VADASE: Real-time GNSS monitoring with a stand-alone receiver

From academy to industry

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Summary

Summary

The groundwork

- In the **early 2000s**, besides standard long-term geophysical investigations, GPS started to be used for tracking **fast displacements during earthquakes**

But...

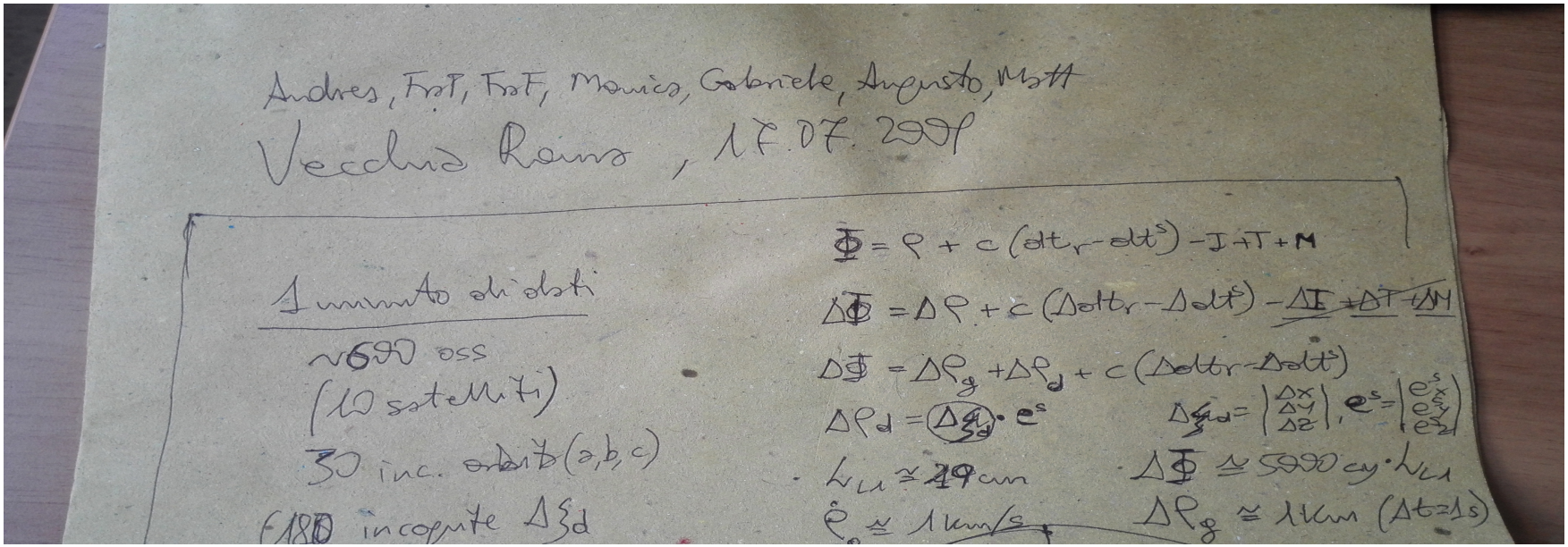
A major challenge to measure with

Real-Time *GPS Science Requirements Workshop* (September 2007)

- **1 cm** GPS displacements accuracy
- in a **global reference frame**
- within **3 minutes** after the earthquake

Exploiting advances in receiver technology - High acquisition rate (**10-50 Hz**)

VADASE concept



The idea: keep it fast, keep it simple!

to directly estimate displacements from the **observations of a stand-alone GNSS receiver** (single station approach)

Summary

How does VADASE work?

The brand new *variometric* algorithm

Variometric **A**pproach for **D**isplacements **A**nalysis **S**tand-alone **E**ngine

