Threat detection to pipelines using an automated aerial surveillance system

G. Pognonec[1], M. Lecchi[1], J.A. Lana[2], B. Raguin[3], M. Sohlbach[4], A. Scholtz[5],

[1]GDF SUEZ – CRIGEN (F)
[2]Enagás (E)
[3]GRTgaz (F)
[4]Trimble (D)
[5]Technische Universität Braunschweig (D)

International Gas Union Research Conference 2014

Copenhagen, Denmark

17th September 2014

Index

1. Background
2. iNTeg-Risk project
3. What a UAS is
4. Regulation for using UAS
5. Automatic surveillance with UAS
6. Experimental Flights
7. Efficiency and risk
8. Future development
9. Conclusion

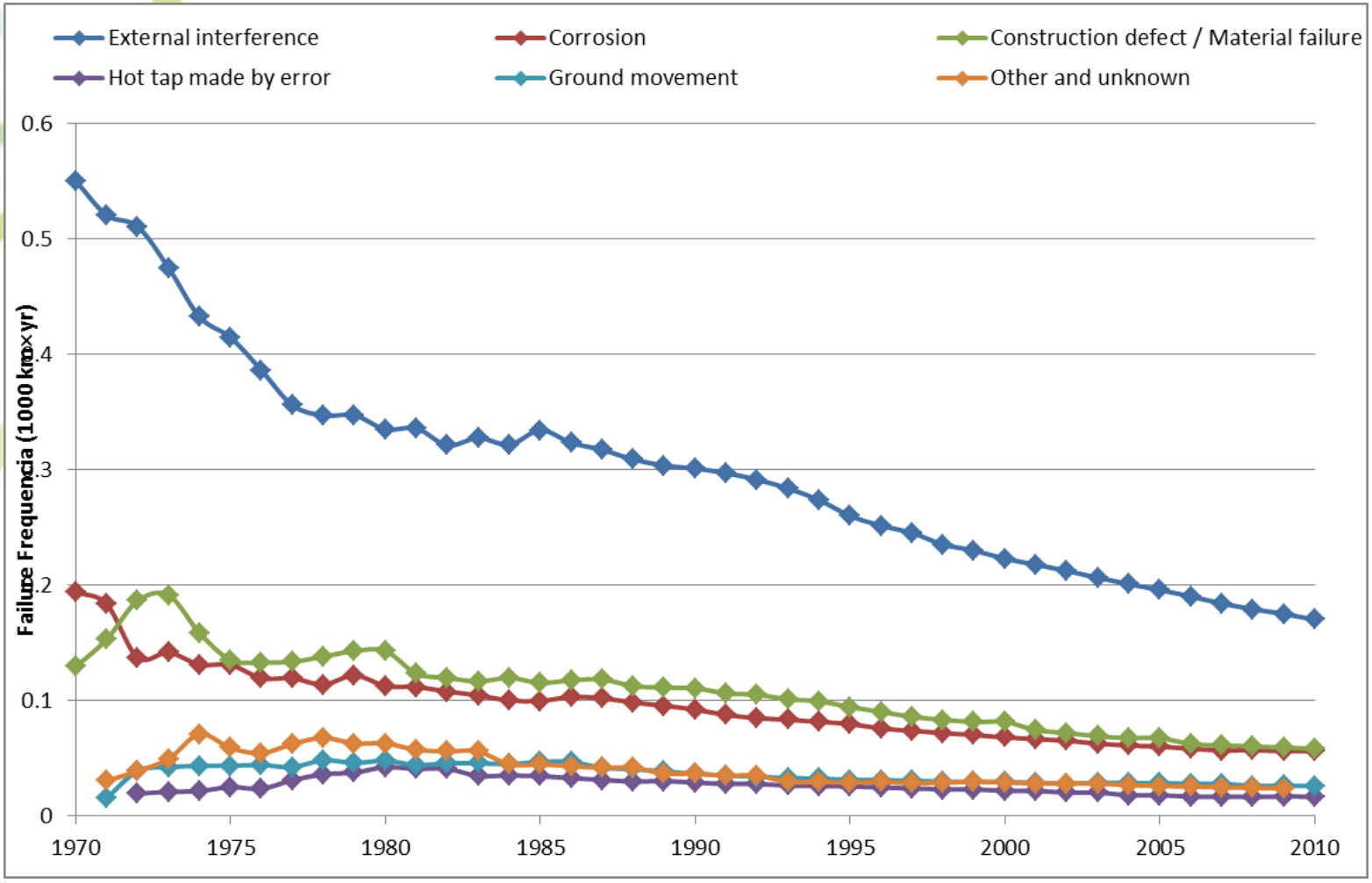
Index

Background

- Natural gas transport by pipeline is one of the safest transportation methods of dangerous goods.
- Gas leakage statistics shown a continuous improve (less leakages) with years:
  - Better surveillance modes.
  - Better construction techniques.
  - Better maintenance procedures.
  - …
- Anyway, accidents happens:
  - About 50 % of unintentional gas leakages are caused by third parties.

