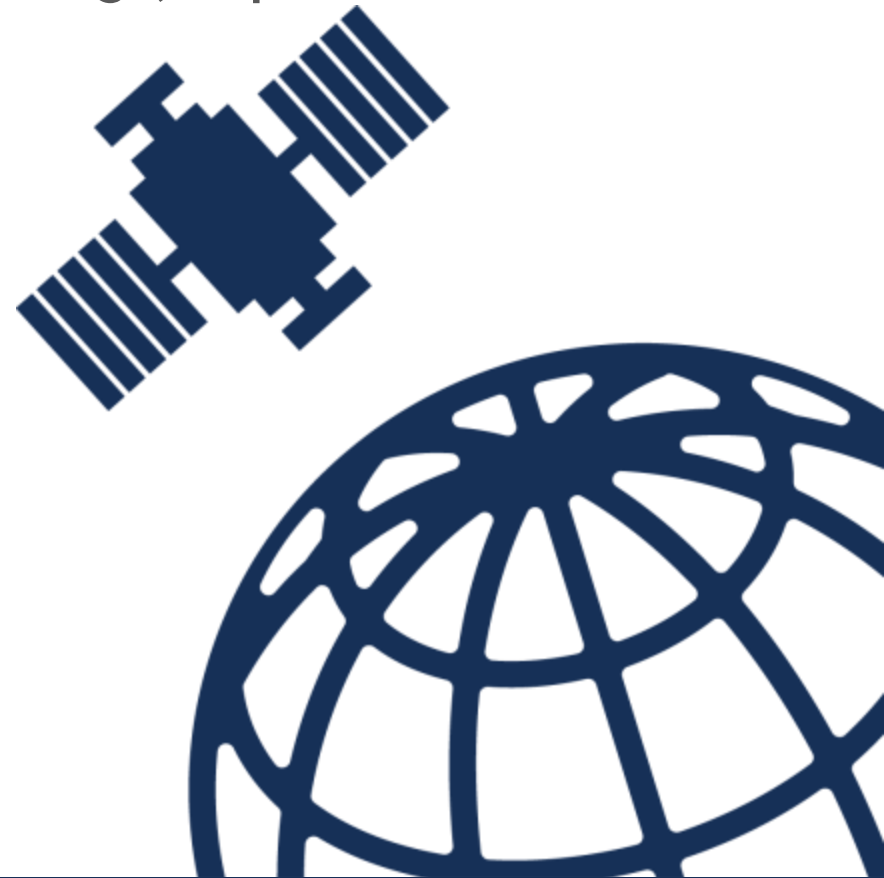


STRIKE3 Project

Standardisation of GNSS Threat reporting and Receiver testing through International Knowledge Exchange, Experimentation and Exploitation [STRIKE3]



Mark Dumville
General Manager, NSL

CGSIC

25-26 September 2017
Portland, OR, US



STRIKE3 is an project to protect GNSS...

- **S**tandardisation of GNSS **T**hreat reporting and **R**eceiver testing through **I**nternational **K**nowledge **E**xchange, **E**xperimentation and **E**xploitation [**STRIKE3**]
- Project funded by European GNSS Agency (GSA) under the European Commission's H2020 Framework Programme



- Start date = 1 February 2016
- Duration = 3 years



Successfully completed Mid-term Review

Some notable developments...

1. GNSS air navigation



Airport operations suspended for 75minutes

2. GNSS road pricing



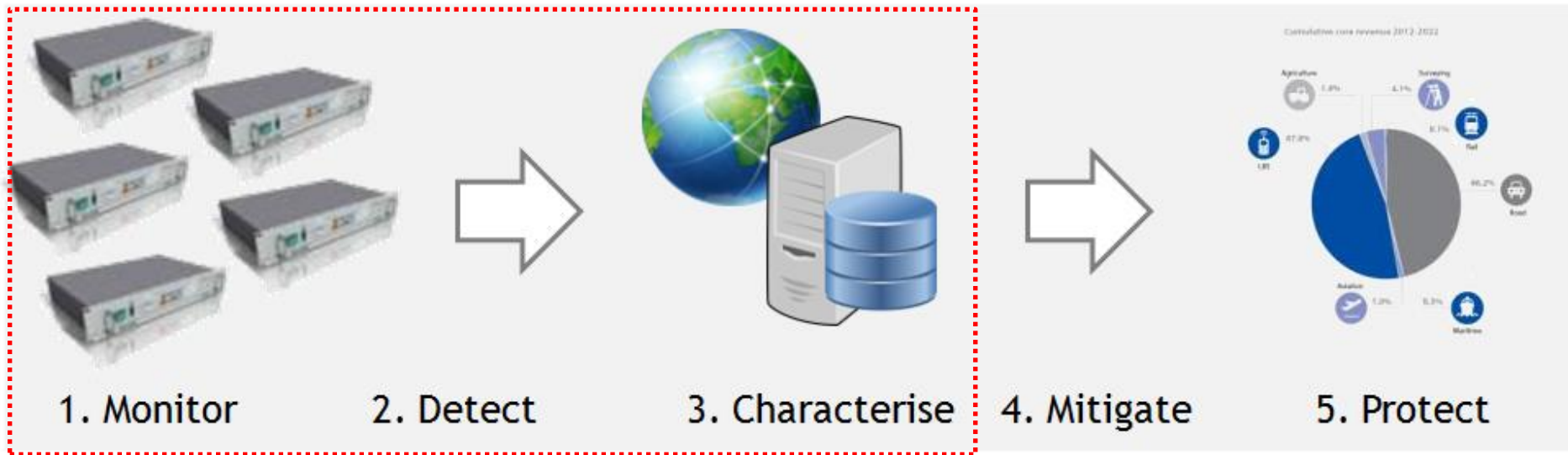
3. GNSS maritime/CNI



Exposed value at risk of £5B over 5 days due to loss of GNSS
See Andy Proctor's CGSIC'17 presentation

STRIKE3 Project Rationale

- 6% of European GDP depends on GNSS (800BEuro)
- At the same time, GNSS vulnerabilities are being exposed and threats to degradation and denial of GNSS services are increasing.



