

JRC-CERN Collaboration Workshop
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Data Size Issues in Structural Assessment and Security

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(Credits: all Colleagues at ELSA)

ELSA-IPSC

Joint Research Centre

The European Commission's in-house
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Stimulating innovation

Supporting legislation

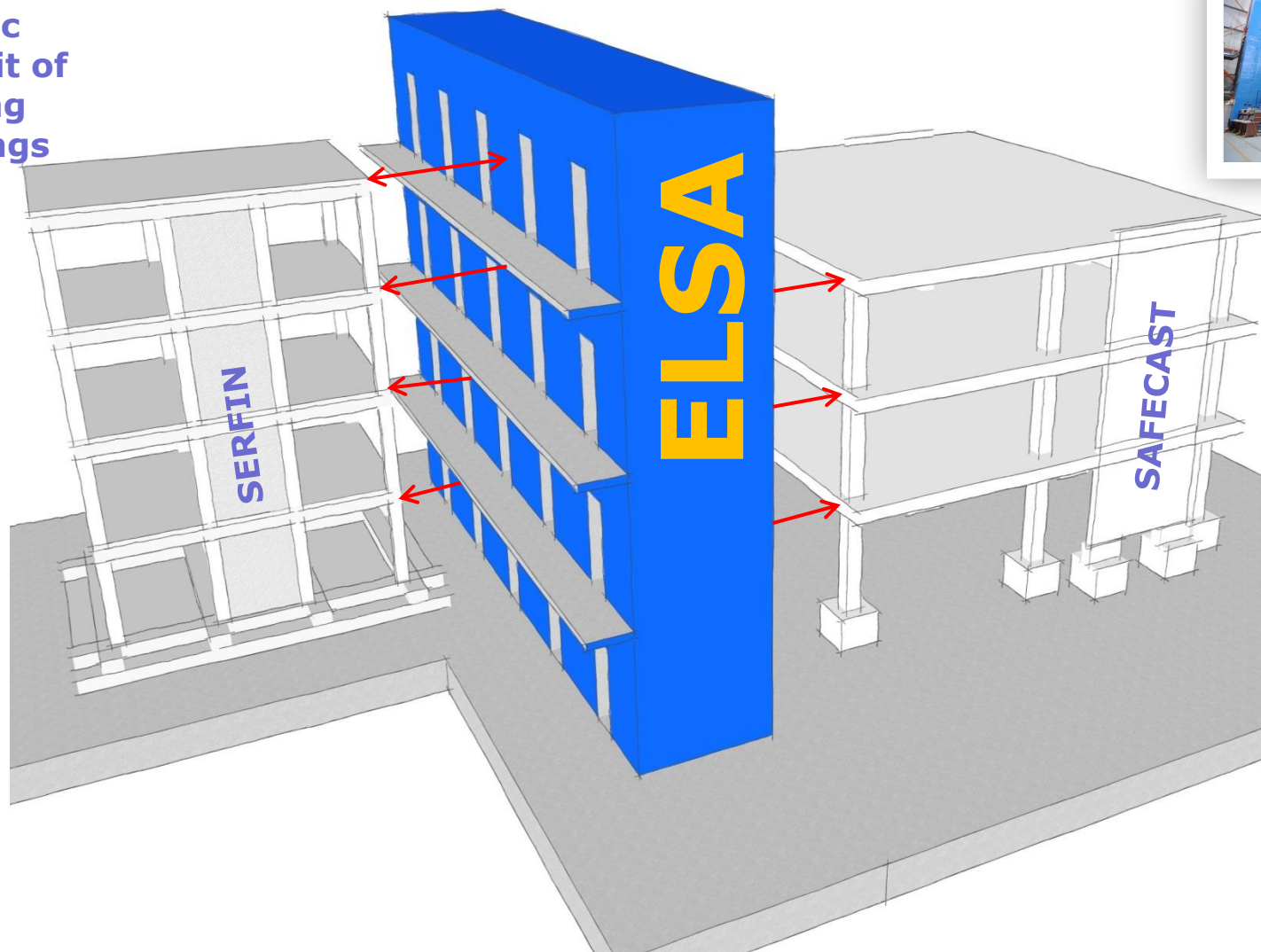
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Outline

- **Data from Laboratory Experiments**
(Volume, Processing and Share with users)
- **Complex Computational Models for Blast Simulation**
(Computation, Volume of results, Visualization)
- **Data from Wireless Sensor Networks**
(Container security, infrastructure management, ...)

