IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Tracking without GPS

Nuclear Security Transport

IAEA - CN-254-99

IRSN

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Summary

- Monitoring nuclear material transports

- Strenghts and weaknesses of the GPS

- Jamming and spoofing

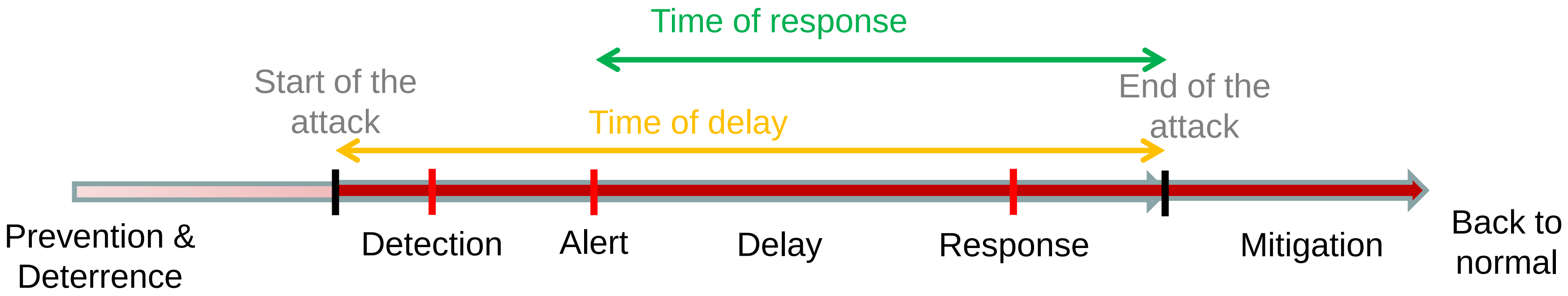
- Possible solutions :
  - Absolute navigation
  - Relative navigation
  - Combination of both

Monitoring nuclear material transports

Nuclear security functions :

(AIEA NSS 13)

- Detection ;
- Delay ;
- Response.



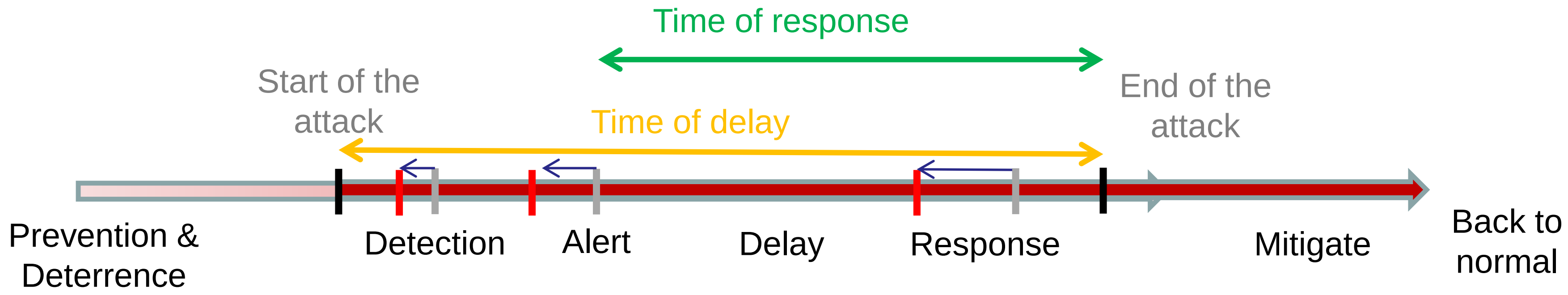
Time of response should be as short as possible

Time of delay should be as long as possible

Monitoring nuclear material transports

An efficient tracking system would

- Improve the detection (and possibly the alert) function ;
- Improve the deployment time of the response force



Time of response would be shortened

Time of delay is unchanged

The risks

However, if not protected enough, a tracking system could be :

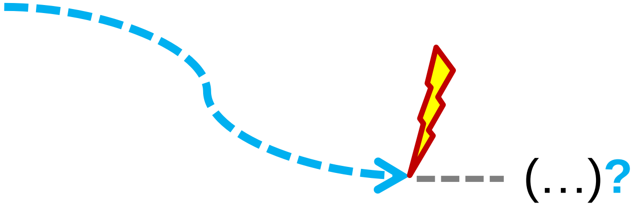
Denied

- For example in a jamming attack :

  The signals are lost. Monitors can observe the absence of signals, but don’t know anymore where is the transport.