Western European statistics

- Improvement year by year.



Source: 8th EGIG report

Pipeline safety management

- Surveillance is a preventive barrier.
- Classical surveillance methods: by foot, car, helicopter or plane.
- Pipeline operators are continually looking for new system to improve surveillance:
  - Techniques based on fibre optic cable.
  - Techniques based on sound detection.
  - …
- *Automated Aerial Surveillance System:*
  - Innovative safety barrier.
  - Aim to reduce cost and environmental footprint.
  - Develop in the framework of ***iNTeg-Risk*** project.

Index

Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related, Risks

iNTeg-Risk

Grant agreement number: CP-IP 213345-2

- R&D Project funded by European Commission:
  - 7th R&D Framework Programme.
  - Global objective was *developed a methodology to detect emerging risk*.

- Organization:
  - 5 Subprojects.
  - 88 partners.
  - Budget: ≈ 19 M Euros.
  - Duration: 54 months: 1/12/2008 – 31/05/2013.

- Our participation:
  - *To study emerging risk of threat detection by an automated aerial surveillance system of industrial infrastructures using an **UAS**.*

Index

Automated Aerial Surveillance System

- Required the utilization of an UAS, but …
- ***What is a UAS?***
- ***Unmanned Aerial System:***
  - Unmanned Aerial Vehicle, UAV.
  - Remote Piloted Aerial System, RPAS.
  - Drone.
  - And more.
- In the context of industrial infrastructure surveillance, like gas pipelines, would be a *small aircraft*, similar to an air model or slightly bigger:
  - With an automatic navigation system: inertial and GPS.
  - Carrying photo and/or video cameras.
  - Able to take off/landing in reduce space.

UAS *CAROLO P200*

- Weight: 6 kg.
- Payload: 1.5 kg.
- Maximum: 4 cameras:
  - 2 digital photo camera.
  - 2 real time video camera.
- Autonomy: 90 min.
- Speed: 75 km/h.

- Very stable flight, gives high quality images.

Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related, Risks
iNTeg-Risk
Grant agreement number: CP-IP 213345-2

UAS *DT18*

- Weight: 2 kg.
- Payload: 0.25 kg.
- 2 camera, one real time video.
- Autonomy: 100 km.
- Speed: 50 km/h.

UAS *ELIMCO E-300*

- Weight: 15 kg.
- Payload: 4 kg.
- 2 or 3 camera, including real time HD video.
- Autonomy: 180 min.
- Speed: 60 – 110 km/h.

UAS *CatUAV Atmos 5*

- Weight: 2 kg.
- Payload: 0.5 kg.
- 2 camera, one real time HD video.
- Autonomy: 180 min.
- Speed: 40 – 75 km/h

Other UAS

These are ***not UAS in the context of the project:***

RQ-4 Global Hawk

MQ-9 Reaper

Index

UAS Regulations

- UAS is a new technology:
  - ***From 2008 new regulation has entried into force.***
- At the beginning of project, 2008, no regulation in participating countries.
- ***Existing regulation in 2014:***
  - General supporting document to RPAS from EC.
  - France & Spain: very restrictive regulation.
  - Germany: no regulation, special permission needed.
- Current general limitations:
  - 2 kg weight.
  - Flight altitude below 150 m.
  - *This limits the fit for purpose*.

Index

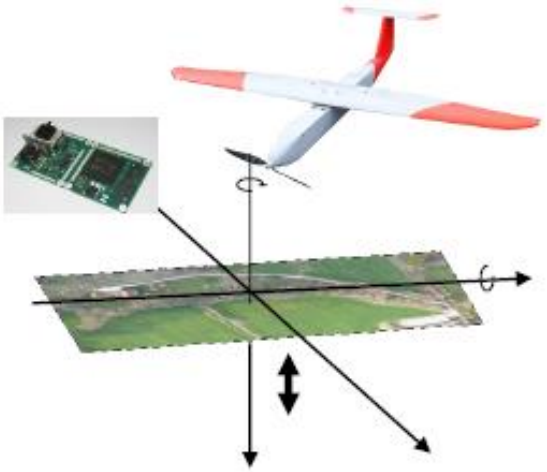
1. Background
2. iNTeg-Risk project
3. What a UAS is
4. Regulation for using UAS
5. **Automatic surveillance with UAS**
6. Experimental Flights
7. Efficiency and risk
8. Future development
9. Conclusion