- STRIKE3 provides a response at an international level to ensure that there is:
 - [a standard for GNSS threat reporting and analysis](#)
 - [a standard for assessing the performance of GNSS receivers and applications under threat.](#)

STRIKE3 Global Monitoring Network

30+ monitoring sites

At a range of infrastructures

- Major City Centres
- City-ring roads
- National timing labs
- Motorways/Road network
- Airports
- GNSS infrastructures
- Power stations
- Railway
- EU Borders
- Ports

At a range of locations

- United Kingdom
- Sweden
- Finland
- Germany
- France
- Poland
- Czech Republic
- Spain
- Slovakia
- Slovenia
- Netherlands
- Belgium
- Croatia
- Latvia
- India
- Vietnam
- Thailand
- Malaysia
- New Zealand
- Canada
- Singapore (pending)



STRIKE3 “DETECTOR” equipment



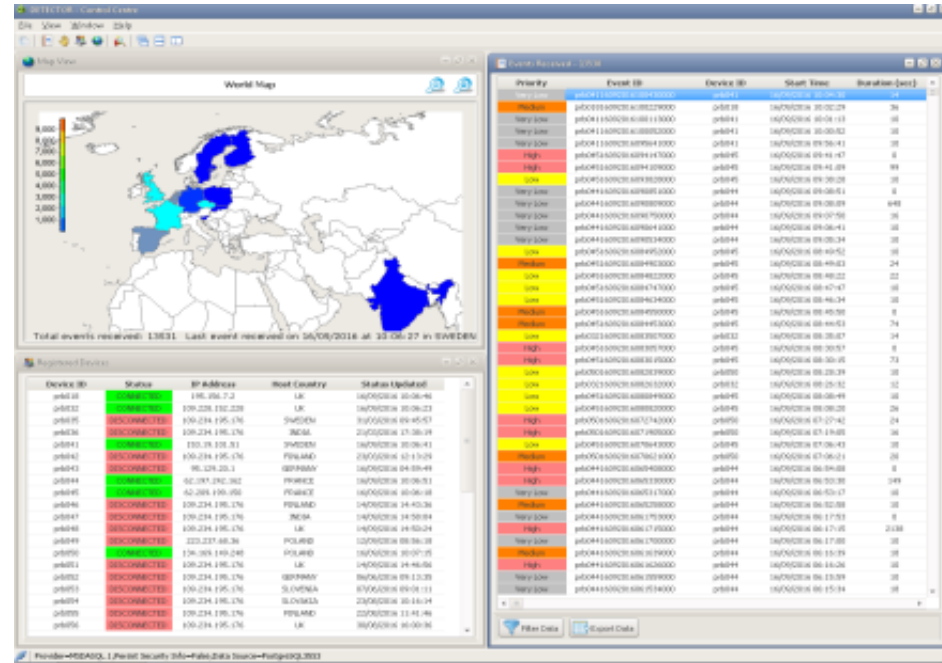
- **GSS100D** - Interference detector
 - GPS/EGNOS/Galileo L1/E1



- **GSS200D** - Interference detector
 - GPS/Galileo/EGNOS/GLONASS L1/E1/G1



- **GSS200D'** - Interference detector
 - L1/L5 + ICAO/Eurocae interference masks
 - Spoofing detection



- Dedicated STRIKE3 project server
- Autonomous and persistent monitoring
- Records events in secure database

* Other equipment is provided by other STRIKE3 partners

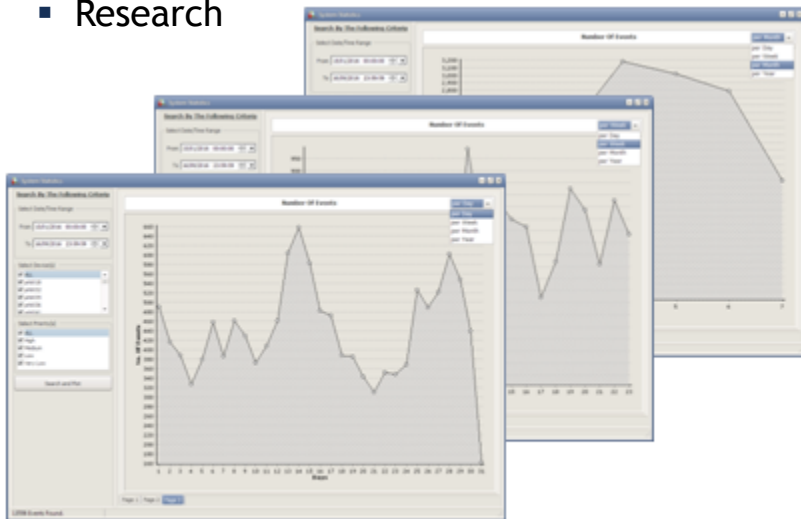
STRIKE3 “Stakeholders”

Involving a range of entities:

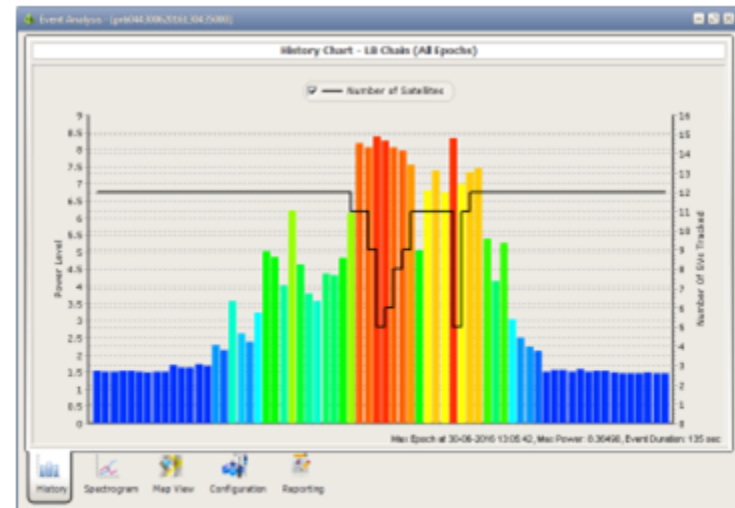
- Government agencies
- Frequency regulators
- Road operators
- Tolling operators
- Airport operators
- Air Navigation Service Providers
- Power grids
- Research

Addressing a range of concerns:

- **What is the scale of the problem?**
- How do the results compare at different locations?
- Are there any patterns at my site? At other sites?
- **What is the impact on GNSS receivers in the vicinity?**
- What is the risk and what options exist to reduce the risk?



