High speed track and tunnel experimentation with SNCF/RFF [Villecresnes site]

Élodie Roché, THALES

HIGH SPEED TRACK AND TUNNEL EXPERIMENTATION OBJECTIVE

Rationale

- Protection of hundreds of kilometers of tracks, and especially high speed tracks and tunnel entrances is a growing concern for operators
- There is a general need to:
  - Detect human trespassing (from terrorist threats to graffiti's)
  - Do so reliably at acceptable costs
  - Minimize unnecessary traffic interruptions
- This happens in such a complex environment (vegetation, urban context, railway, wild animals, graffiti, etc.) that no in-lab experimentation can really emulate
- Furthermore no “miracle technology” will provide a fully automatic solution applicable network-wide and humans will remain in the loop to take the proper decisions, provided pertinent information is available
- There is accordingly a clear need for a toolbox of tested solutions and validated principles of operation with an operator in the loop

Experimentation objective

- Such operational evaluation of different solutions for protection of high speed tracks and tunnel entrance could not be addressed in Zmigrod (which is a test ring)

- This is why PROTECTRAIL decided to set-up a dedicated experimentation over ~1 km of tracks during ~3 months
  - 1 tunnel entrance
  - Two bridges (1 pedestrian and 1 road (with sidewalk))
  - Active TGV traffic on this area: ~160km/h ~every 3 minutes

- RFF/SNCF conditions were to do so without impacting the high frequency line operations

- Principle of the experimentation: record over several weeks all events detected and associated videos to assess relevance and estimate if operator could have been in position to decide

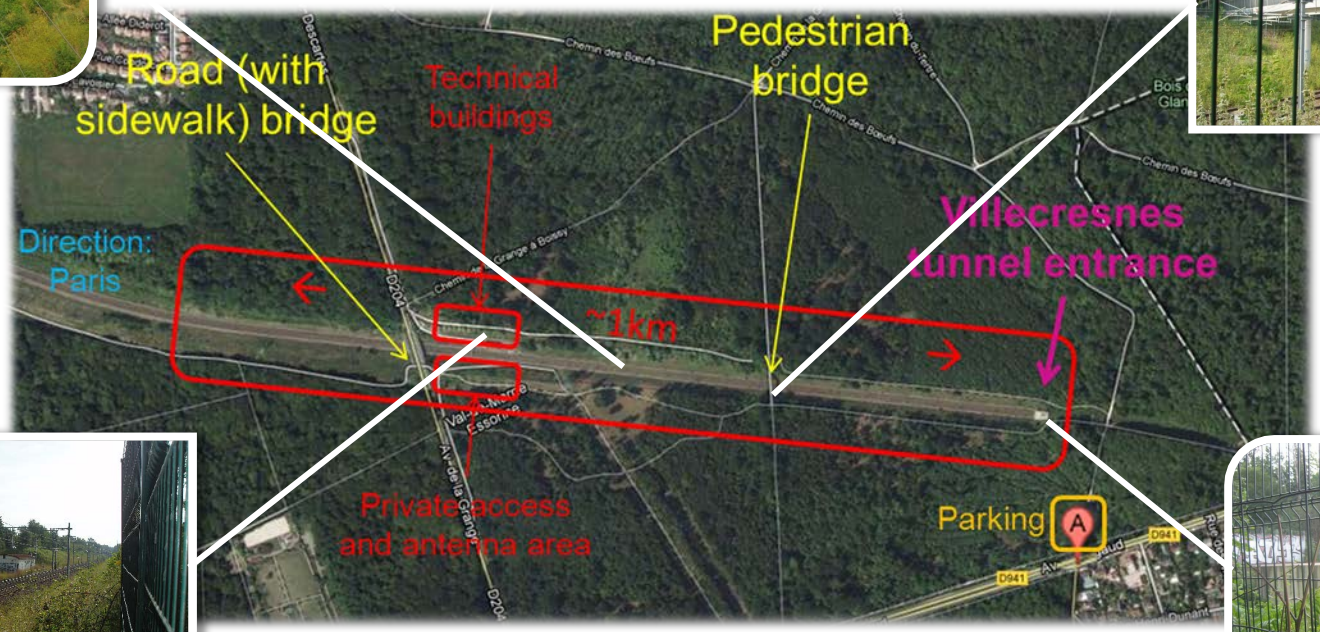
- Objective was to compare relevance of different options (internal to PROTECTRAIL and invited) and assess their ability to survive the environment on the long term (maintenance, etc.)

CHOSEN SITE: VILLECRESNES TUNNEL
(FRANCE SOUTH-EAST HIGH SPEED LINE)

Google maps:

31 Av. Gourgaud/D941, Villecresnes (see next slide)

TGV experimentation



IMPLEMENTED SOLUTIONS

Demonstration contributors

SNCF

RÉSEAU FERRÉ DE FRANCE

THALES

ALSTOM

Selex ES
A Finmeccanica Company

ISL

Rockwell Collins

SICK
Sensor Intelligence.

Contributors' solutions

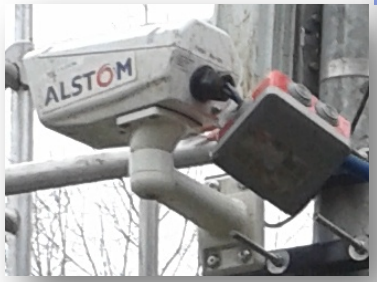
- Presented by SNCF/RFF:
  - Radar system (Rockwell Collins)

  - Scanning laser barrier for tunnel entrance protection (SICK)
  - WiMESH network (Luceor)

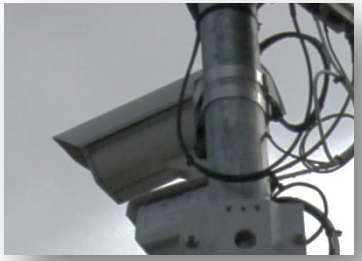
Contributors' solutions

- PROTECTRAIL partners:
  - Automatic intrusion detection on thermal camera
    - » THALES Theresis

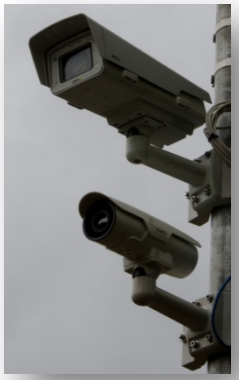
    - » ALSTOM



  - Compact system for real-time movement analysis (ISL)