Velocities estimation

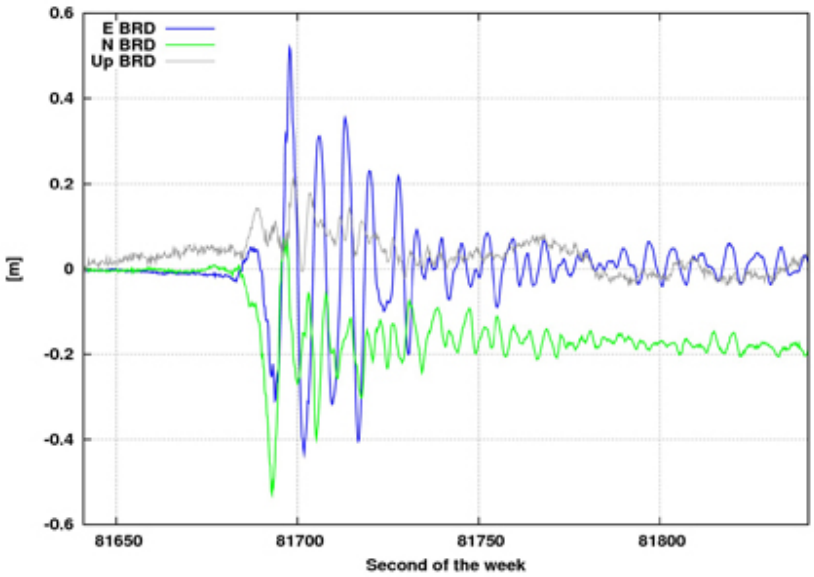
- **epoch by epoch "velocity"** estimation for two generic consecutive epochs
- **at least four satellites, common to the two epochs**, are necessary
- **cycle slips** identification and removal (**no need of ambiguity fixing**)

Waveforms determination

- waveforms can be reconstructed **integrating the estimated velocities**

Summary

The boost: European Satellite Navigation Competition 2010



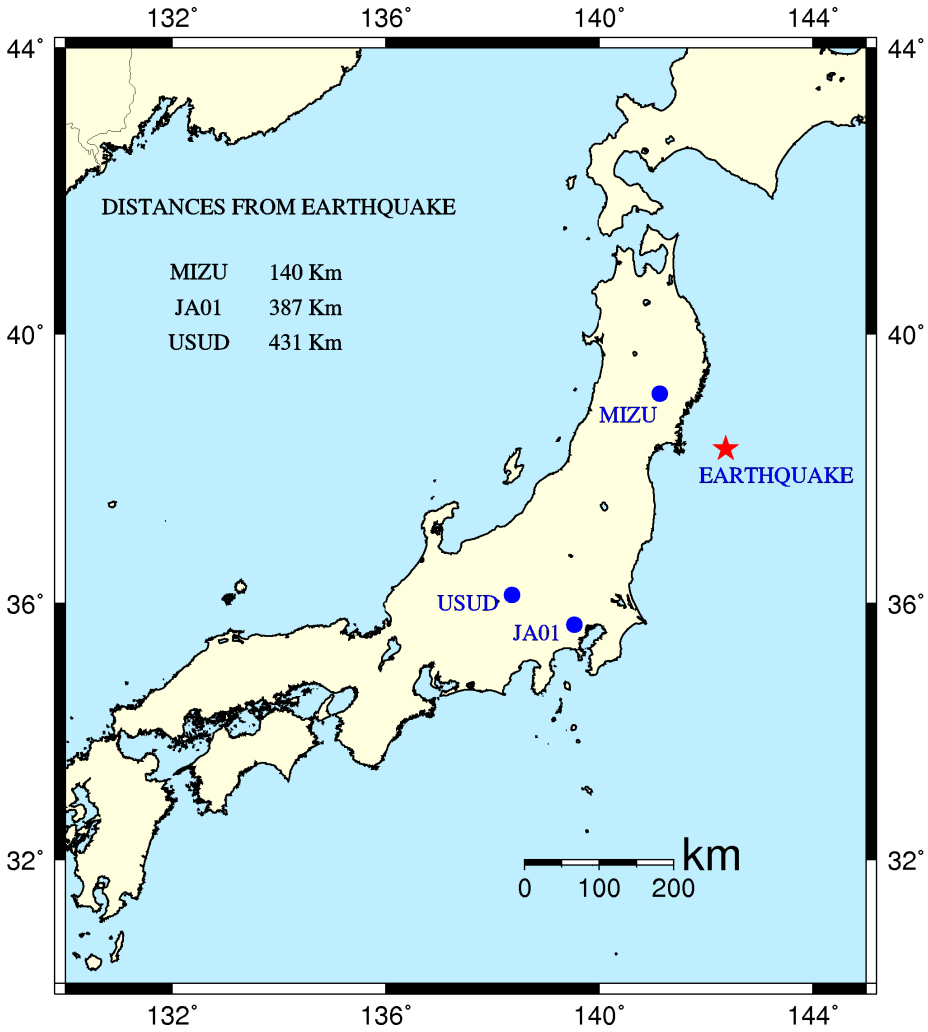
Baja (Mex) April 4 2010, MW 7.2

Waveforms obtained with VADASE were compared with solutions provided by established strategies: the results supported VADASE submission for ESNC 2010