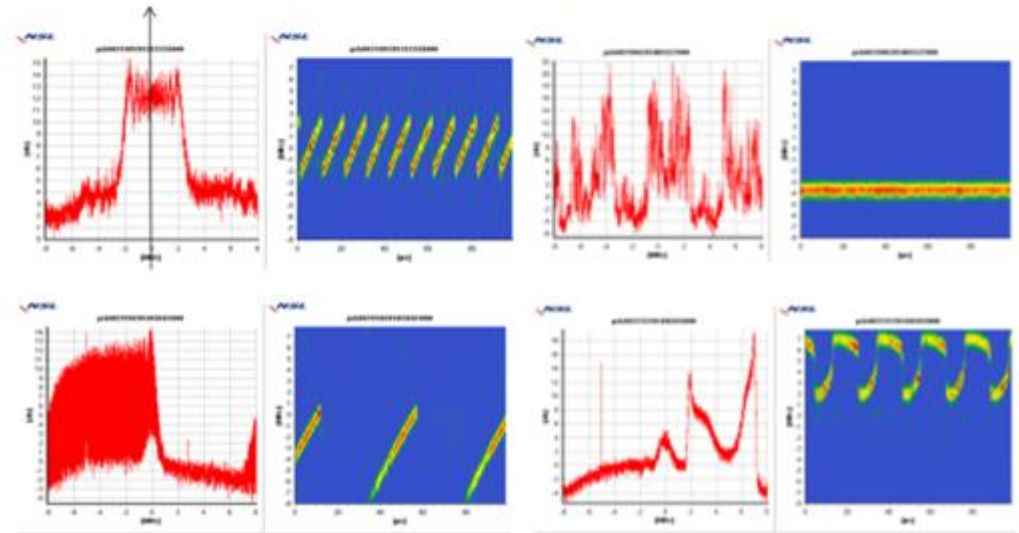
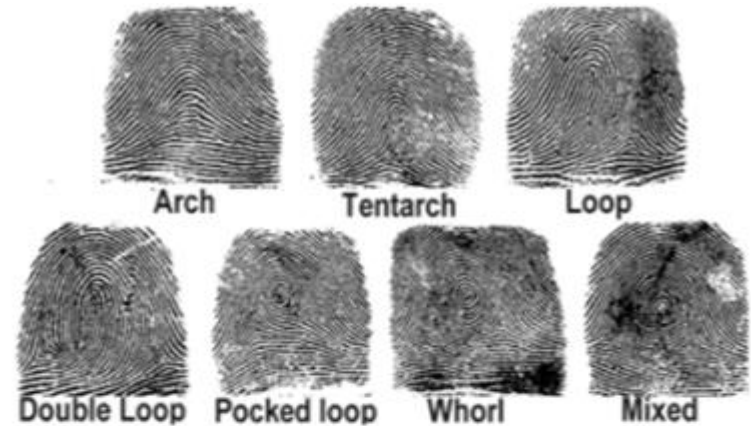
Number of events per location per time



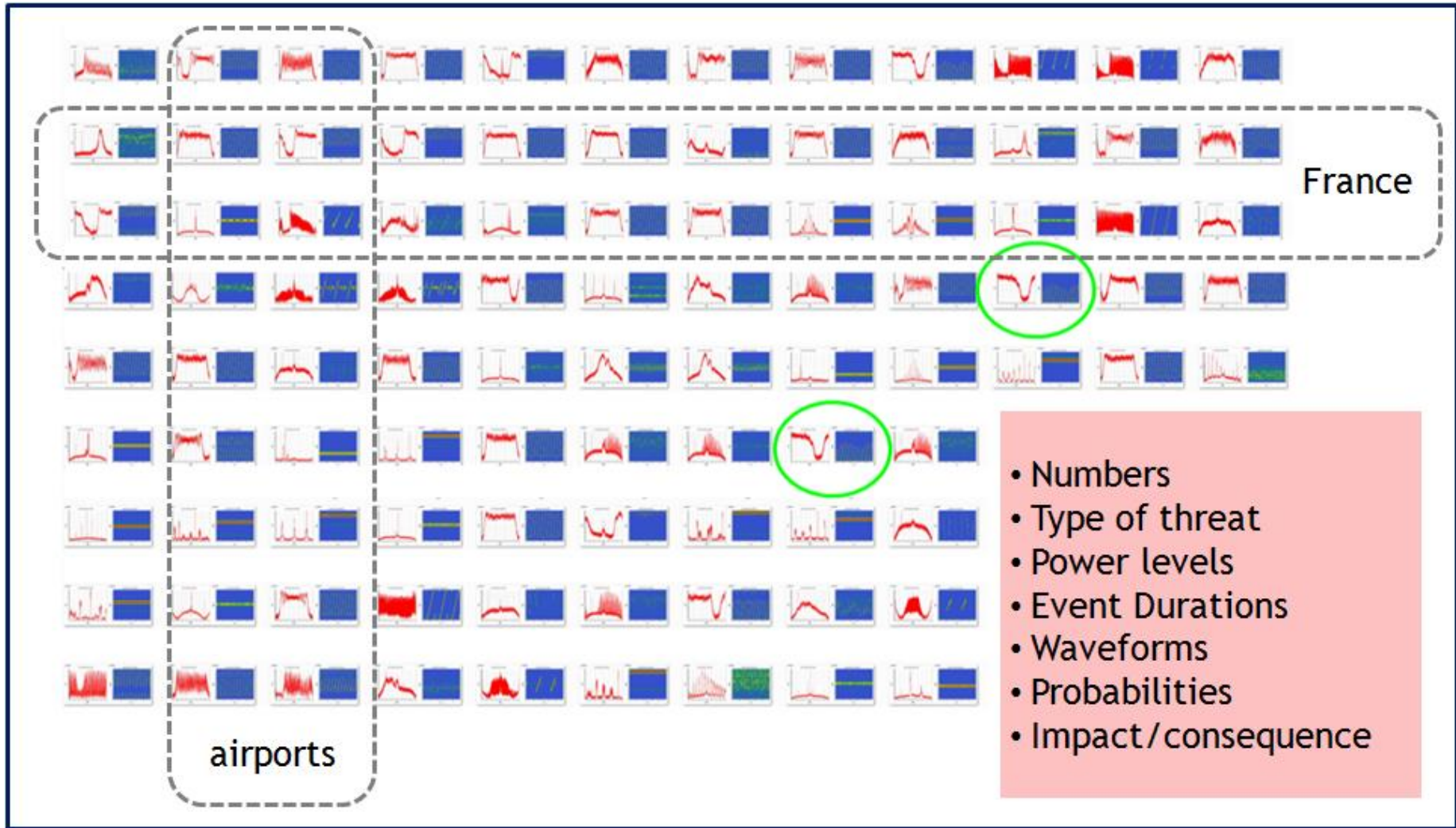
Impact of an event on “Satellites in view”

