High speed track and tunnel experimentation with SNCF/RFF [Villecresnes site]
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
- ISL
- Rockwell Collins
- SICK

PROTECTRAIL – TGV demonstration – 27/05/2014
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

- Camera IR - ALSTOM
- Camera IR / visible - THALES
- Camera AXIS 1604-E - SELEX
- Compact system with artificial intelligence linked/cabled - ISL
- Radar system - Rockwell Collins
- Laser barrier for tunnel entrance protection - SICK
- Optical fibre (Orange)
- Wi-Fi/WiMesh coverage (LUCEOR)
- Mast (1,2',3,4) – THALES (installer)

System Overview:
- Mast 1
- Mast 2'
- Mast 3
- Mast 4

Components:
- TCS_camV
- THERESIS
- RCF
- SEL_cam1
- SEL_cam2
- ALSTOM
- SICK
- ISL

Navigational Information:
- Route de la Wirtemberg
- La Thèse
- Le Petit Parc aux Rues
- Le Petit Wirtemberg
- Grange Vallée et Forêts Briardes
Architecture

Thales Vélizy

Automatic intrusion detection (Thales Theresis) → CCTV basic service (PC, recorder, replay) (Thales TCS) → "Object other than train" algorithm (Selex ES)

Villecresnes site

Laser barrier for tunnel entrance (SICK) → Radar system + camera (Rockwell Collins) → Compact system for real-time movement and analysis (ISL) → 2 Cameras (thermal imaging and visible light) (Thales TCS) → 2 cameras (thermal and visible light) (Selex ES) → Thermal analytics processing system (Alstom) → Power (SNCF)
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

1. Electrical box 1
   - Rockwell Collins box
   - Optical fiber

2'. Electrical box 2'
   - Camera + Radar
     - Rockwell
   - Axis Q6035-E

3. Electrical box SELEX
   - Selex

4. Electrical box SICK
   - SICK

Connections:
- 5m between 1 and 3
- 4m between 2' and 4
- Arrows indicate connections between installations

PROTECTRAIL – TGV demonstration – 27/05/2014
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

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

Today

Conclusions – Cost Benefit Analysis

25 February 2014
PROTECTRAIL TGV demo
With an onsite visit
CONCLUSIONS
Detection areas

Detection areas:

- ISL
- RCF
- THERESIS
- ALSTOM
- SICK
- SELEX Cam1
- SELEX Cam2
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
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
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
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

- Road (with sidewalk) bridge
- Technical buildings
- Pedestrian bridge
- Villecresnes tunnel entrance
- Private access and antenna area
- Parking

Direction: Paris

1 km
Villecresnes tunnel entrance

Tunnel entrance (behind the wall)

Tunnel is here below

Tracks (direction Paris)

Tunnel entrance (behind the wall)

Tunnel is here below
Villecresnes tunnel entrance
Along the tracks

About 20 meters between the tracks and the fences
Pedestrian bridge and visibility from there

- Height ~2m50
- Fences
- Road (with sidewalk) bridge
- Tunnel entrance
Road (with sidewalk) bridge

Height ~2m50

Access to the technical buildings (mechanical locker protected gate)
Vicinity of the road (with sidewalk) bridge

- Technical buildings (including mast)
- Private access that may be used to install some equipments (TBC)
- Pedestrian bridge
- Antenna area
- Trail along the fences