VADASE the winning idea of:

- **DLR Special Topic Pize**
- First Audience Award ($>$ 100 ideas)

Tohoku-oki Japan earthquake, $M_w = 9.0$

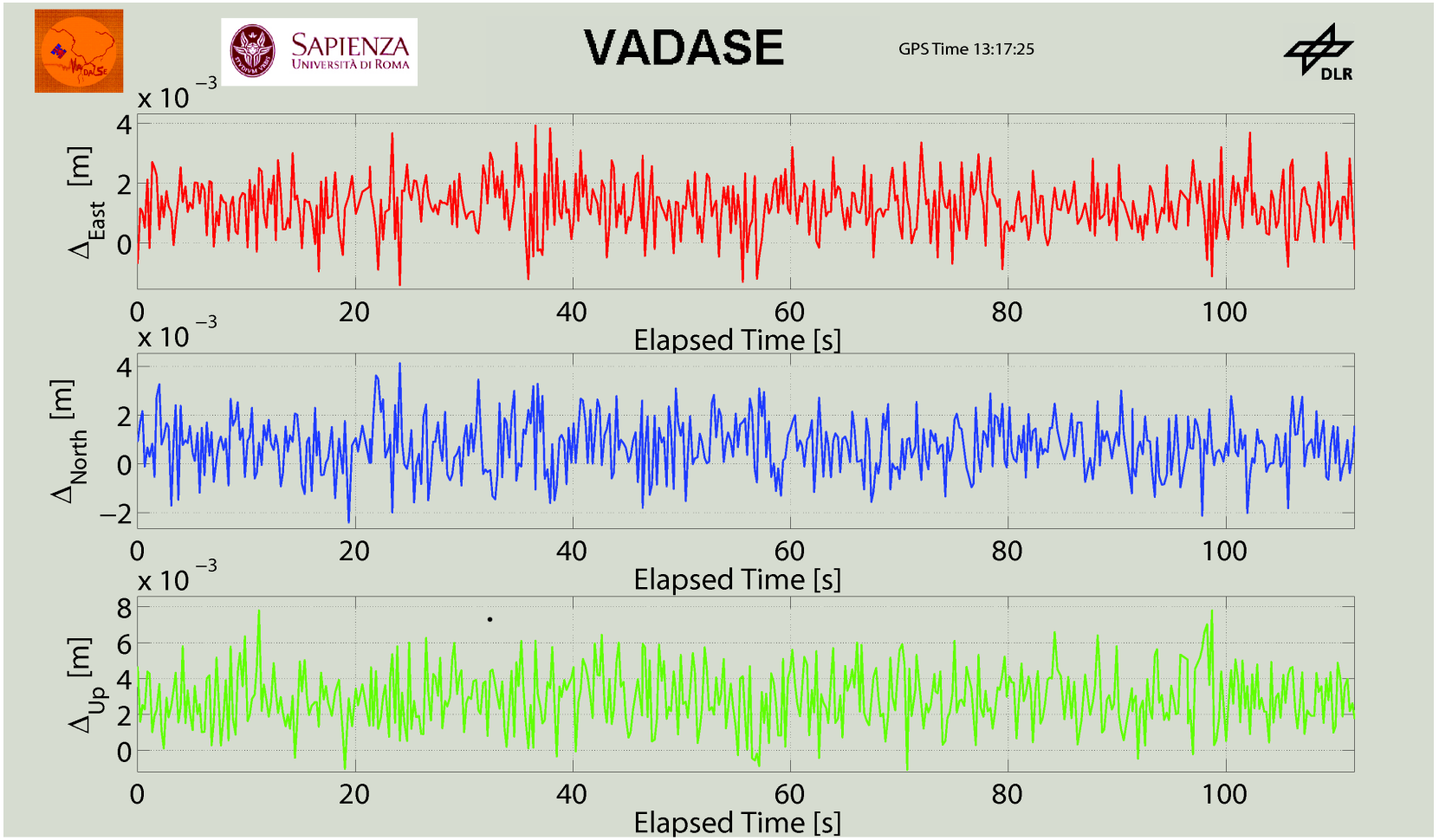


- VADASE provided the **first displacements computation**
  - **[IGSMAIL-6358]** - March 11, 04:13:35 PST 2011
  - solutions published on the **Tohoku-oki Event Supersite Website** - March 12, 2011
- **"Excellent work"** [Dr. K. Larson, University of Colorado, Boulder]

Cover story GIM International volume 25, number 5, May 2011

Incubation experience at DLR — March 2011

First VADASE real-time solution within EV network

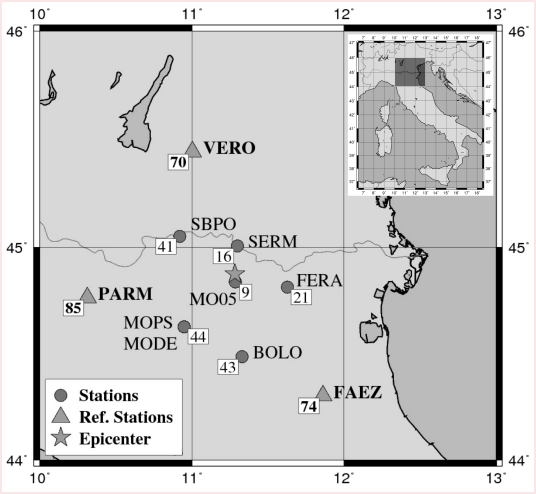


Emilia Earthquake May 20, 2012, $M_w = 6.1$

Key issues

- **comparison with** renown software (BERNESE, TRACK, APP-PPP, CSRS-PPP)
- **processing of VADASE L1 solution**

Overall results



- reference solutions:
  within **1 cm** in horizontal and **1.5 cm** in height
- VADASE L3 - reference solutions:
  within **1.1 cm** in horizontal and **1.5 cm** in height
- VADASE L1 - VADASE L3 and reference:
  within **1.7** cm in horizontal and **1.8 cm** in height

Summary

The vision: VADASE onboard a commercial GNSS receiver

- an **autonomous, real-time monitoring solution**

Leica Geosystems

- key market player providing **reliable, robust, precise GNSS solutions** (HW/SW)
- tens of years of experience, open to innovation, interested in new technologies
- large existing network of customers and receivers, **world-wide**

Win-Win situation

- combine the **innovative algorithm** from Academia and the **experience and resources** from Leica Geosystems to turn VADASE into an accessible, usable, customer-oriented product

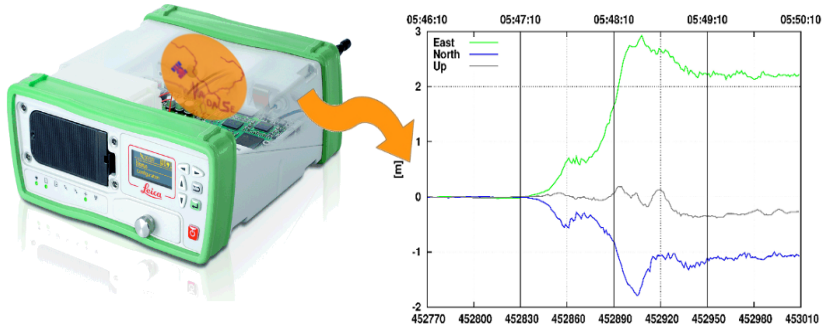
Leica Geosystems pre-evaluation phase of VADASE

1 - Desktop software

- post-processing with file input
- tested against known displacement scenarios

2 - "Hosted" by Leica receiver

- separate application executed along with other tasks in **real-time**
- tested by external partners (Japan, USA, ...)
- collect feedback and suggestions for improvement