STRIKE3 “Fingerprint”

1. Size, pressure, patterns
2. Identify distinguishing features
3. Classify the signature
4. Identify different “families”
5. Identify new “families”
6. Preserve the evidence
 - Create a catalogue
 - Reference for future events
 - Automatic pattern recognition



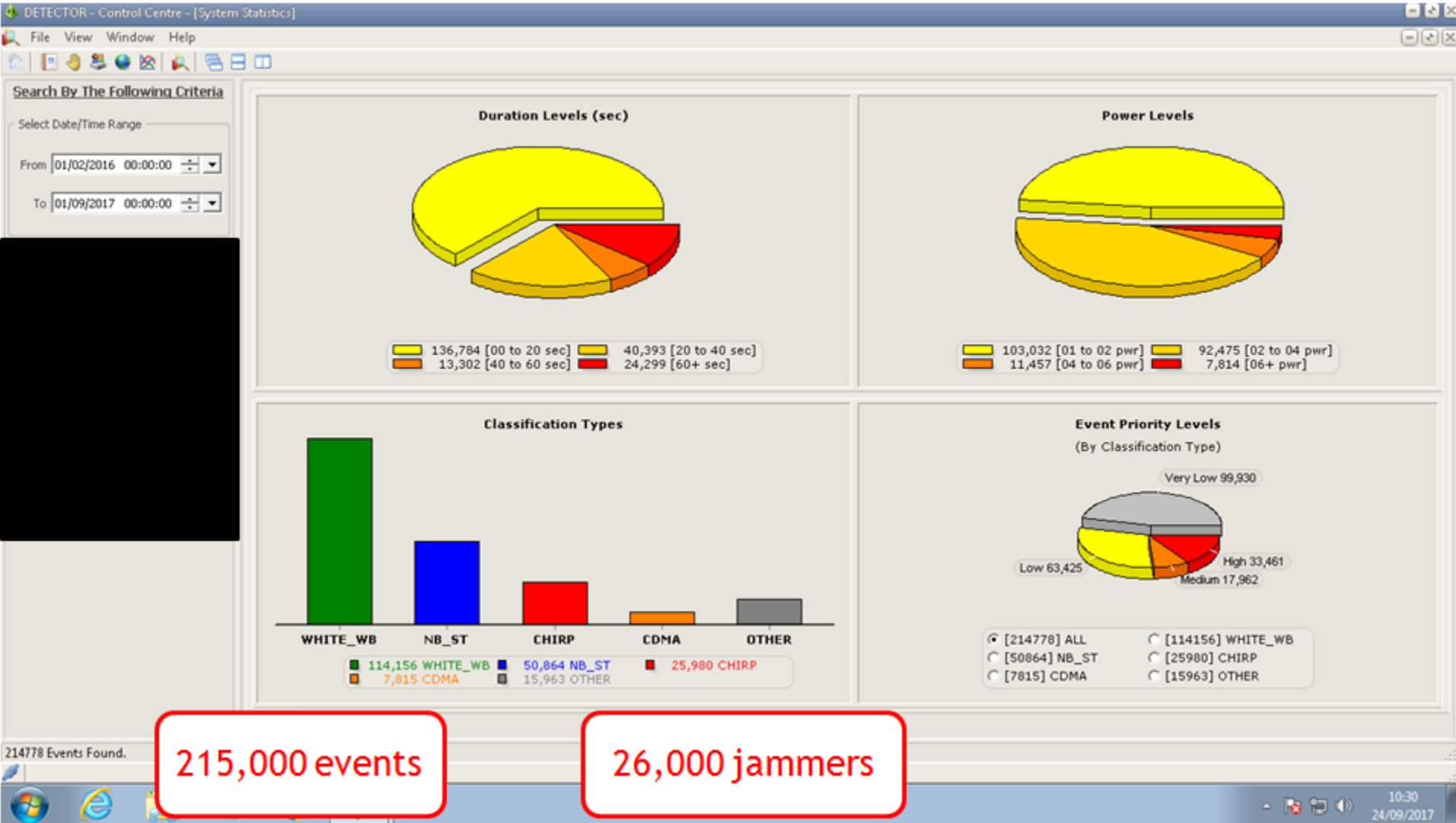
STRIKE3 “Database” [215,000 events]



Start of project until 31/03/2017



STRIKE3 “Database” [1/2/2016 – 1/9/2017]



215,000 events

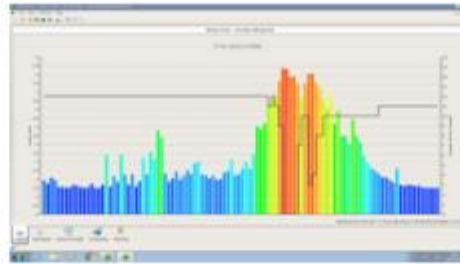
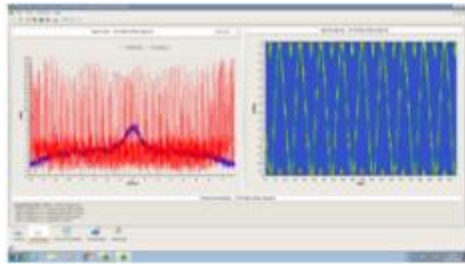
26,000 jammers



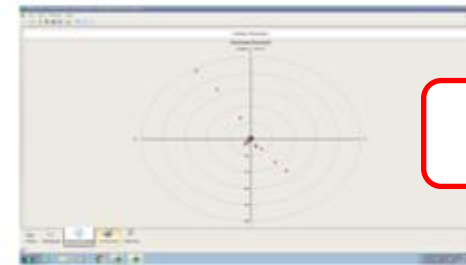
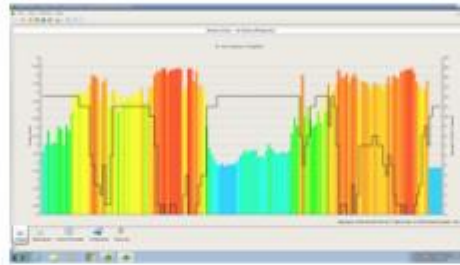
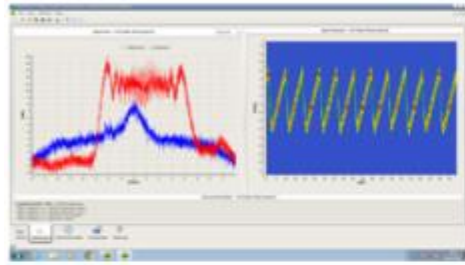
STRIKE3 Jammer events (day-of-week, time-of-day)