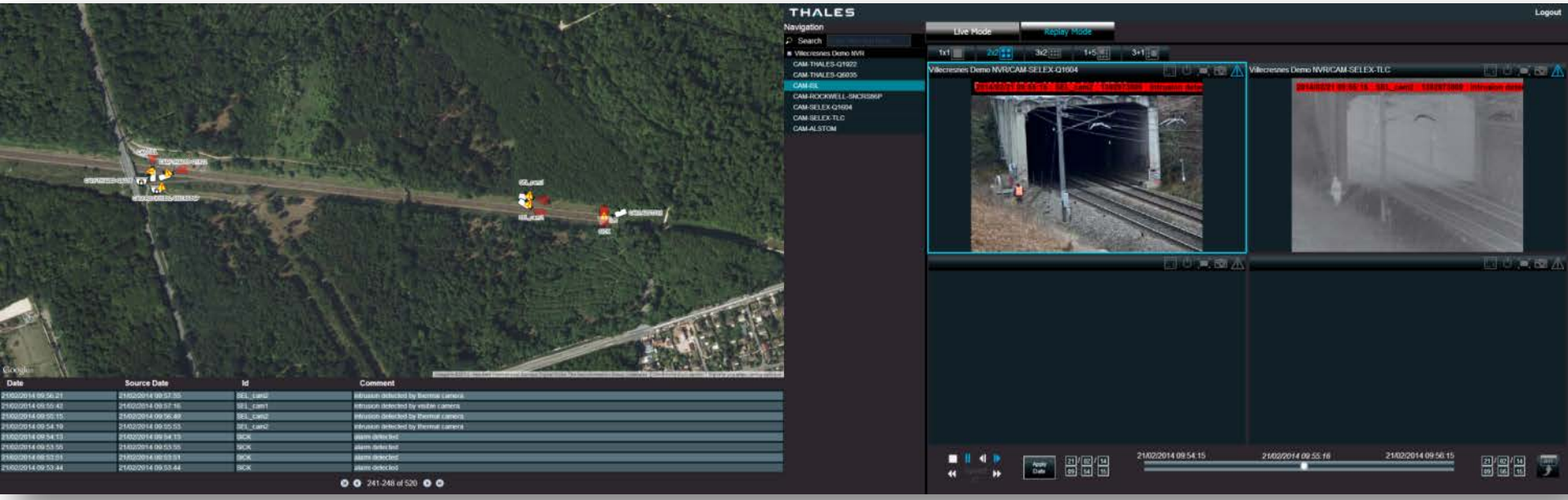
  - Tunnel entrance intrusion detection system (thermal + visible) (Selex ES)



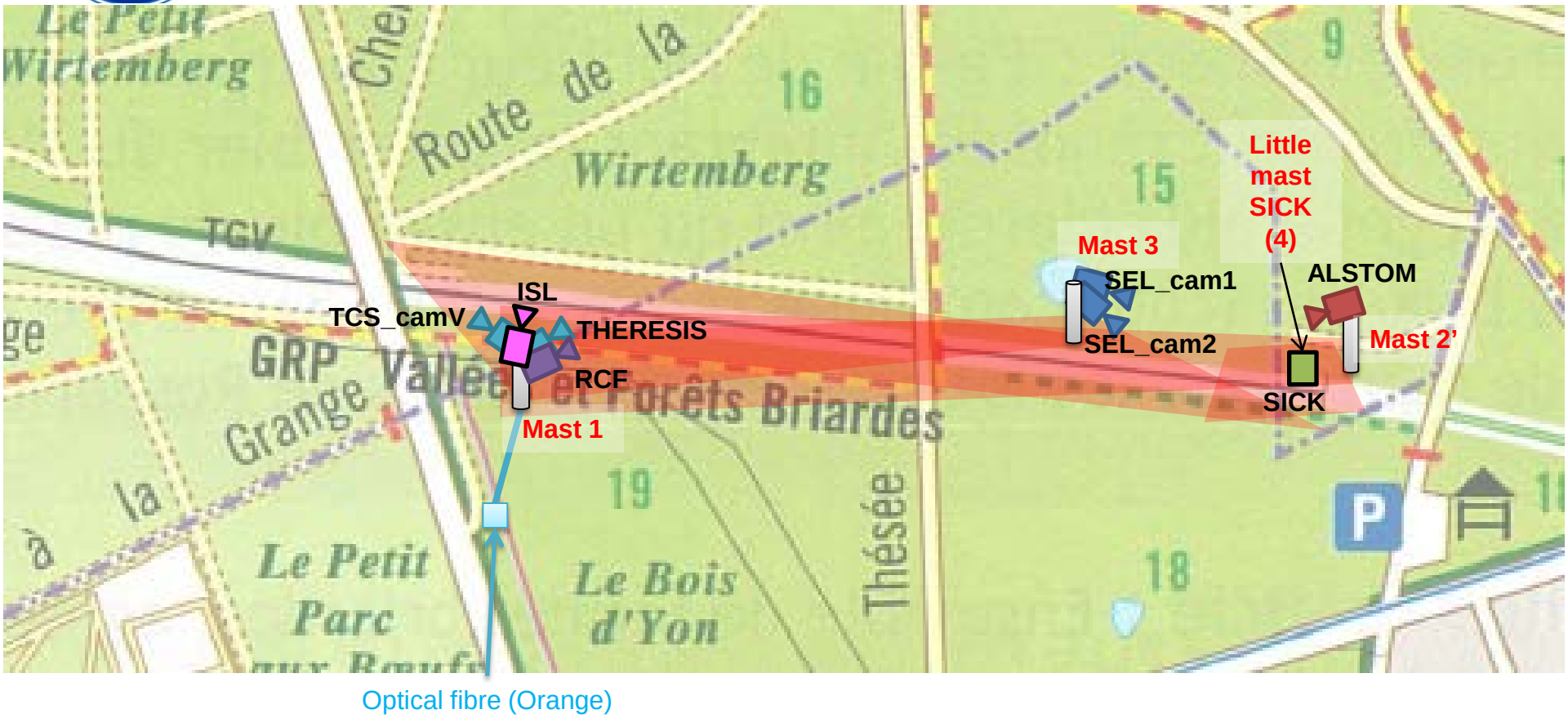
PROTECTRAIL TGV Supervisor Developed by THALES

- Supervisor infrastructure for data correlation and alarms validation
  - Real-time and recorded

- Alarms sent through HTTP to allow easy integration by all partners



Implementation



Optical fibre (Orange)