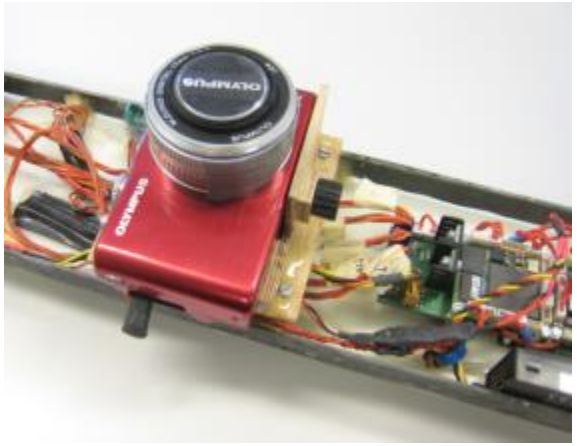
Steps in authomatic aerial surveillance

- Step 1: Image acquisition.
- Step 2: Image processing.
- Step 3: Threat detection:
  - Utilisation of a software for detecting differences between *images taken at different times*.
- All the steps are highly automated to minimise human intervention.

Step 1: Image acquisition

- Elements needed: UAS
  - Unmanned aircraft.
  - Autopilot.
  - Global Navigation Satellite System , GNSS.
  - Inertial Measurement Unit (IMU):
    - UAS's position and attitude (roll, pitch, yaw).
  - Camera system.

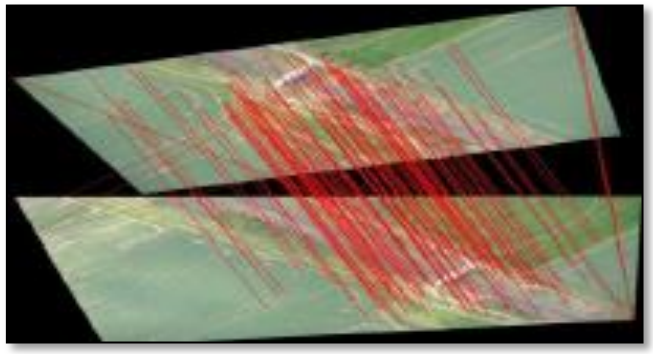


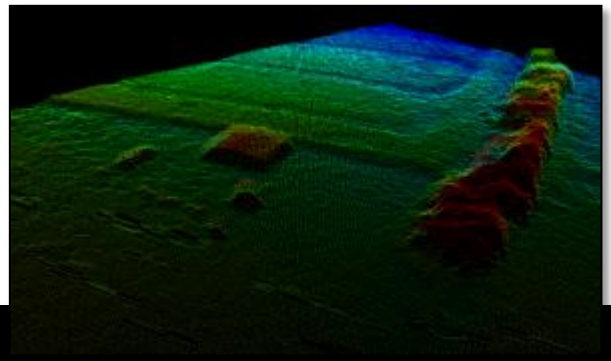


- Each acquired image is referenced by coordinates and position within 3D space.

Step 2: Rectification and mosaicking

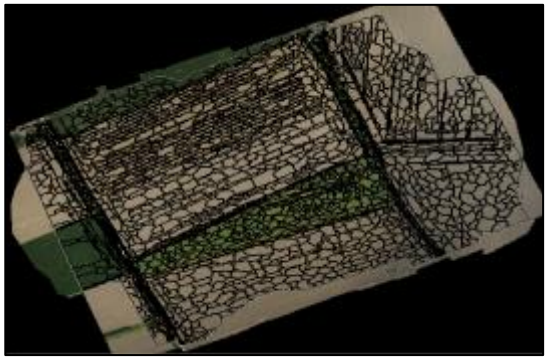
- Automatic detection of tie points in aligned images.
- Automatic generation of height model.
- Automatic orthorectification and mosaicking.