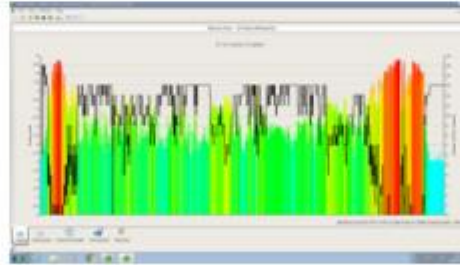
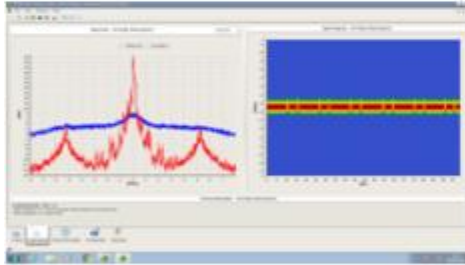
STRIKE3 RFI event durations & impacts



~0m



2x ~50m



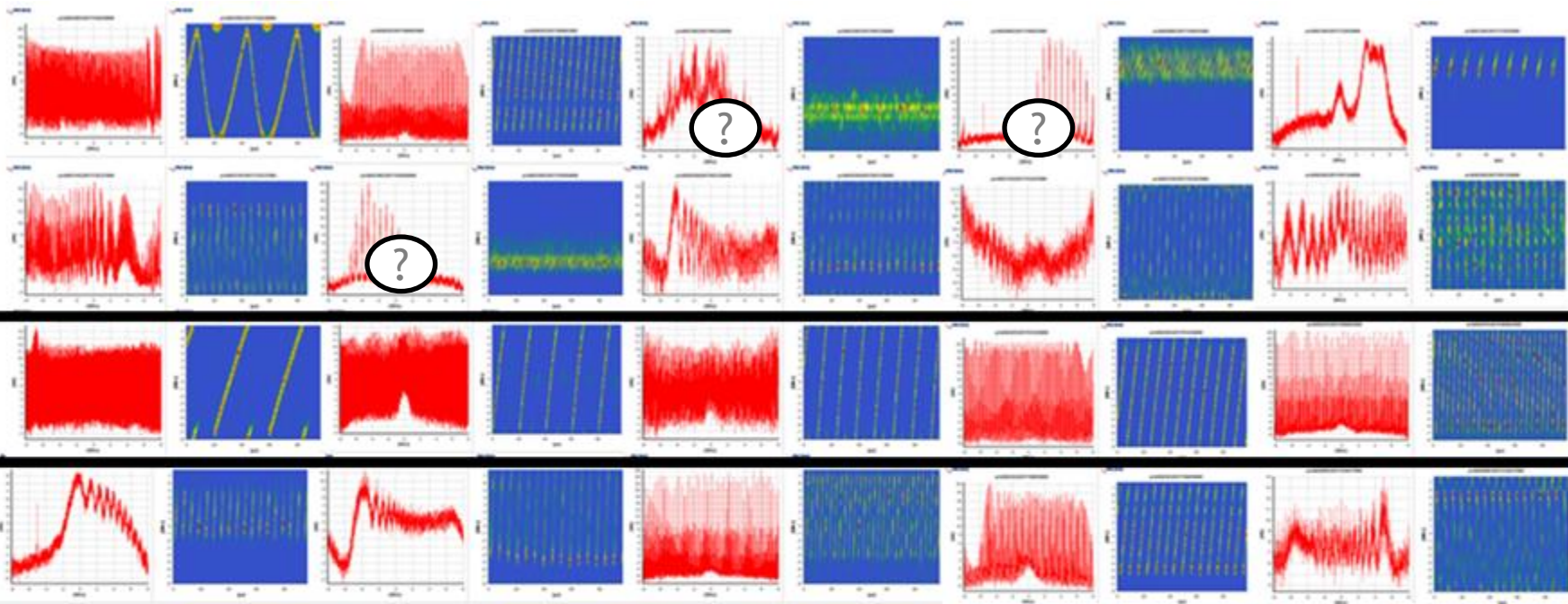
2x~50m



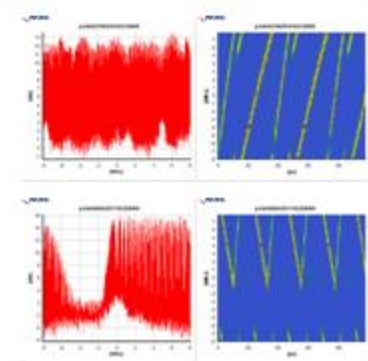
~5m



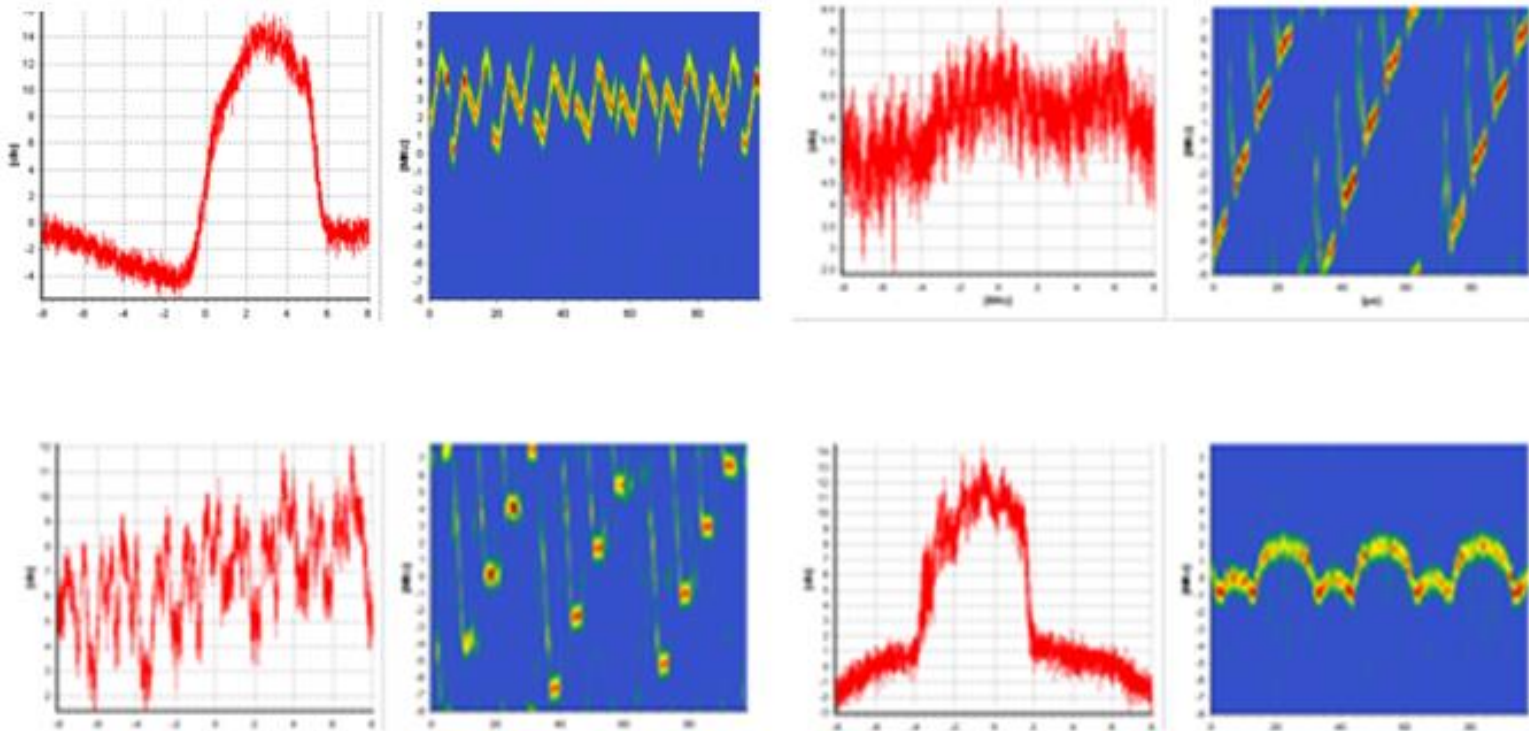
Typical “Chirp” Jammer Waveforms



- There are lots of jammer waveforms, characterised by:
 - Bandwidths, power, centre frequency, signal(s)
 - Additional parameters: sweep rate, direction, return



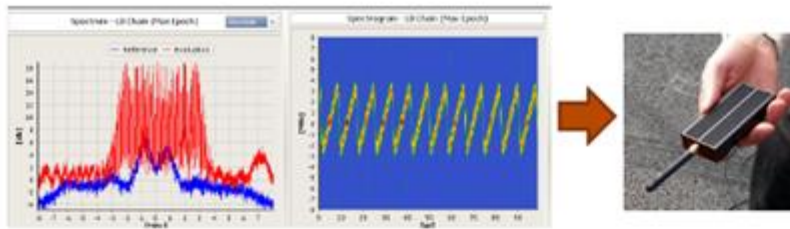
“Exotic” Jammer waveforms are emerging...



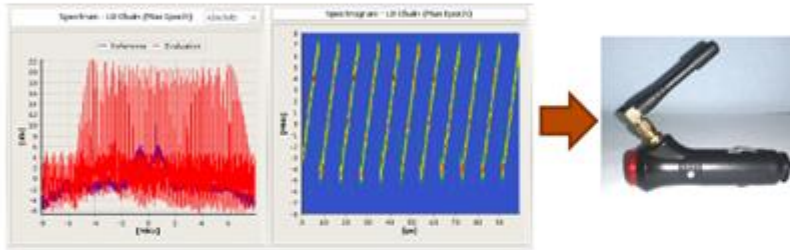
Simple Rules to support validation

- It has a structure (it is deliberate, purposeful)
- It is mobile (exhibits same power profile as a jammer)
- It is seen multiple times (avoids being a one-off rogue “signal”)