Laser barrier for tunnel entrance protection - SICK

Radar system - Rockwell Collins

Compact system with artificial intelligence linked/cabled - ISL

Camera IR - ALSTOM

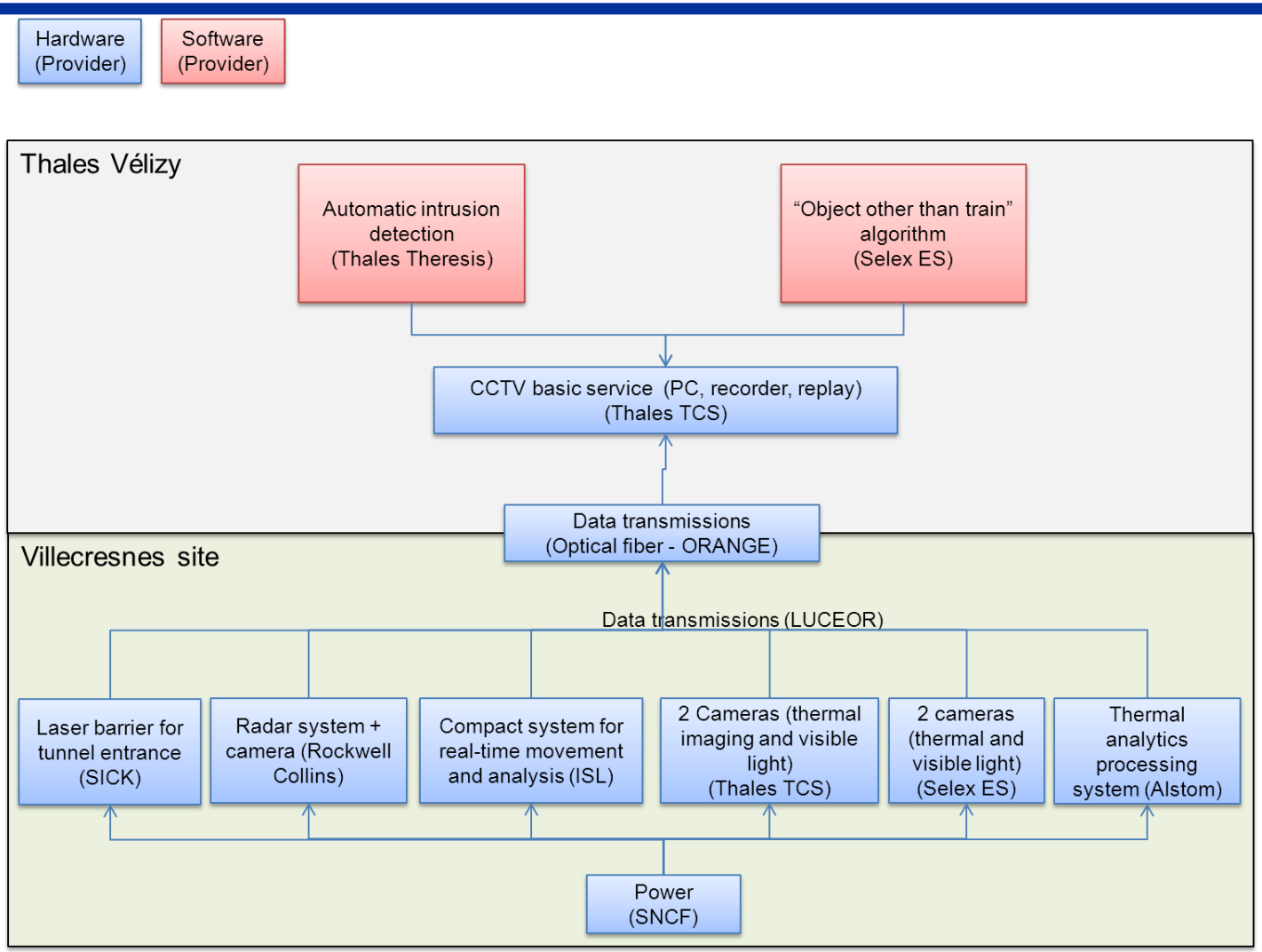
Camera IR / visible - THALES

Camera AXIS 1604-E - SELEX

Mast (1,2',3, 4) – THALES (installer)

Wi-Fi/WiMesh coverage(LUCEOR)

Architecture



Data storage, transmission – Power

- Data storage/transmission:
  - Recording at Thales Vélizy premises in order to run the video algorithms remotely to avoid intelligence on the experimentation site

  → Local WiMESH network provided by LUCEOR
  - Sustained 10 Mbps link between WiMESH and Vélizy site through optical fiber (Orange)

- Power supply:

  → Power supply provided by SNCF

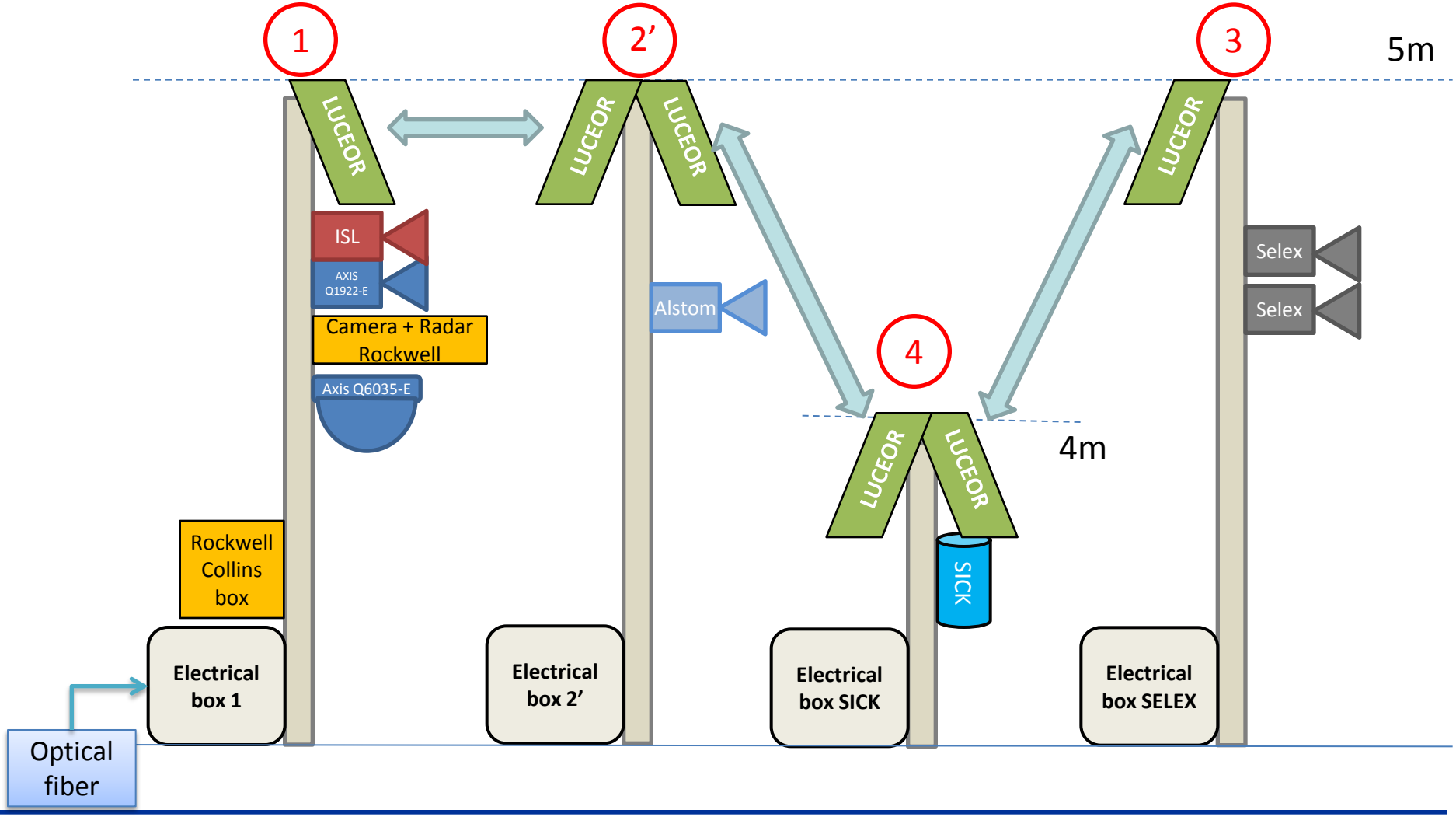
- Achieving these support functions without interfering with SNCF operations and without local infrastructures proved to be a challenge!

