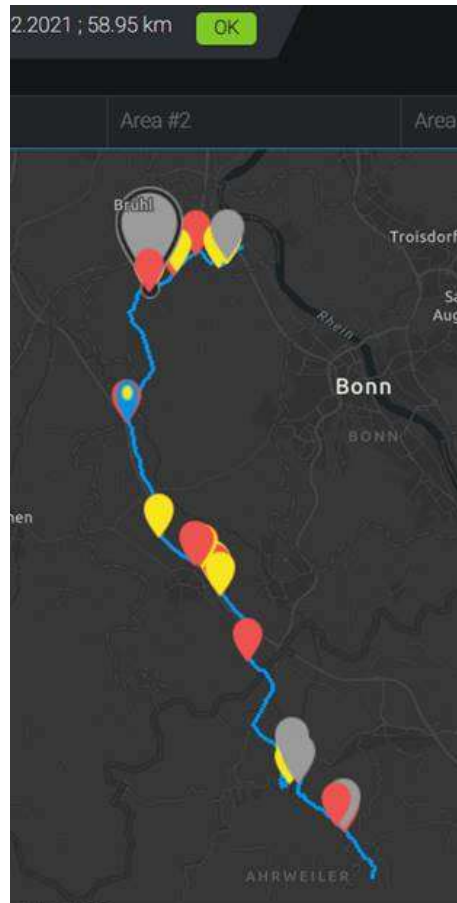
Around 11:00 above fiber both providers **no detection**
Around 11:30 above pipeline provider 1 **no detection** provider 2 **detection** (accuracy 400 m)



Results

False alarms/Nuisance alarms

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□ 26.01.	red 30	yellow 16
□ 27.01.	red 9	yellow 18
□ 30.01.	red 8	yellow 16
□ 31.01.	red 9	yellow 19
□ 01.02.	red 9	yellow 10
□ 02.02.	red 13	yellow 19
□ 03.02.	red 24	yellow 9
□ 06.02.	red 7	yellow 13
□ 07.02.	red 11	yellow 13
□ 08.02.	red 17	yellow 9

Results

Different ways

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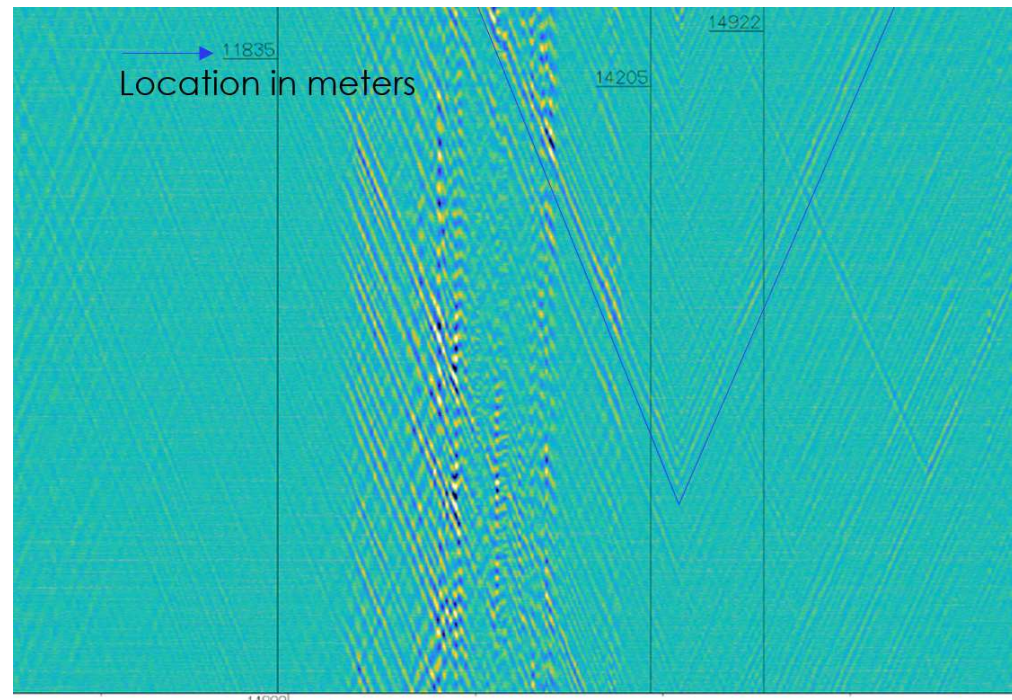
- ▣ One provider showed no success after six months (high rate of false alarms and less accuracy). Trial stopped.
- ▣ The other (keen) provider decreased the rate of false alarms and improved accuracy. Trial continued.