It might delay the detection and alert

It might delay the response force



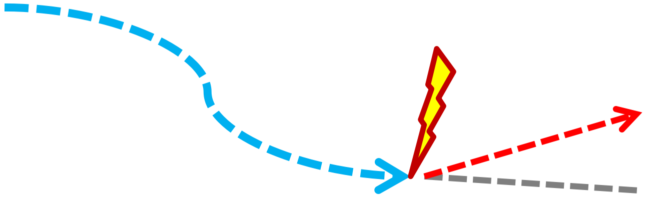
Corrupted

- For example in a spoofing attack :

  Fake signals are sent to the tracking system. Monitors won’t detect anything and might think everything is normal. The true position of the transport is unknown, another position is believed to be true.

It might inhibit detection and alert

It might fool the response force



Tracking system

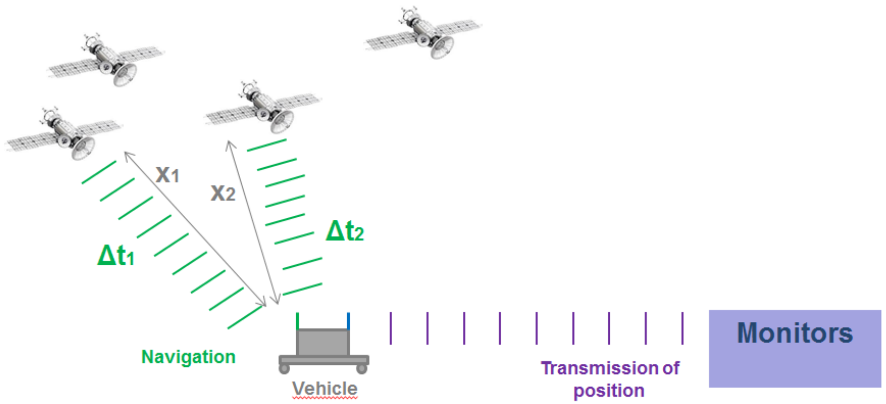
An efficient tracking system should be :

- Accurate :
  - As close as possible to areal-time monitoring, able to detect any change in speed or direction ;
- Reliable :
  - Won't collapse unexpectedly. If the tracking is lost, monitors should be able to suspect a deliberate attack, not a system failure ;
- Robust :
  - Resists to hazards, natural (vibrations, extreme temperatures, radiations…) or malicious ;
- Trustworthy/safeguarding :
  - The data should not be intercepted nor distorted.

GNSS technology

- Global Navigation Satellite System

  (GPS, GLONASS, Galileo, Beidhou…)



- Nowadays, the only technology which is :
  - Available 24/7 ;
  - Whatever the weather ;
  - Works everywhere ;

    (as soon as you are on the surface of earth)
  - < 10 meters ;
  - Cheap.

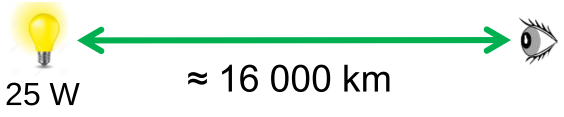
➡ This hegemony makes it use everywhere

Known weaknesses

- But GNSS also have weaknesses :