Installations onsite

- Installations of the devices onsite:
  - Wiring and devices on 5 meters high masts
  - Licenses/authorizations:
    - ONF (National Forest Service): OK
    - Cities (Limeil-Brévannes, Yerres): OK

  - No special security for the devices / material / hardware (no surveillance)
    - Insurance provided by each partner

Installations on the masts



TGV experimentation timeline

2013 → | July | August | Sept | Oct | Nov | Dec

Freeze of the solutions
- Details of each equipment

Freeze of the architecture
- Data storage, transmission and power
- Location of the solutions

Today

2014 -> | January | February | March | April | May

On-site installation
- Solutions
- Power supply
- Transmission and Optic fiber

Preliminary tests (integration) & learning phase

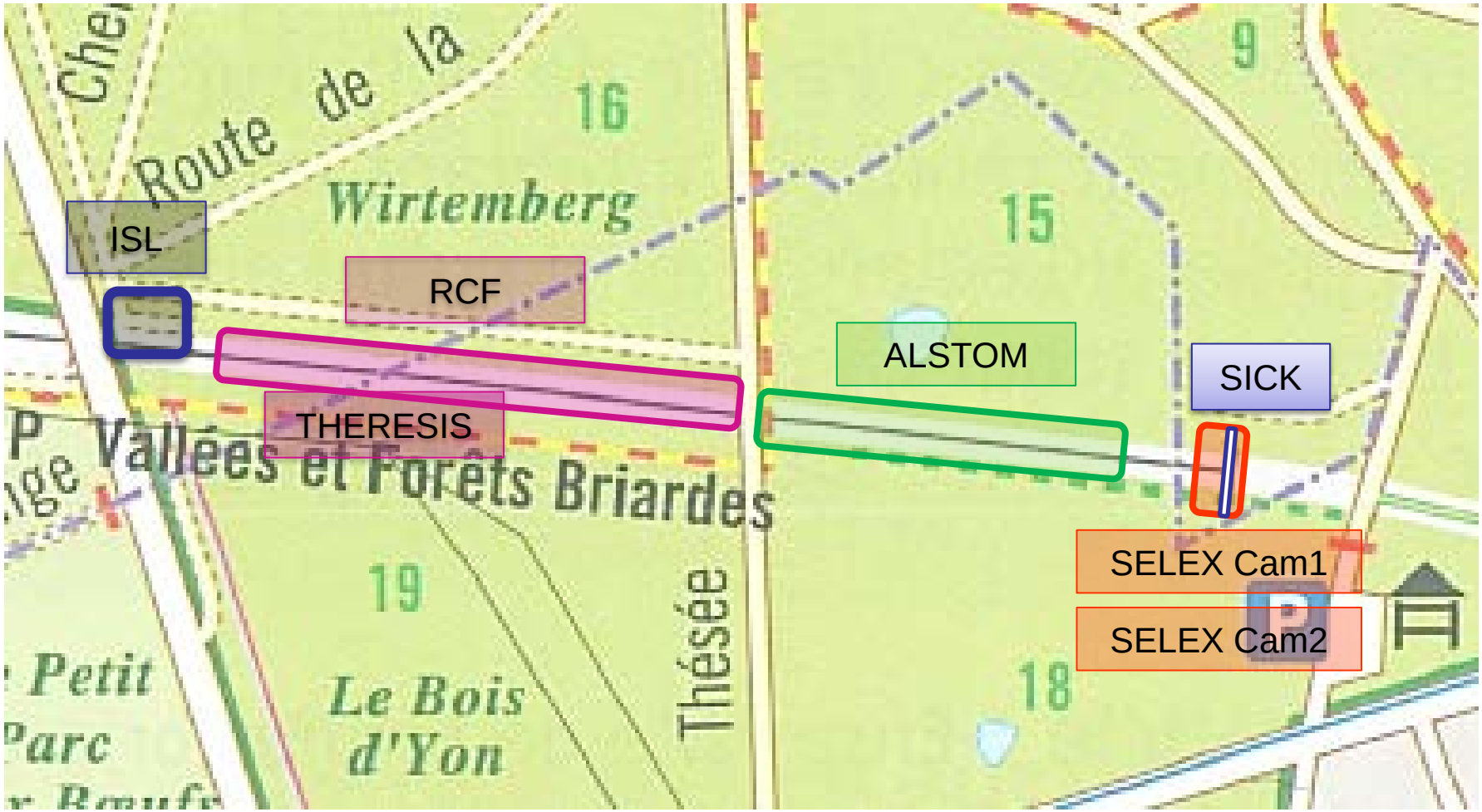
Experimentation
- "Real-time" detections
- Data storage and treatment in Thales Vélizy

Conclusions – Cost Benefit Analysis

25 February 2014
PROTECTRAIL TGV demo
With an onsite visit

CONCLUSIONS

Detection areas



Generalities

- All the detections have been understood thanks to the video:
  - Thermal camera obligatory to validate alarms during the night
    - And useful to detect persons behind vegetation!

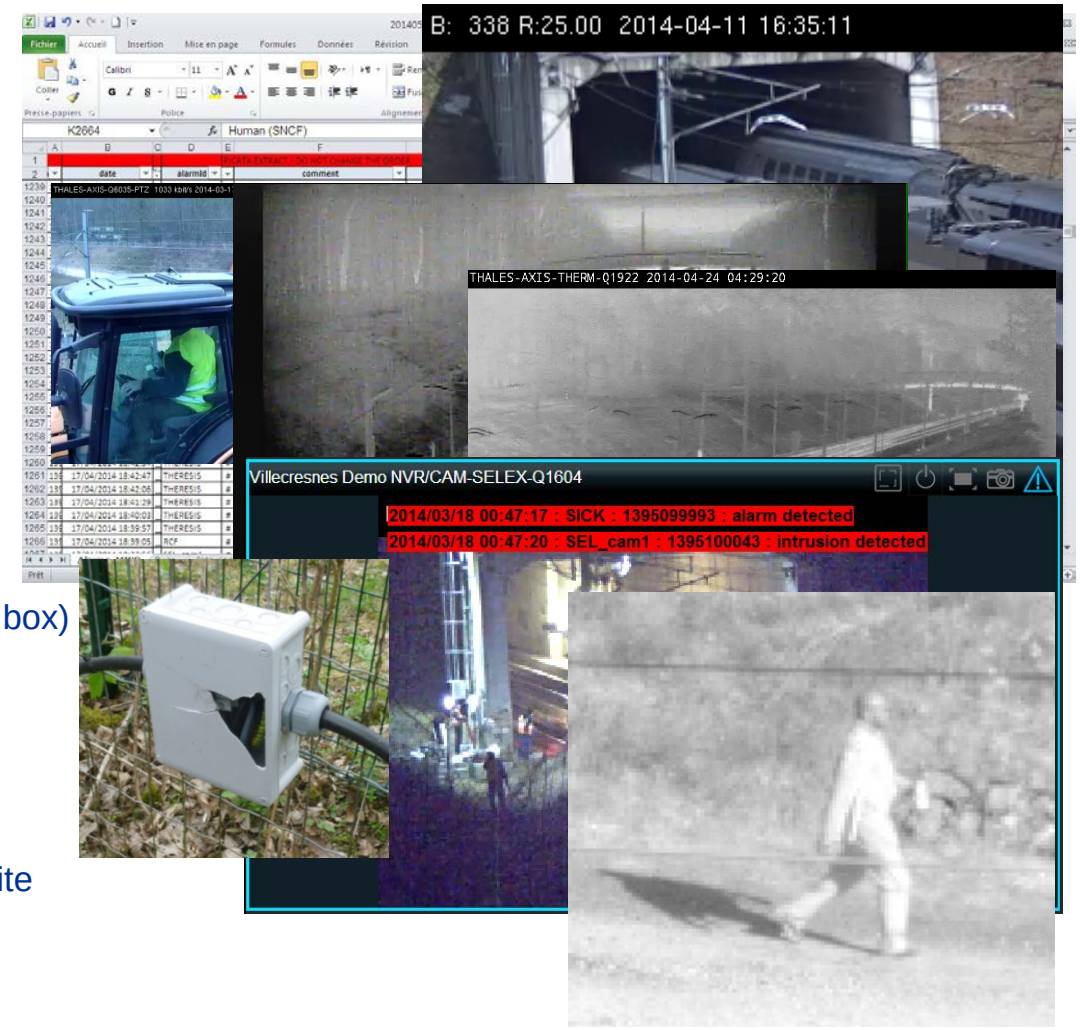
  - Video or image is essential for the operator to assess the alarms
- False detections due to criteria complexity
  - Reality is very different from in-lab tests
    - For example, projected shadows, trains speed, lights reflection, vegetation, animals, etc.
  - Some partners have improved their system during the experimentation
    - Distinct enhancement observed