Results

Pig detection

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- „triangle signal phenomena“ identified as spheres



Results

Nuisance alarms reduction (NAR)

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- Improvements of algorithms (system learning)
- Some examples

- Date: 14/02/22
- Time of arrival: 12:15
- Alert type: Mechanical digging
- Range in meters: 27350
- Description: Agriculture field tilling
- Conclusion: Suspected as NAR



Results

NAR

24

- Date:15/02/22
- Time of arrival:11:20
- Alert type: Mechanical digging
- Range in meters:44000
- Description: Drifting PE pipeline installation
- Conclusion: Suspected as NAR



- Date:15/02/22
- Time of arrival: 12:55
- Alert type: Mechanical digging
- Range in meters:36667
- Description: Excavator working
- Conclusion: Real activity

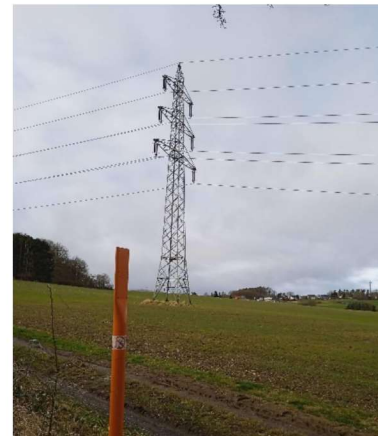


Results

NAR

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- Date:16/02/22
- Time of arrival: 11:51
- Alert type: Mechanical digging
- Range in meters:42720
- Description: Electric pole might vibrate strongly by a wind burst
- Conclusion: Suspected as NAR



- Date: 16/02/22
- Time of arrival: 12:37
- Alert type: Mechanical digging
- Range in meters: 33865
- Description: Agriculture tilling
- Conclusion: Suspected as NAR



Results

NAR

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- Date:17/02/22
- Time of arrival: 11:53
- Alert type: Mechanical digging
- Range in meters:4760
- Description: real activity, about 100 meters from the pipeline as a result suspected as NAR
- Conclusion: Suspected as NAR



- Date:16/02/22
- Time of arrival: 11:04
- Alert type: Manual digging
- Range in meters:52230
- Description: Woodwork
- Conclusion: Suspected as NAR



Results

NAR

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- Agricultural activities
 - ▣ classification of different machines (process)
- Geofencing
 - ▣ blocking alerts from known construction sites
- Grouping