- It is seen multiple sites (demonstrates a distributed product)

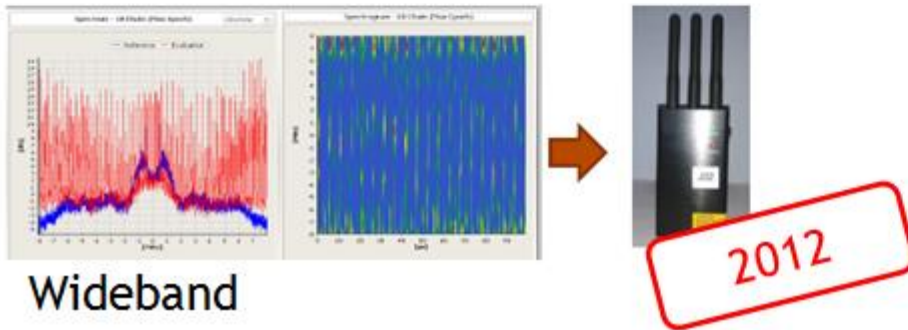
Matching “waveforms” to jammer “type/models”



5Mhz bandwidth, 1575Mhz centred



8Mhz bandwidth, drifting centre



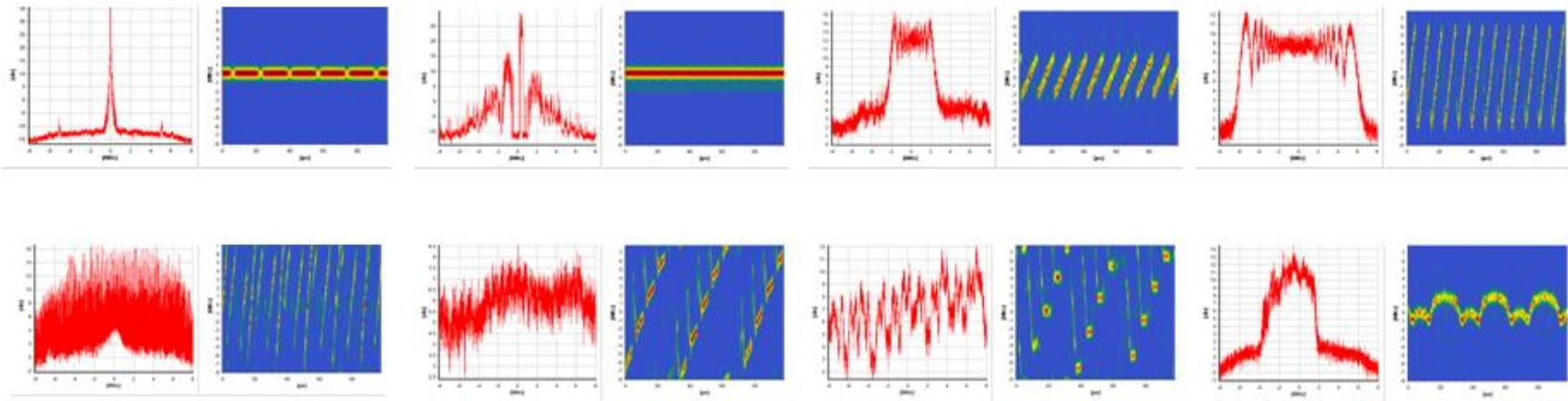
Wideband

The figure shows two side-by-side plots. The left plot is a 'Spectrum - LP Chain (Pwr Spect)' showing a red waveform with a drifting center frequency. The right plot is a 'Spectrogram - LP Chain (Pwr Spect)' showing yellow diagonal lines that curve upwards over time, indicating a drifting frequency. An orange arrow points from these plots to a photograph of a handheld jammer device with a black antenna. A red stamp with the year '2017' is overlaid on the bottom right of the device image.