Generalities

- Easy integration of alarms from different partners (both PROTECTRAIL and not PROTECTRAIL)
- Need for a long period of tests to have realistic conclusions… 3 months was great but not sufficient!
- Ideally, all videos should be viewed (everything has been recorded) in order to define false-negative rate
  - Potential intrusions detected by no sensor are not checked!
  - But the likelihood is very low…
    - A lot of alarms…
    - & redundant systems on the access points

Some figures…

- 3 months test
  - Minus 4 days without power supply…
- 5262 alarms to review
  - 1028 alarms due to trains
  - 629 false alarms
  - 1 tractor
  - 1 “watchman”
  - 372 alarms due to animals
    - 2 “friends” named Foxy 1 and Foxy 2
  - A lot of maintenance work
- 0 deterioration
  - (except a small damage on an electrical box)
- 60 real human intrusions
  - Detected through 2614 alarms
  - All SNCF ones
  - Except maybe one →
  - ~105 hours of human presence on the site
- No snow… but sun, rain and fog



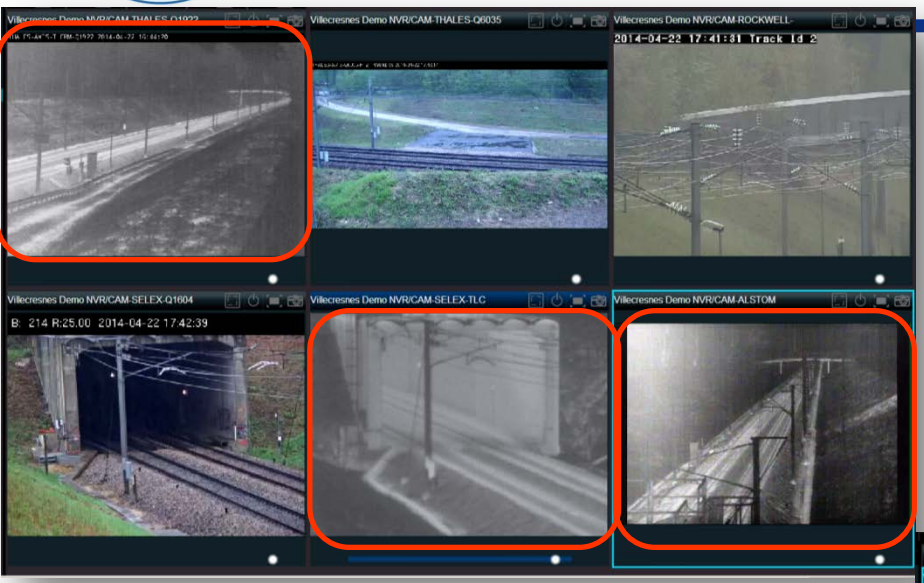
Weather conditions

Thermal cameras

Sunny - Morning

Sunny - Afternoon

Weather conditions



Thermal cameras

Fog…

Rain

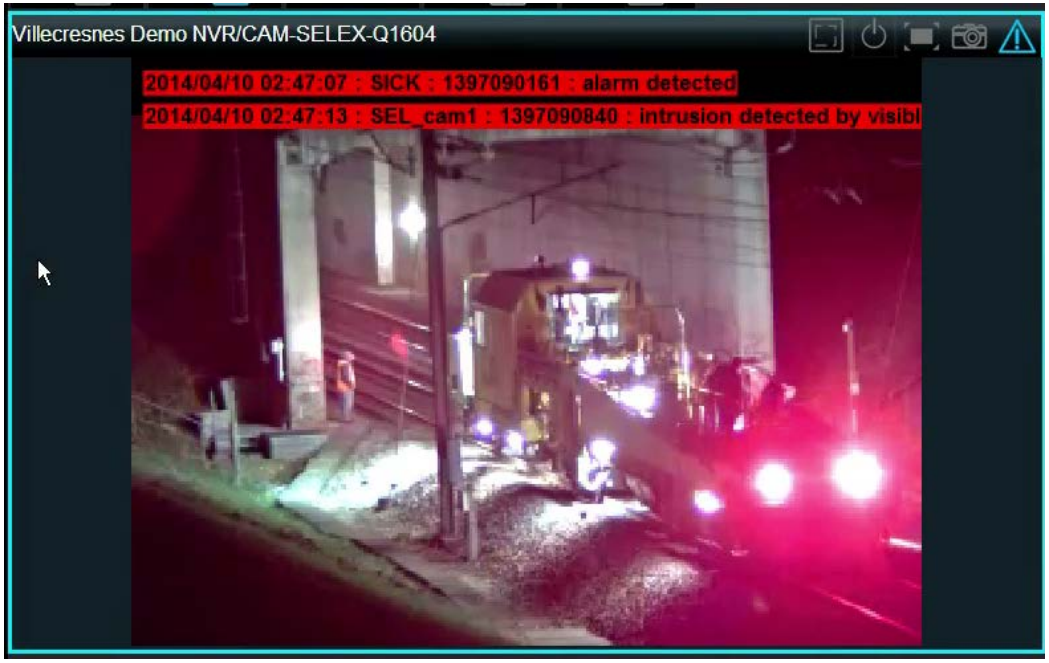
Scanning laser barrier for tunnel entrance protection – SICK

- All intrusions inside the tunnel have been detected
- Some false alarms due to shiny trains or windows
  - Installation/security constraint: not too close of the entrance → missing the back wall of the tunnel
- For a “real” implementation:
  - To avoid occlusions due to trains:
    - Install the sensor above the tunnel, looking top-down
    - Install two sensors (one looking each side of the entrance)
  - Need a fixed reference: back wall of the tunnel, etc.
  - Improvement of train filtering: detection of slow trains or trains that are stopped with the beginning or the end in the field of detection (meaning less than 2m detected)
    - A solution could be to add 2 simple sensors to confirm that it is a train

Tunnel entrance intrusion detection system (thermal + visible) – Selex ES

- On visible camera, all intrusions have been detected
- On thermal camera, conclusions are more difficult as the camera had to be restarted frequently and was off half of the time
  - But less false alarms per day on, as less sensitive to luminosity changes → Thermal camera could be used alone, even if both cameras can be used for data fusion
- Some alarms due to trains
  - Improvements in the algorithm decreased the false alarms
- For a “real” implementation:
  - Wider field of view
  - Lower the alarms due to trains thanks to additional improvements or coupling with a system detecting trains
  - Idea: camera installed above the tunnel, looking top-down to avoid occlusions due to trains

SICK and SELEX ES alarms



FILM VISIBLE

FILM THERMAL

Automatic intrusion detection on thermal camera – ALSTOM

- Around one month detection
  - Due to settings, the emails were not delivered to the relevant address → need more time to analyze this period in details
- Most of the human intrusions detected
- Some false alarms detected: unexplained and very few due to trains
- A lot of “camera rebooted” problems
  - Initial use case: camera design dedicated to work alone and to send email including short video sequence only when an intrusion is detected
  - In this experimentation: the video stream was requested all the time → may have saturated the camera
  - Missing some time to test other settings
- For a “real” implementation:
  - Remain with the original specification, e.g. without extracting full time the video stream