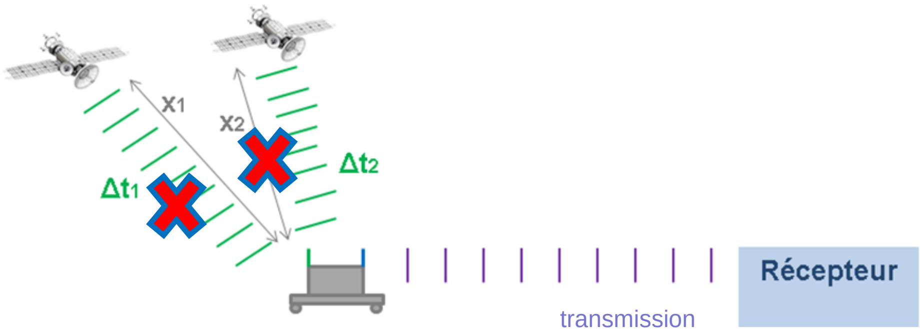
  No authentication

  Signal strenght (GPS) on the surface of earth : 10^{-16} W

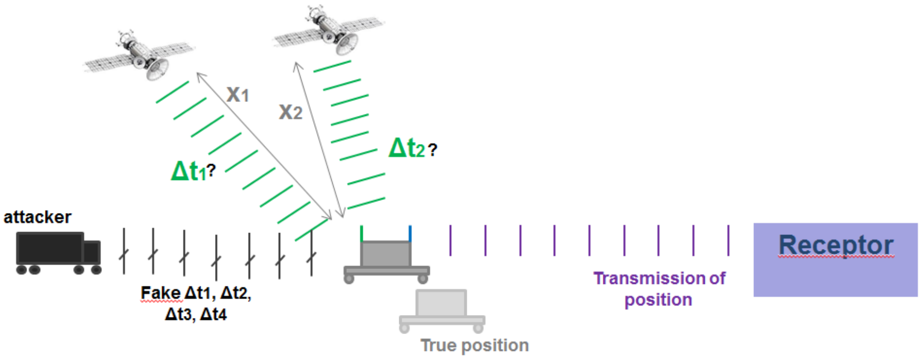


➡ Any occurrence at the same frequencies might blind the receptors

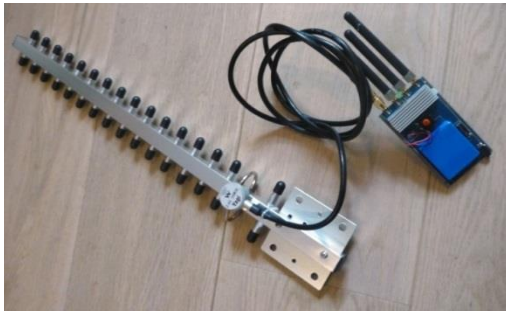
Jamming attacks :

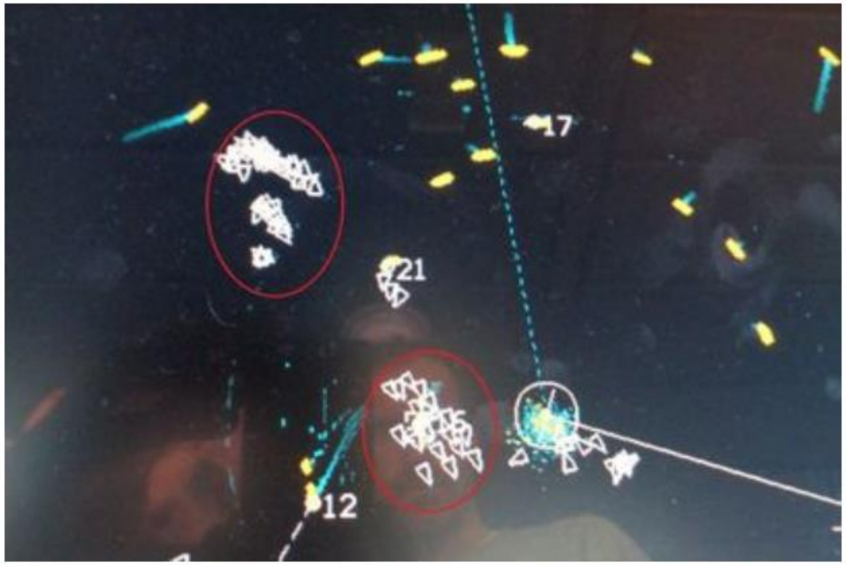


Spoofing attacks :



GPS jamming and spoofing : what used to be military is spreading to civil application and organized crime





AIS data showing multiple ships on top of each other during their time in the Black Sea

Credit **Gurvan Le Meur**

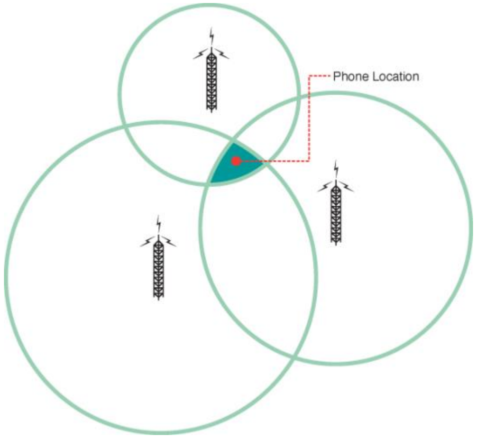
But jamming can also be unintentional !