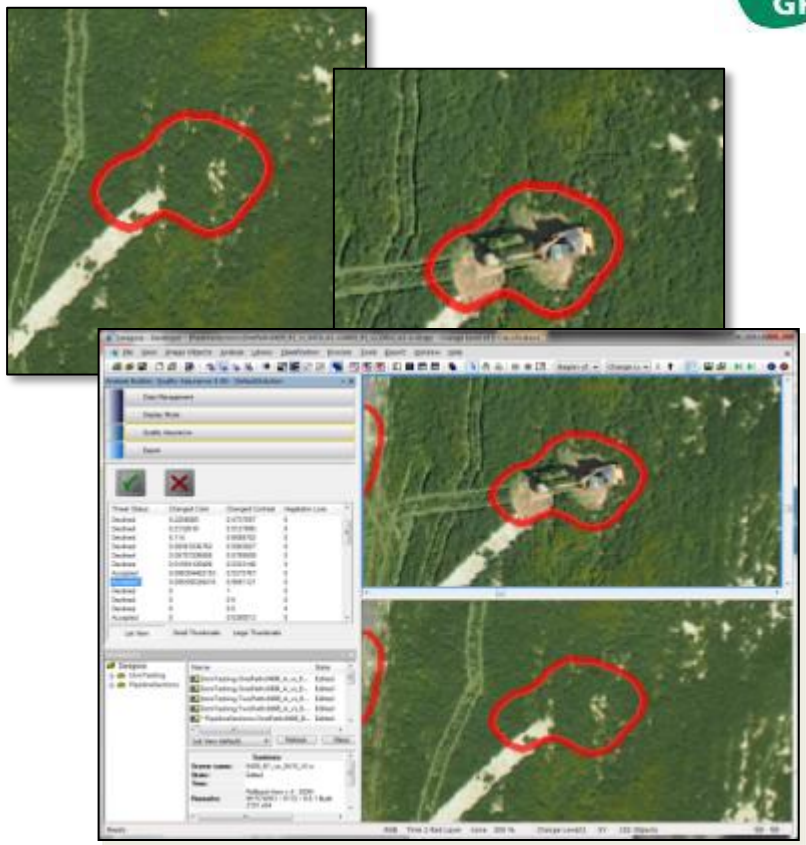




Step 3: Analysis and threat detection

- Automatic object-based detection of potential threats.
- Comparison of images taken at different times.
- Comparison and weighting of three criteria:
  - Color layers: red, green & blue.
  - Contrast.
  - Shape.
- Automatic threat detection.
- Manual validation of threats.





Index

Experimental flights

- 5 flight campaigns:
  - Spain, June 2009.
  - France, October 2009.
  - Germany, July – September 2012.
  - France, October 2012.
  - Spain, April 2013.

- Two UASs tested:
  - *Carolo P200*, develop by TUB for the project.
  - *DT18*, French provider fulfilling French regulations.

- The campaigns allowed:
  - To develop the software:
    - Image processing and mosaicking.
    - Threat detection.
  - To highlight the *importance of camera/UAV integration*.
  - To demonstrate the suitability of the UAS to take images, useful for the purpose, from a pipeline corridor.
  - To check the efficiency of the whole system: UAS + software.
  - To gain experience in UAS operation for this type of work.

Images above ROW (Spain 2009)

Suitability of images (Spain 2009)

Importance of UAS/camera integration (France 2012)

Rolling shutter effect

Problems to produce mosaic and performing threat detection.

Unstable flight: rotating ground object

Final prototype system (Spain 2013)

Time 1, Threat 1

Time 2, Threat 1


Time 1, Threat 2


Time 2, Threat 2


Time 1, Threat 3


Time 2, Threat 3


Time 1, Threat 4


Time 2, Threat 4


Time 1, Threat 5


Time 2, Threat 5


Time 1, Threat 6


Time 2, Threat 6

Result get with the *right camera and UAV integration*:

- Detection of *soil changes*, not only machinery.

Index

Efficiency

- The efficiency of the automatic aerial threat detection system should still improve:
  - Importance of manual validation to reduce POFA.

Flight Campaign	UAS	Threat Detection	Automatic		Verification		Comments
			POD [%]	POFA [%]	POD [%]	POFA [%]	
France 2009	Carolo P200	iNTeg-Risk Version 1	94	93	89	6	Test of first threat detection system including visual search for omitted threats
Germany 2012	Carolo P200	iNTeg-Risk Version 2	100	35	100	0	Data acquisition for further development of threat detection system
France 2012	DT-18	Third party	50	98	97	0	Verification of automatically detected changes and visual search for omitted threats.
Spain 2013	Carolo P200	iNTeg-Risk Version 2	76	91	76	0	Final test of threat detection system with real world data; no visual search for omitted threats.

POD: Probability Of Detection – POFA: Probability Of False Alarm

Risk to third parties of UAS

- No reliable statistics today:
  - Civil application too recent.
  - UASs are mainly used in military environment.
  - No civil incident reporting system still implemented.

- iNTeg-Risk project:
  - 1 accident in 99 flights (66 hours).

- Kinetic energy in case of accident is smaller that with helicopter/plane.

- Risk should not be higher than current aerial surveillance system.

Index

Future developments

- GRTgaz is studying how to use UASs taking into account:
  - Current performance of technology.
  - Limitations imposed by Regulation.
- Main option: short sections of pipelines where plane/helicopter cannot operate.
  - Test campaign foreseen in 2014.
- GDF SUEZ is looking for new application of UASs in energy sector, not only for gas pipelines.

Index

Conclusions

- The work done at *iNTeg-Risk* project has allowed *to develop and to test a new innovative automatic aerial surveillance system*.

- The works performed highlighted the importance of:
  - *Integration UAV/camera*.
  - Regulations.

- With some additional development, the automatic aerial surveillance system will be ready for being deploy as a new surveillance procedure.

Technische Universität Braunschweig

Trimble

GRTgaz

GDF SUEZ

BY PEOPLE FOR PEOPLE

enagas

Thank for your attention

Any question?