Automatic intrusion detection on thermal camera – ALSTOM

FILM

Radar system – Rockwell Collins France

- After test and configuration phase, good results
  - ~1 false alarm per day on (mostly due to wind, no small animals)
  - When an intrusion is detected:
    - Possibility of zoom (day time)
    - Intruder followed while present on the area
- Wind: biggest problem as it moves trees at the edge of the fences
  - Could be improved thanks to filters
  - More time needed, but RCF contributed without PROTECTRAIL budget!
- Alarms validated with an additional thermal camera during the night
- For a “real” implementation:
  - Parameter the system to send the alarm quickly or not depending on the use case/field of view
  - Put the system on a longitudinal axis to decrease sensitivity to catenary movement and to avoid them from masking part of the scene
  - More calibration required within the detection area with human targets to parameter the system
  - Antenna parameters: 40° azimuth & 25° “rising” → can be placed high up with a little dead zone on the ground

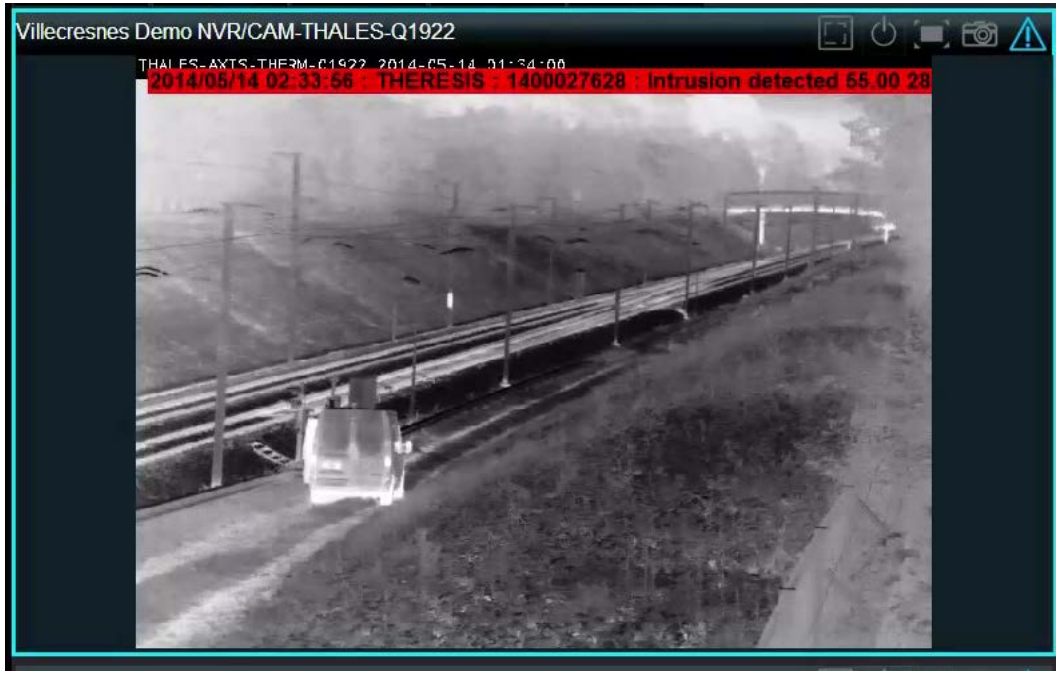
Radar system – Rockwell Collins France

FILM

Automatic intrusion detection on thermal camera – THERESIS

- All human intrusions detected
  - Day & night
- Good vision even with fog
- Alarms due to trains and foxes reduced thanks to:
  - Filters improvement
  - Clustering on the fragmented detections
- For a “real” implementation:
  - Better to really align the camera to the tracks
  - Possibility to increase the focal length of the camera optics to gain detection on a longest distance (here, ~450m)
  - To decrease the false alarms:
    - Decrease detection sensitivity
    - Use of estimated 3D speed with precise calibration
    - Store full track information on several seconds to improve classification
  - Alarms can be managed depending on the use case

Automatic intrusion detection on thermal camera – THERESIS



FILM

Compact system for real-time movement analysis – ISL

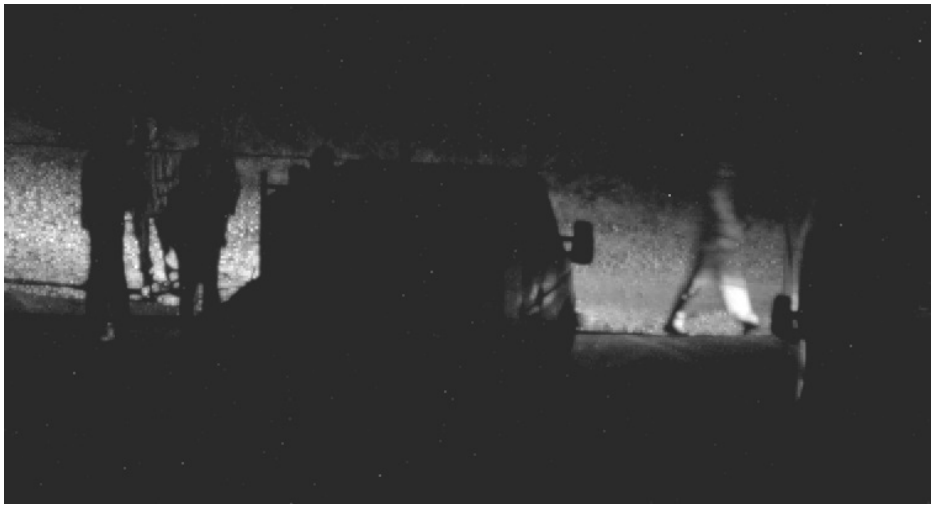
- First evaluation in a specific intrusion detection application
  - Thanks to PROTECTRAIL: TRL=5 ➔ TRL=6

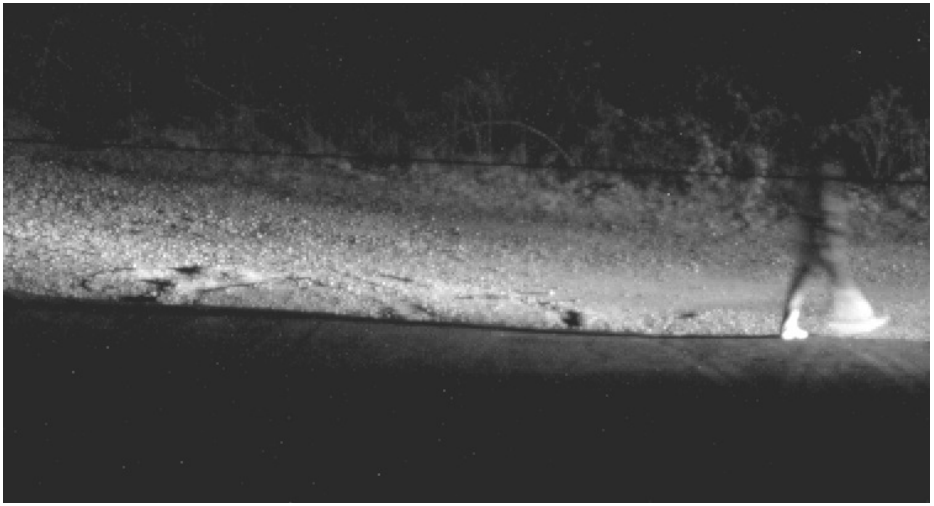
- Good results:
  - Significant intrusions reported with at least 1 alarm per person intrusion
  - Efficient filtering of trains, cars and irrelevant movements (vegetation, catenary wires)
  - Night mode validated using standard CMOS sensor