Waveform detected at 4 STRiKE3 sites Europe and outside EU

*STRIKE3 Threat Reporting Standards

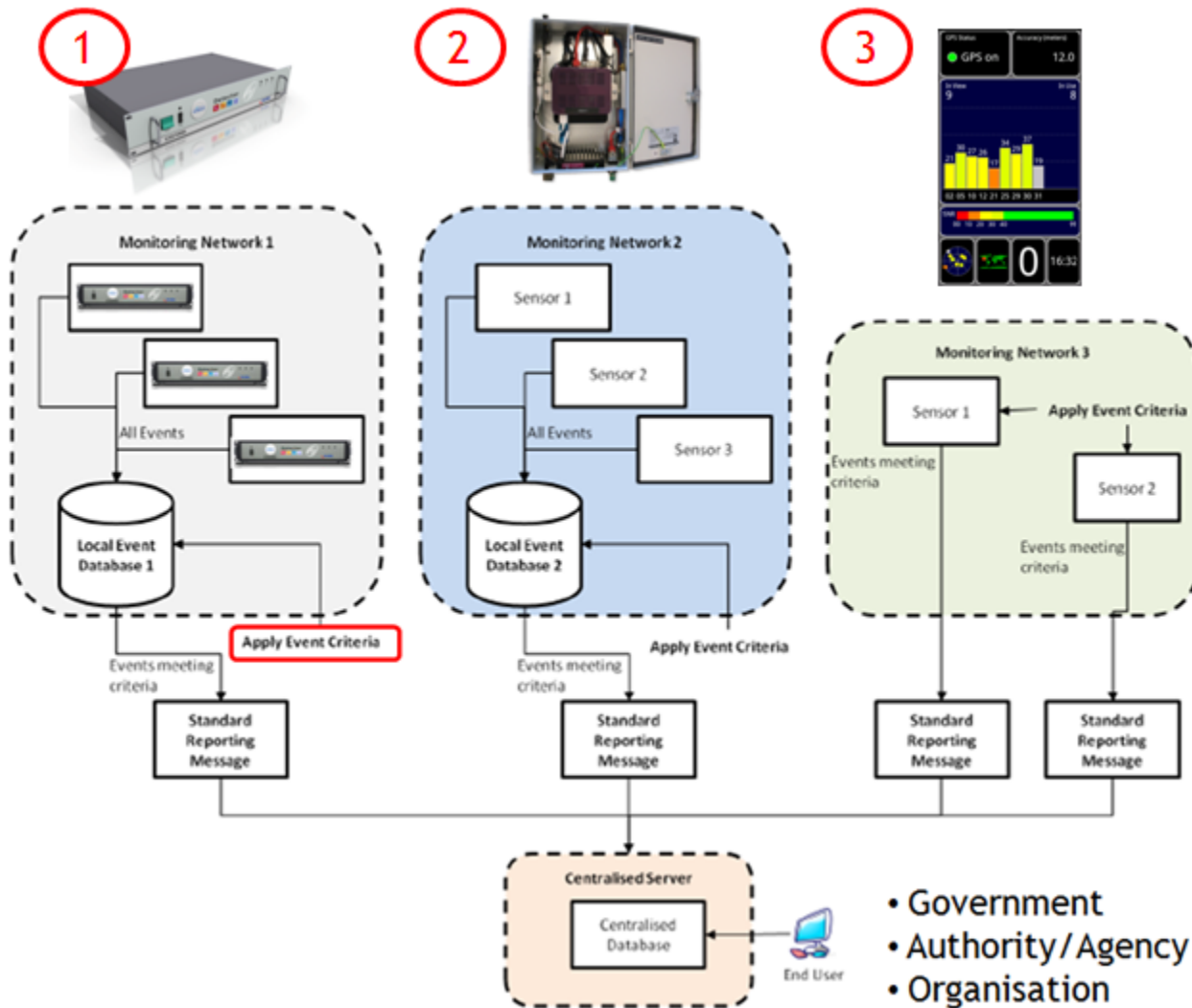
- Many more “RF threat waveforms” than reported in literature
- Large number of jammer “families” (varying complexity & impact)
- There is a need to share knowledge with international communities



- Multiple RFI monitoring systems exist, with difference features
- Any standard should reflect a minimum level of data
 1. Suppliers and vendors can offer advanced features
 2. Minimum requirement for monitoring and exchange



STRIKE3 Threat Monitoring and Reporting Standard

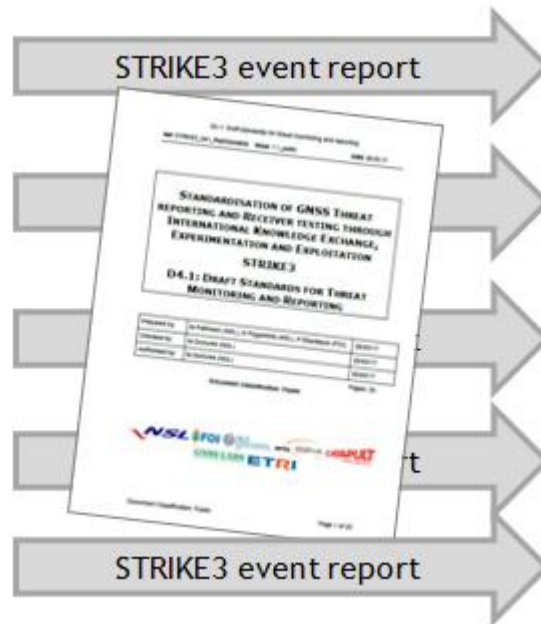


- Government
- Authority/Agency
- Organisation



STRIKE3 “Systems of Systems” Database

- Ensure event reports from different monitoring systems are compatible
- Minimise changes to existing monitoring system equipment
- Limit “sensitive” information that needs to be sent (and stored)
- Protect against data “Integrity” issues (copies/changes)
- Flexibility in data provision and analysis