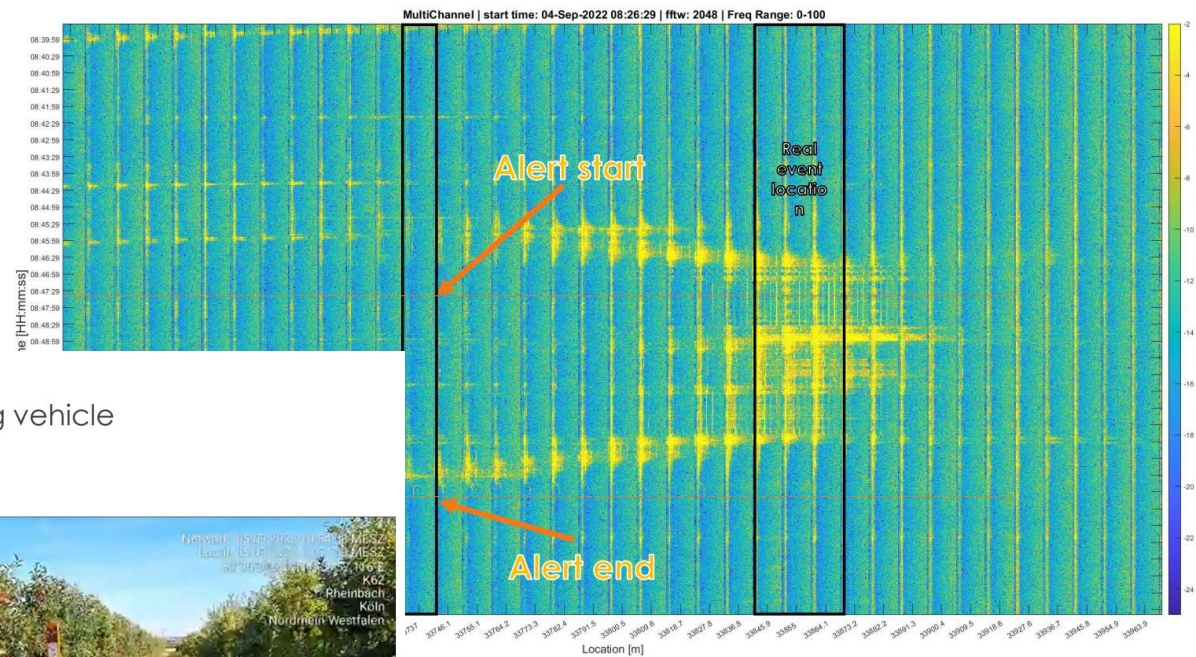
Results

Events as signals

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This event shows a quite area, arrival of a vehicle, mechanical signals with impulses signal in the beginning, middle and end before vehicle leaves the area.

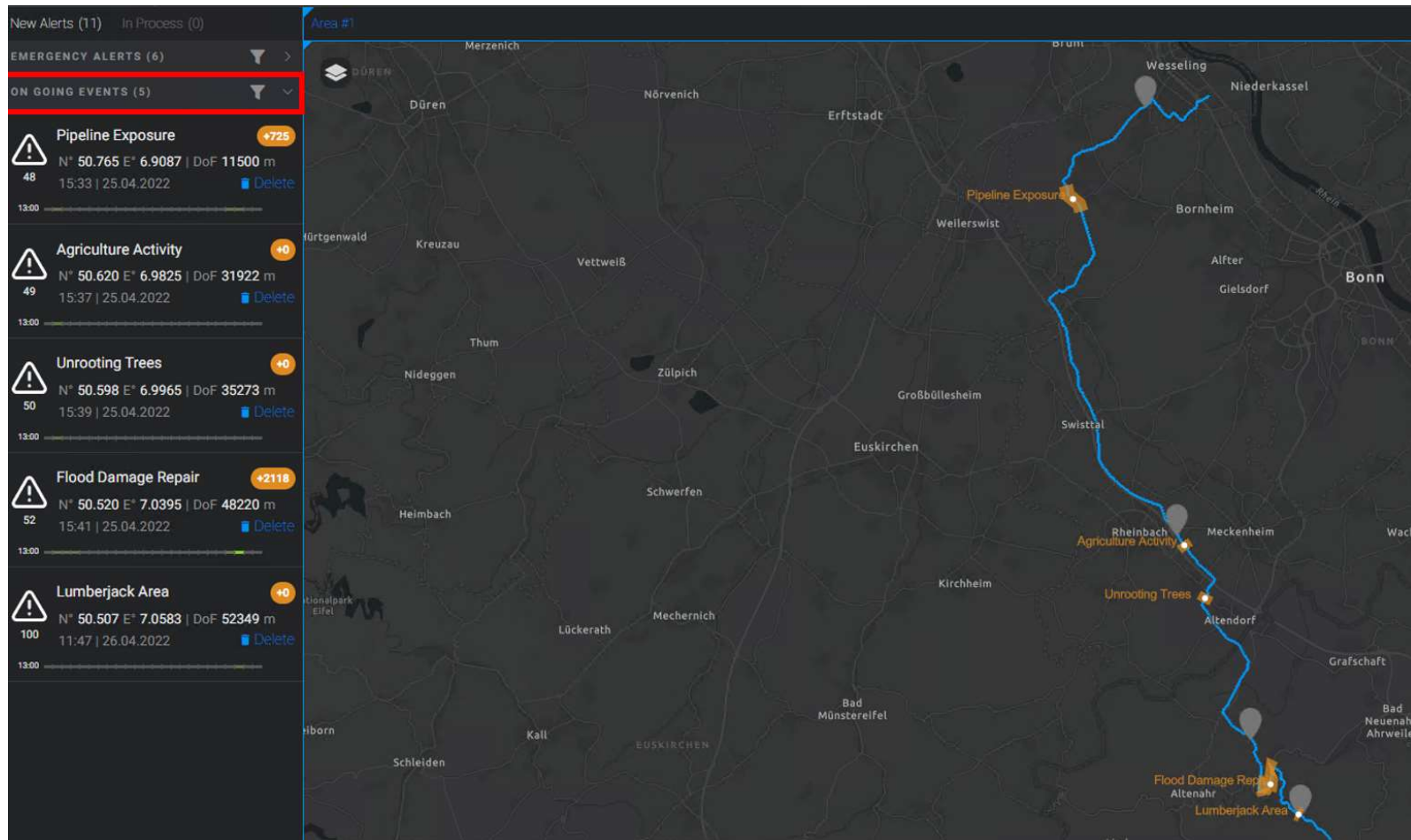
- Apple plantation
- This alert was caused by the harvesting vehicle loading boxes. A very active location