- For a “real” implementation:
  - Fixed mounting point (not sensitive to wind)
  - Transversal movement analysis
  - No need of high bandwidth, intrusion assessment with photographs

- Future development:
  - Association with ISL-ELSI Artificial Intelligence Chip for high level recognition and classification tasks
    - Suspicious human vs. authorized staff, animals (birds, boars, deers, foxes, etc.)
  - Use of thermal cameras or high sensitivity sensors

Compact system for real-time movement analysis – ISL





TGV supervisor – THALES

- Proved to be a good and simple tool for an operator to interpret alarms real-time and post-event:
  - A web application: no deployment needed on workstations, a recent browser is enough
    - On one or two monitors: map, alarms, video streams live and recorded
  - Adds convenient features to classic video functionalities
    - Easy extraction of videos as AVI files and ISO22311 files
    - Snapshots, in addition to trick-play features
  - Alarms are strongly linked to videos, for an efficient real-time and post-event analysis
    - Alarms displayed as a list, geo-localized on a map and overlaid on the video
  - Cartography can use any WMS (Web Map Service) server or Google Maps

TGV supervisor - Film

FILM

Lessons for an operator

- A first toolbox of solutions has been tested in real conditions
  - Some industrialization remains necessary
  - But real implementation based on the described systems can now be recommended

- An operational approach with operator in the loop to confirm the detections as applicable

- Interesting findings are that:
  - Recent progress on camera technology allows greater distance between systems (typically a minimum of 450m)
  - Especially as recognition is not required
  - Thermal cameras allow to detect trespassing and for the operator to assess alarms also during the night & during bad weather conditions
  - Additional systems (radar and laser) are complementary to imagery

Conclusions

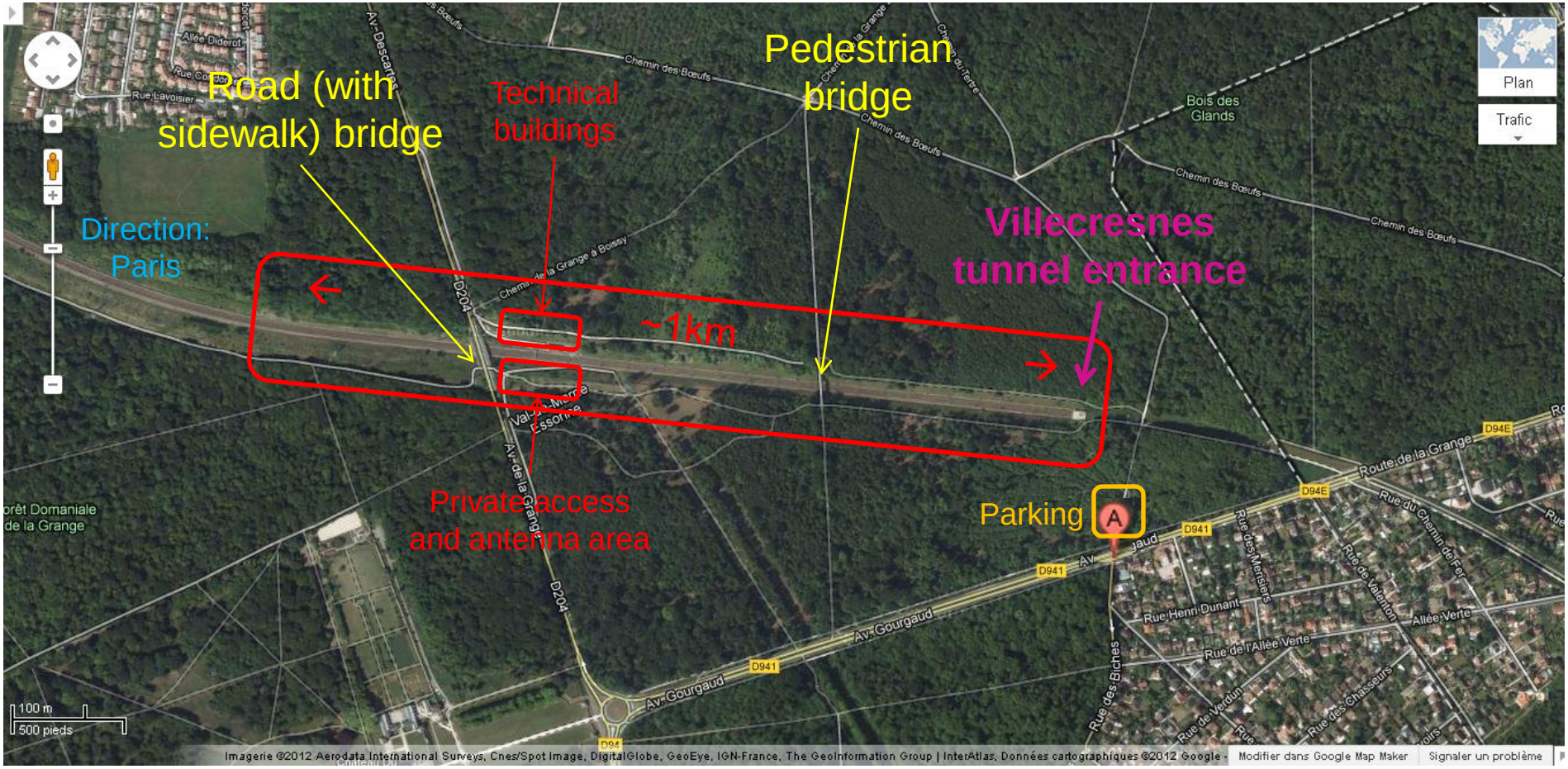
- This experimentation has been really appreciated by all the partners
  - Tests in real environment are much better than tests in-lab to improve the solutions

- It couldn’t have been achieved without the support of SNCF and RFF: THANK YOU!

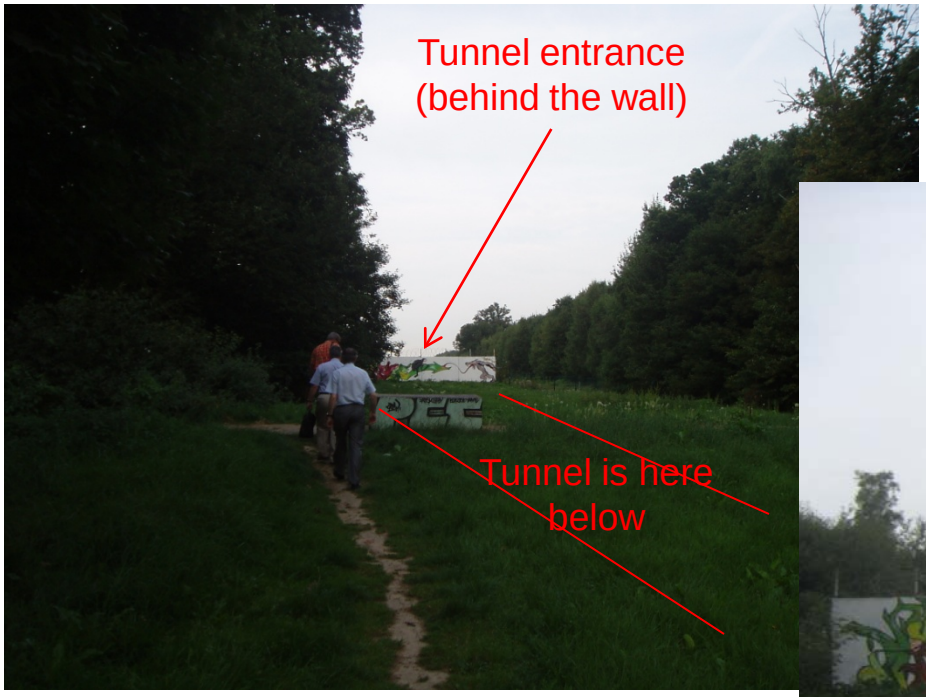
MEET US AT OUR TGV DEMO BOOTH FOR MORE INFORMATION