STRIKE3 Monitoring Centre

Table of STRIKE3 interference events as updated by various centres around the world

Equipment Type	Frequency Band (MHz)	Start Date/Time (UTC)	Duration (sec)	Daily Power (dBm)
GNSS-IR	1676.42	18/09/2017 14:42:45	58	14.2284
GNSS-IR	1676.42	18/09/2017 14:28:54	14	5.8267
GNSS-IR	1676.42	18/09/2017 12:40:08	38	28.8624
GNSS-IR	1676.42	18/09/2017 11:48:54	44	18.3122
GNSS-IR	1676.42	18/09/2017 11:16:48	26	11.8880
GNSS-IR	1676.42	18/09/2017 07:28:50	9	11.8810
GNSS-IR	1676.42	18/09/2017 06:57:47	14	7.4736
GNSS-IR	1676.42	18/09/2017 06:54:23	16	16.5200
GNSS-IR	1676.42	18/09/2017 06:48:44	28	19.8775
DTORIS	1676.42	18/09/2017 06:25:46	8	14.7885
GNSS-IR	1676.42	18/09/2017 04:14:09	68	5.8267
GNSS-IR	1676.42	18/09/2017 04:02:47	343	16.5485
GNSS-IR	1676.42	18/09/2017 03:38:58	11	16.2561
GNSS-IR	1676.42	18/09/2017 03:36:46	28	28.2427
DTORIS	1676.42	18/09/2017 04:19:41	6	11.7889
GNSS-IR	1676.42	18/09/2017 02:58:58	17	16.2516
GNSS-IR	1676.42	18/09/2017 02:47:54	31	6.9465
GNSS-IR	1676.42	18/09/2017 02:38:58	37	7.2645
GNSS-IR	1676.42	17/09/2017 21:37:51	16	6.8776
DTORIS	1676.42	17/09/2017 19:48:24	9	16.4094

Event Details

Event ID: 1809180917144245

Event Definition: IR

Frequency Band (MHz): 1676.42

Start Date/Time (UTC): 18/09/2017 14:42:45

Duration (Sec): 58

Event Power (dBm): 14.2284

Country: IR

City: IR

State: IR

Operator: IR

Remarks: IR

IP: IR

URL: IR

Device: IR

Model: IR

Manufacturer: IR

Serial Number: IR

Software Version: IR

Hardware Version: IR

Notes: IR

**System-of-systems
RF Interference database**

STRIKE3 Quarterly Scorecards

- STRIKE3 produces summary sheets every 3 months
- Includes update on STRIKE3 network and database

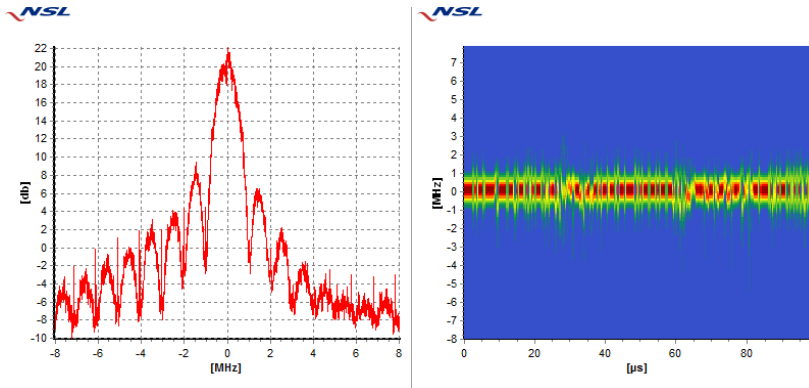
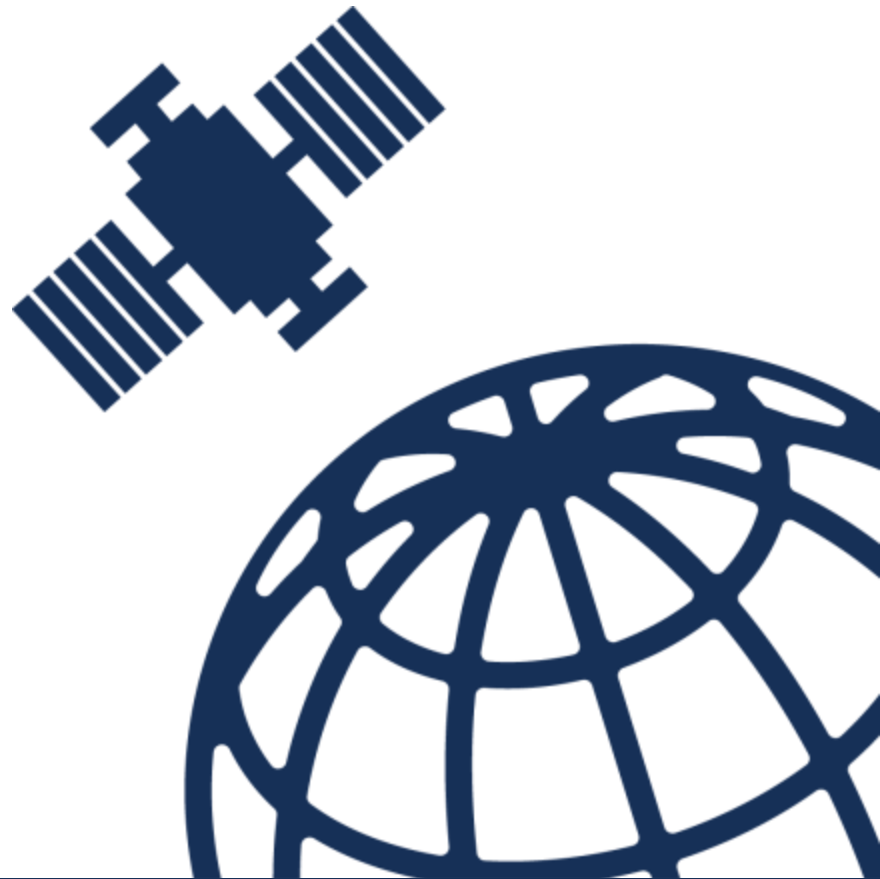


Available from: www.gnss-strike3.eu



We would welcome discussions with entities interested in hosting a STRIKE3 monitoring unit

Thank you



mark.dumville@nsl.eu.com