Results

User interface

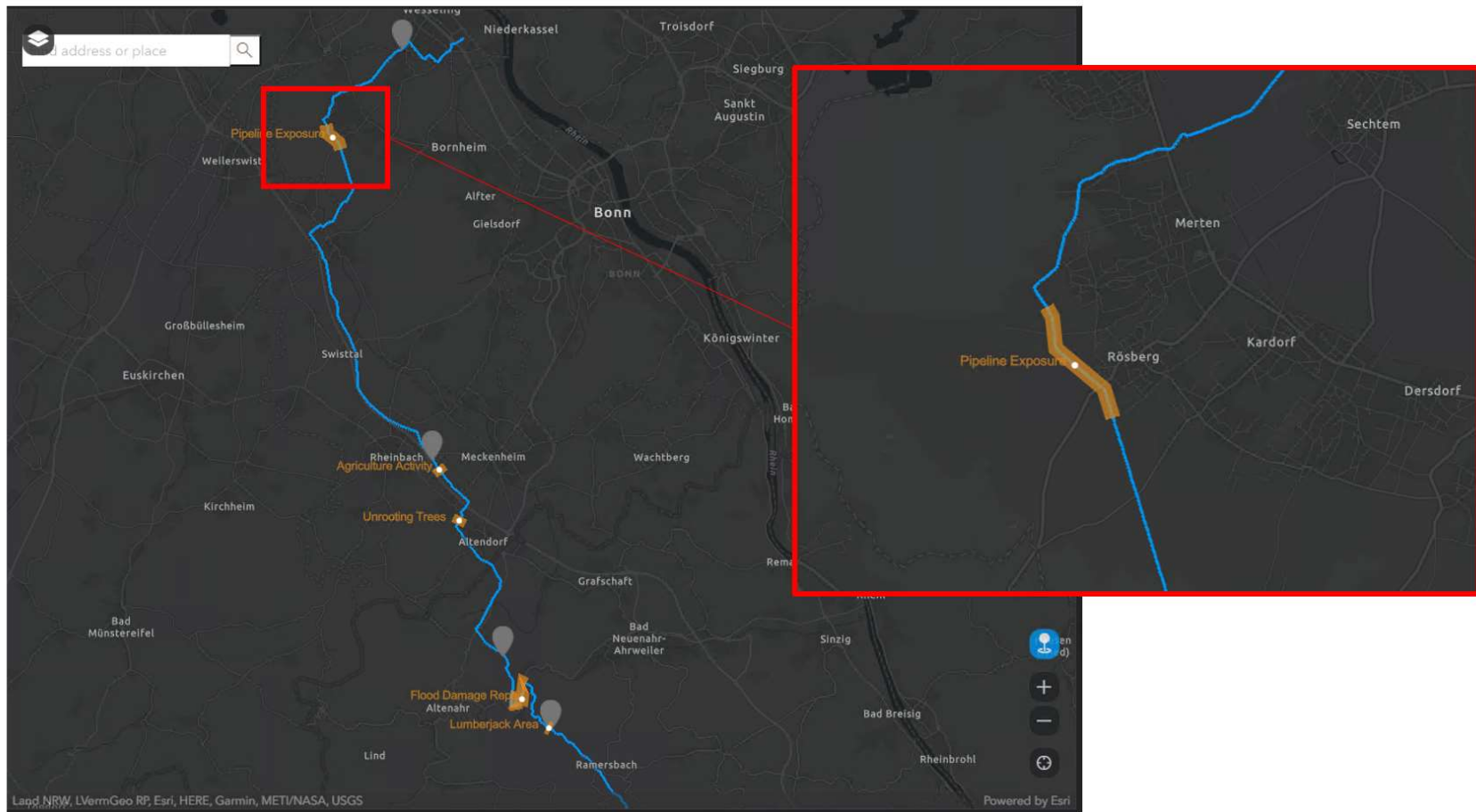
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Results