Leica Geosystems VADASE development

3 - Real-time on board

- integrated into the processing engine of the Leica Geosystems receivers
- real-time **receiver displacements**
- streaming/logging results
- GPS + GLO + BDS

VADASE

GM10

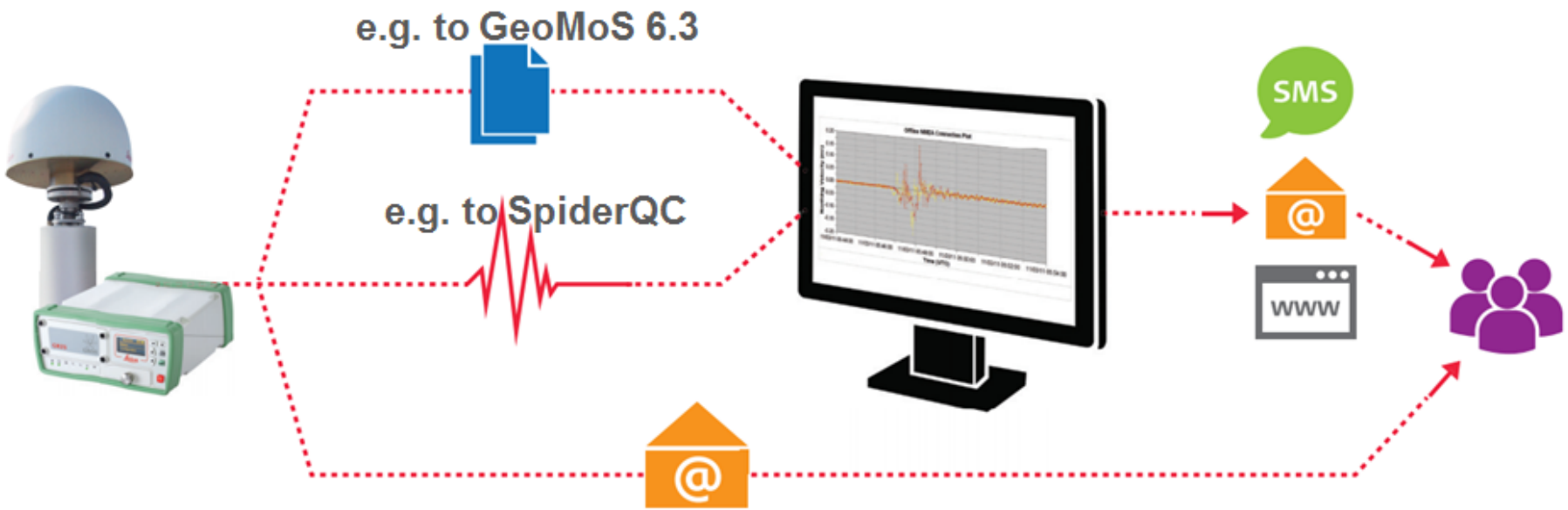
GR10

GR25

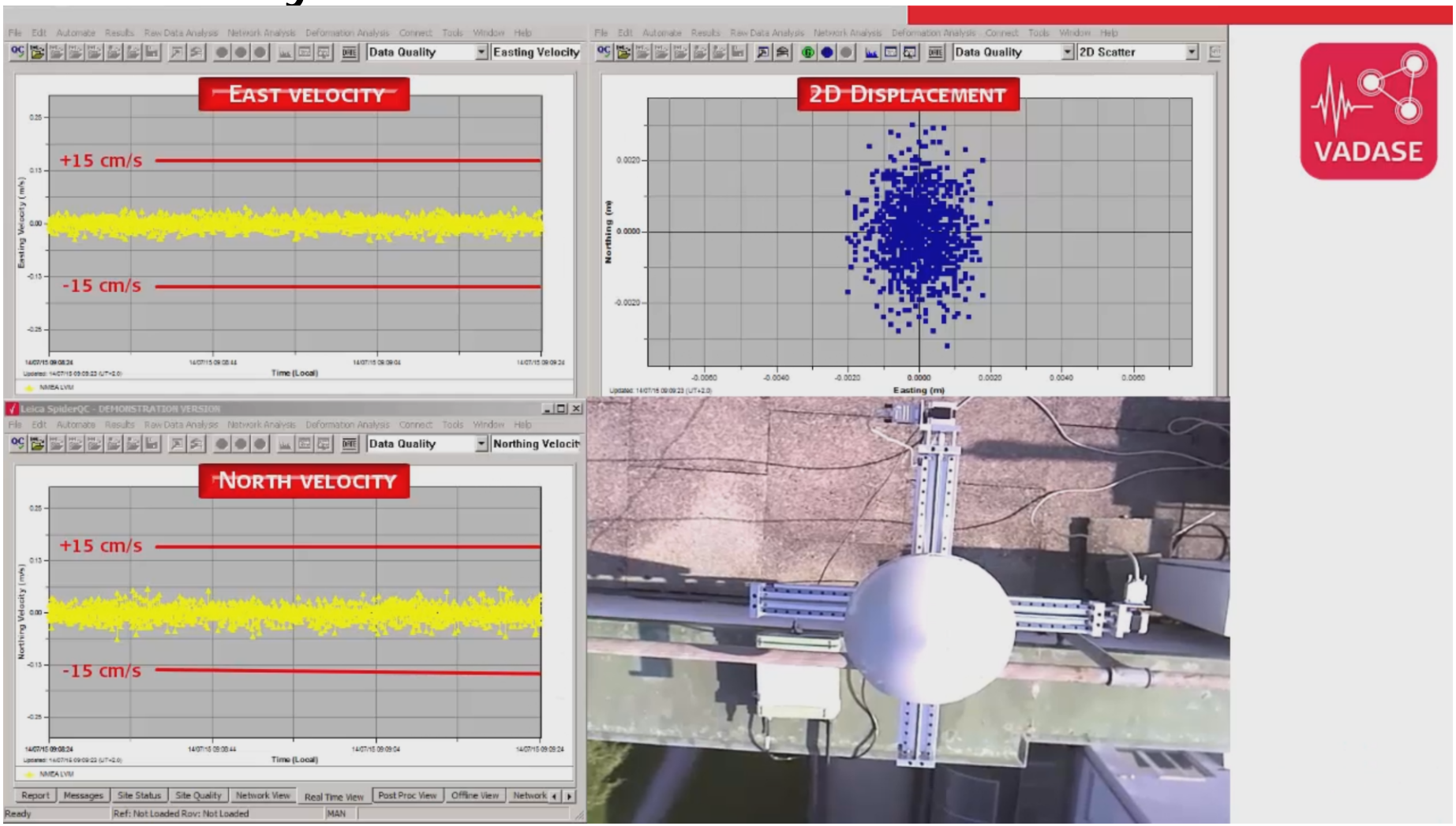
Leica Geosystems VADASE

4 - Autonomous GNSS monitoring solution onboard a receiver

- **integrated into the Leica Geosystems' product suite**
- Leica SpiderQC, Leica GeoMoS to **visualize results**
- check displacements against thresholds
- user **notification mechanism** (e-mail, SMS, reports)



Leica Geosystems VADASE in action



Leica Geosystems VADASE: Use Cases

Seismology

- co-seismic displacement retrieval
- waveforms reconstruction and analysis

Early Warning Systems

- **natural or man-made hazards** (volcanic, earthquake / tsunami, fracking, ...)
- safety monitoring for infrastructure elements close to potential hazards (landslides, ...)

Structural Monitoring and reference stations

- enhances structural and geotechnical engineering monitoring
- permanent **reference stations** "accident" monitoring

Leica Geosystems VADASE: Velocity and Displacement Autonomous Stand-alone Engine

Interested in Leica VADASE?

Find more information here:

- GM10
- GR10
- GR25

Technical details and result analysis

- Leica VADASE white paper

Introduction to Leica Geosystems

- Leica VADASE full video

Summary

Conclusions and outlook

Conclusions

- **fully autonomous** - stand-alone GNSS solution
- no additional hardware needed, no communication link
- typical sensitivity of **1 cm/s** horizontal and **2 cm/s** vertical for displacement detection
- high-rate (**up to 20 Hz**) and multi-constellation

Outlook

- support **full kinematic mode**
- **integration with other sensors** (e.g, MEMS, accelerometers)

Thank you very much for your kind attention