(interferences, collateral damage of long range jammers)

Tracking without GPS

- Absolute navigation
- Relative navigation
- Combination of both

Absolute navigation

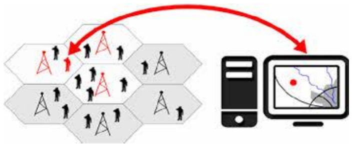


- Radio-navigation :
  - Different tags, frequencies, protocols

- New development thanks to the Internet of Things

- Example : skyhookwireless system
  - GPS, GSM, Wi-Fi
  - Congregates technologies in order to increase accuracy and reliability
  - Works even if one technology is willingly denied

Multiplicity of frequences



- Avoid common paths of failure

- Efficient against jamming
  - To jam them all, need to spread the energy on all frequencies

    → Need for the malevolant to get close to the target
  - If one resists to jammers

    → tracking continues

However, does not stop spoofing attacks

Difficult to spoof them all

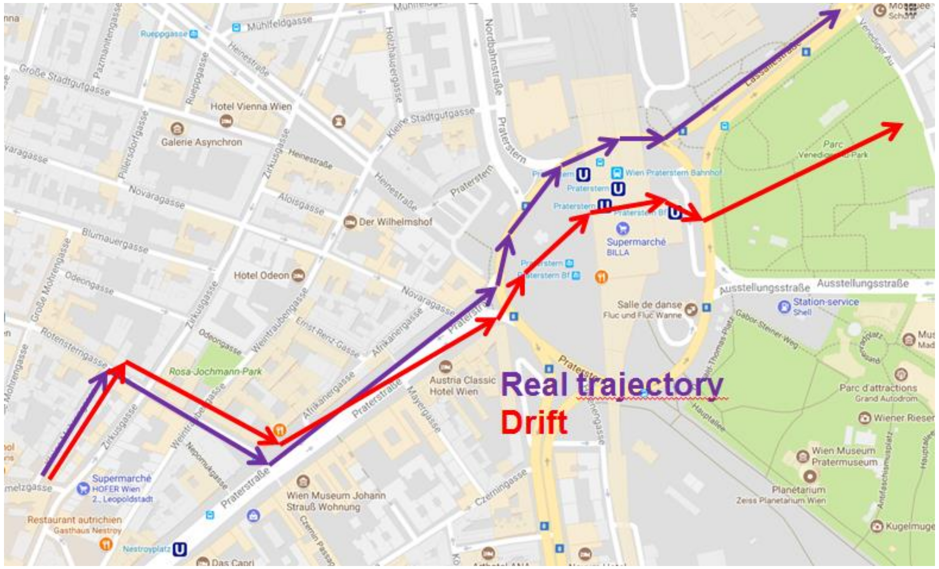
But if one is spoofed, how to know which one to trust ?

→ need for one trusted technology

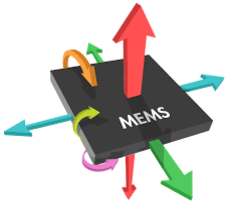
Relative navigation

- Continuous and autonomous

- But drift



- Known in aeronautics, submarines
  - Efficient, but expensive



- New development with UAV, MEMS
  - Cheap, but less efficient
  - Tricks could be used to increase the accuracy :