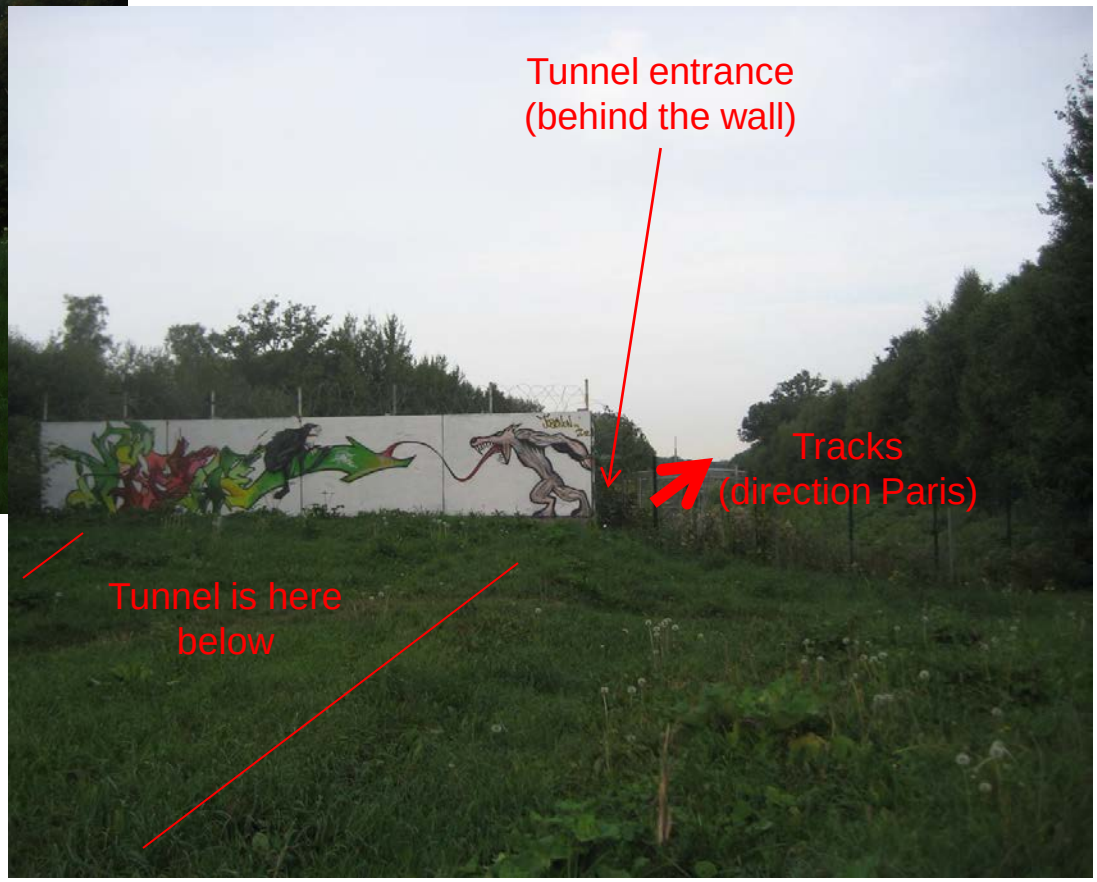
THANK YOU!

Villecresnes site overview



Villecresnes tunnel entrance

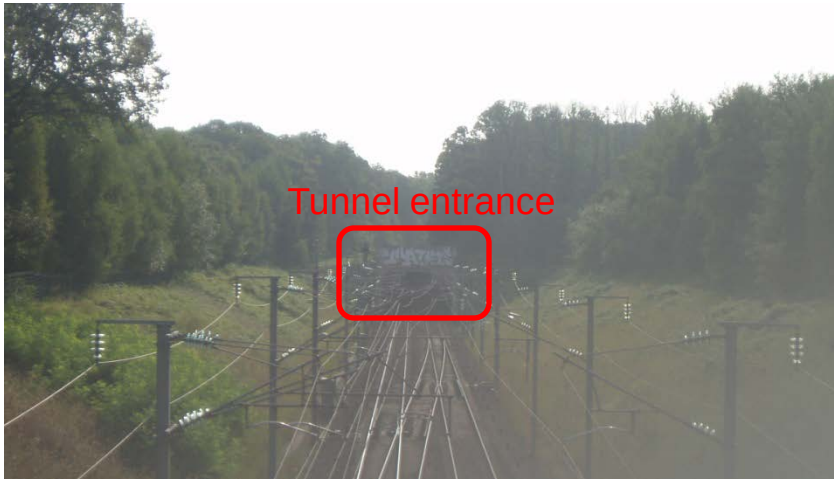


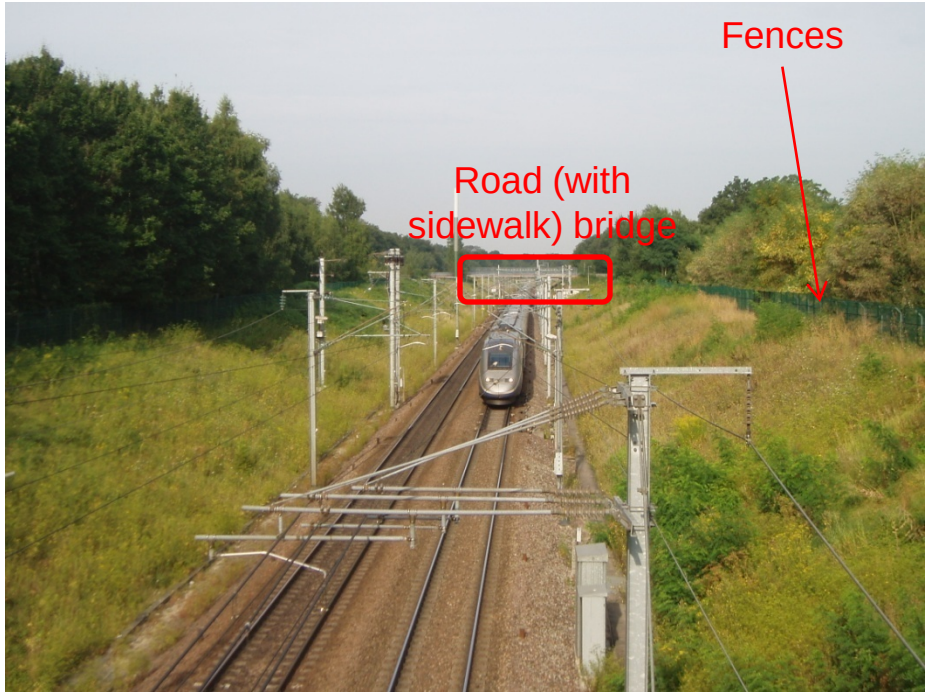


Villecresnes tunnel entrance

Along the tracks

Pedestrian bridge and visibility from there





Road (with sidewalk) bridge

Access to the technical buildings (mechanical locker protected gate)

Vicinity of the road (with sidewalk) bridge