Geofencing

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Results

Geofencing

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Location Management

Map Management

User Management

Policy Management

Technician Management

← Back







⊕ Add New

Perimeter Type	Site Name	DoF	Distance From Center	Start Time	End Time	
licensed	Pipeline Exposure	11500	750 m	15:33 25.04.2022	15:33 25.04.2022	⋮
licensed	Agriculture Activity	31922	200 m	15:37 25.04.2022	15:37 25.04.2022	⋮
licensed	Unrooting Trees	35273	200 m	15:39 25.04.2022	15:39 25.04.2022	⋮
licensed	Flood Damage Repair	48220	1000 m	15:41 25.04.2022	15:41 25.04.2022	⋮
licensed	Lumberjack Area	52349	100 m	11:47 26.04.2022	11:47 26.04.2022	⋮

Results

Alert history

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Events (49/49) Last 24 Hours ▾ Event Type ▾ Priority ▾ x Clear				
<input checked="" type="checkbox"/>	 302 N° 50.762 E° 6.9134 DoF 11978 m	Max Priority: High	Started: 15:42 25.04.2022	Ended: 15:48 25.04.2022
<input checked="" type="checkbox"/>	 2903 N° 50.507 E° 7.0592 DoF 52419 m	Max Priority: High	Started: 15:57 25.04.2022	Ended: 15:58 25.04.2022
<input checked="" type="checkbox"/>	 6841 N° 50.527 E° 7.0409 DoF 49097 m	Max Priority: High	Started: 16:25 25.04.2022	Ended: 16:28 25.04.2022
<input checked="" type="checkbox"/>	 8436 N° 50.762 E° 6.9134 DoF 11968 m	Max Priority: High	Started: 16:38 25.04.2022	Ended: 16:43 25.04.2022
<input checked="" type="checkbox"/>	 11903 N° 50.525 E° 7.0404 DoF 48808 m	Max Priority: High	Started: 16:59 25.04.2022	Ended: 17:39 25.04.2022
<input checked="" type="checkbox"/>	 17958 N° 50.525 E° 7.0404 DoF 48795 m	Max Priority: High	Started: 17:42 25.04.2022	Ended: 17:44 25.04.2022



19.10.2022

Results

Current status

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- Excavator work for 10 minutes
- Time: 09:49 – 09:59
- Location: 50.6252 6.9782
- **Detected** - ID 99.594734
- Alert was combined with the following manual digging test due to system bug that was fixed.

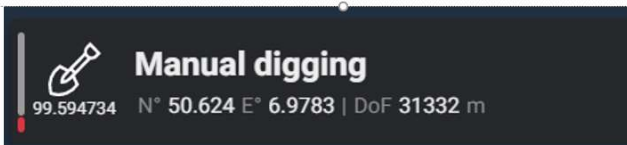


Results

Current status

34

- Manual digging for 6 minutes
- Time: 10:08 – 10:14
- Location: 50.6252 6.9782
- **Detected** | ID 99.594734

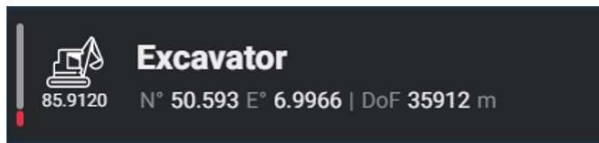


Results

Current status

35

- Excavator work for 10 minutes
- Time: 11:02 – 11:12
- Location: 50.5937 6.9966
- **Detected** - ID09-85.9120
- Alert time includes covering the hole and manual digging which came right after that, due to a very short break between events.



Results

NAR

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Date	Notifications per day
24.01.2022	1
25.01.2022	48
26.01.2022	1
01.02.2022	0
02.02.2022	40
03.02.2022	13
07.02.2022	0
08.02.2022	31
09.02.2022	20
28.02.2022	0
01.03.2022	30
02.03.2022	2
09.03.2022	0
10.03.2022	28
11.03.2022	21
15.03.2022	0
16.03.2022	20
17.03.2022	2
18.07.2022	5
27.07.2022	1
05.08.2022	0
15.08.2022	2
23.08.2022	3
01.09.2022	0
12.09.2022	2

Conclusion

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- ❑ Amazing sensitivity
- ❑ Rate of false alarms started high, decreased
- ❑ Various algorithm optimizations led to an improvement of classification
- ❑ Enhancement of UI by various software updates

- ❑ Currently not perfect
- ❑ Decision pending

Finally...

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☐ Questions ?