Gyrometer accelerometer

Magnetism

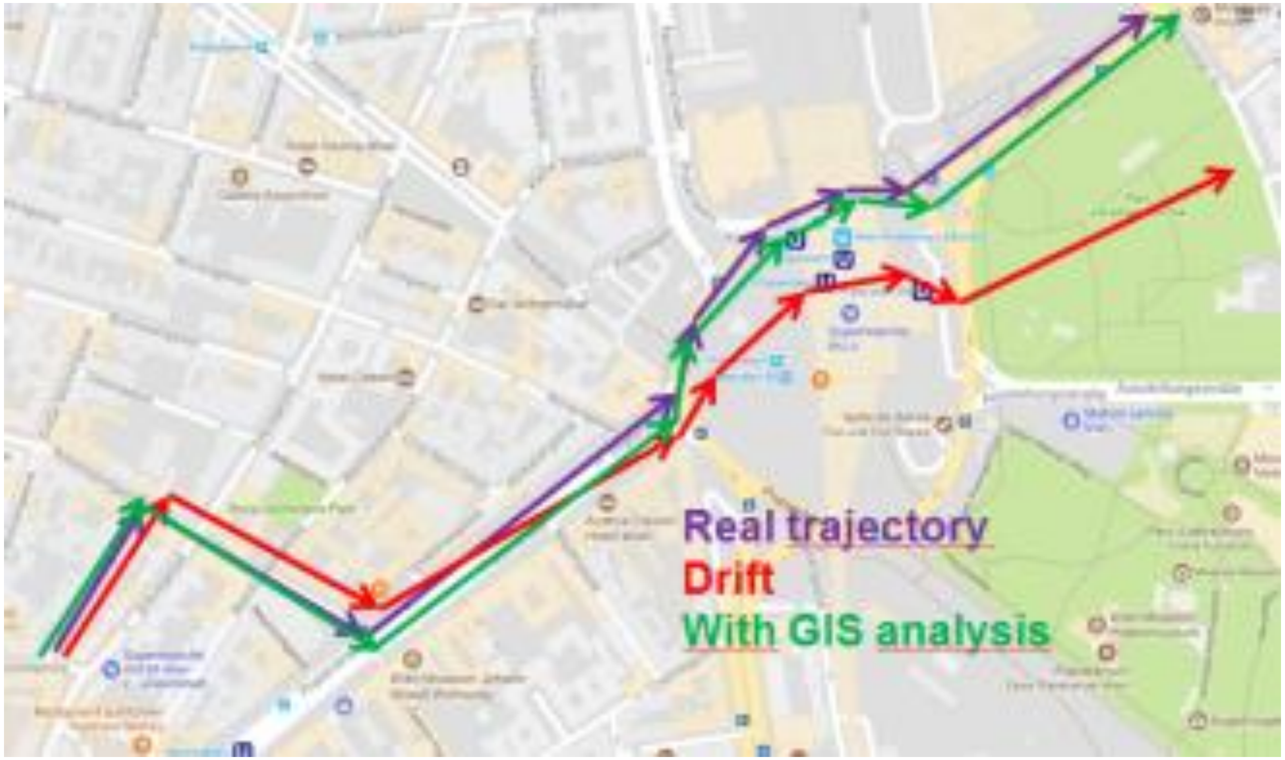
Pressure

Real trajectory
Drift
With GIS analysis

GIS analysis

Relative navigation

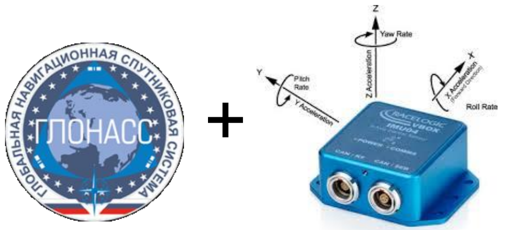
- Using those « tricks », a simple inertial system can track a 2D-transport for dozens of minutes
  - Not enough for a self sustaining system
  - But allows combination in case of GPS deny



Orders of magnitude :

Inertial drift	≈50m
With magnetometers	≈5m
With GIS analysis	≈1m

Combination



One absolute system

Accurate

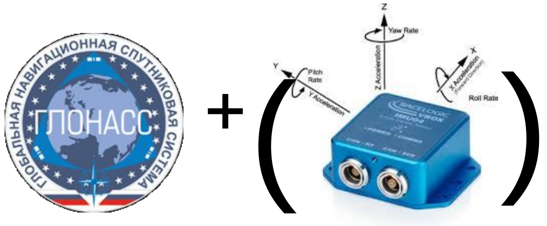
Can be jammed or fooled

One relative system

Trustworthy

Accurate for a short time only

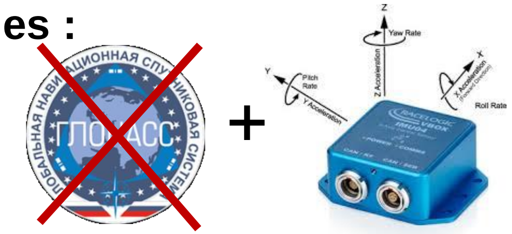
Normal situation :



Tracking is achieved using the absolute system

Relative system is used as a comparison
It detects any incoherence between accelerations and tracking

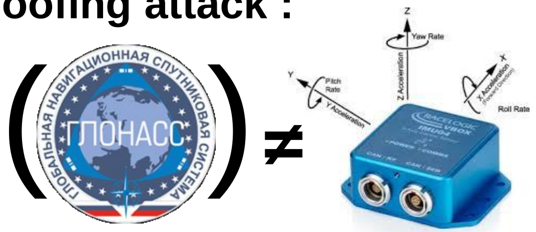
Jamming attack / interferences / obstacles :



Absolute system is denied
Question : is it done willingly or is it normal ?
⇒GIS analysis (tunnel, obstacles…)

Tracking is achieved with the relative system
Response force is alarmed
(in case of too long denying)

Spoofing attack :



Incoherence detected between absolute and relative system
=> Absolute is corrupted

Tracking is achieved with the relative system
Attack is caracterized

Conclusion and prospects

- What used to be considered as State restricted is now available to anyone (spoofing, inertial units…)

- GNSS are known to be vulnerable, attacks have already occured in organized crime

- A combination of both technologies would benefit the accuracy of absolute systems and the robustness of relative ones.
  - And still be affordable for civilian companies

- If one wants to anticipate evolutions in jamming/spoofing and tracking tools, he should keep an eye on UAV’s world.

Thanks for your attention