**Seismic
Retrofit of
Existing
Buildings**



**Innovative
Connections
in Precast
Buildings**

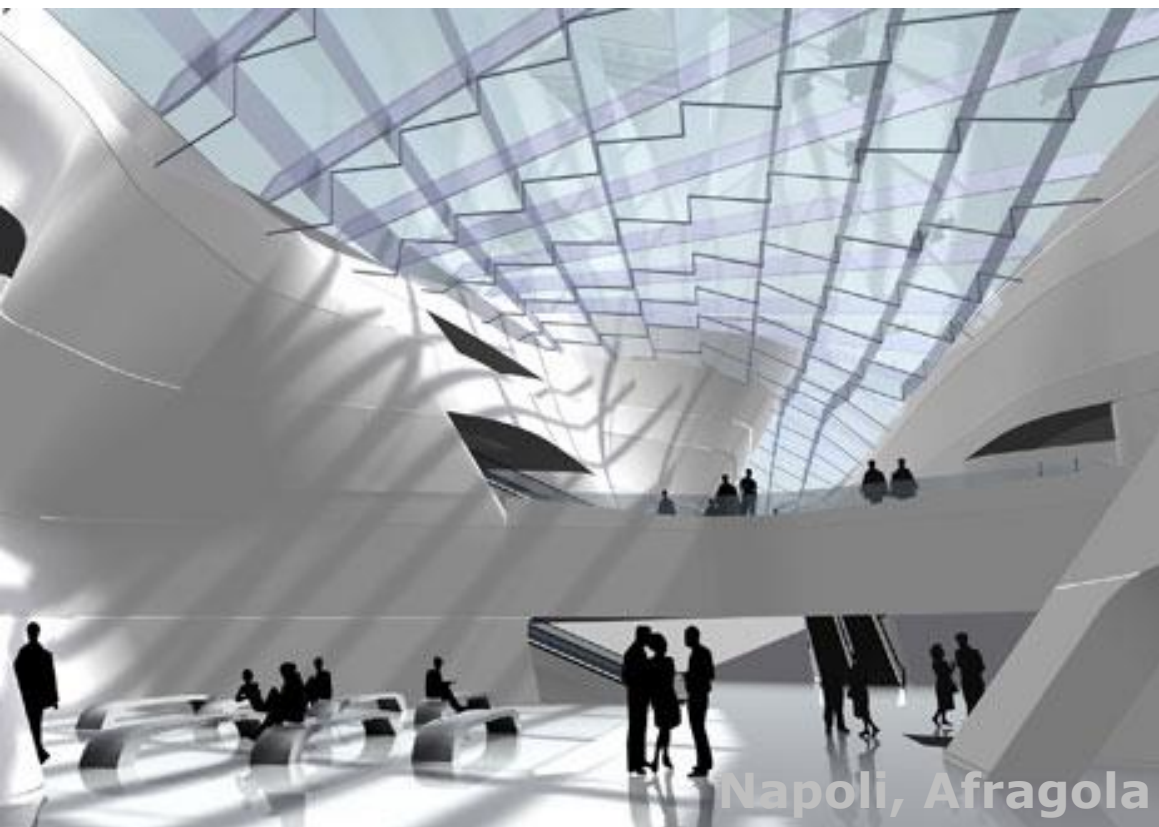
Recent tests, ...



SAFECAST



Critical Infrastructures: Energy, Lifelines, Transport and Communications, ...



**European
guidelines for
the protection of
physical
infrastructure**

Numerical simulations

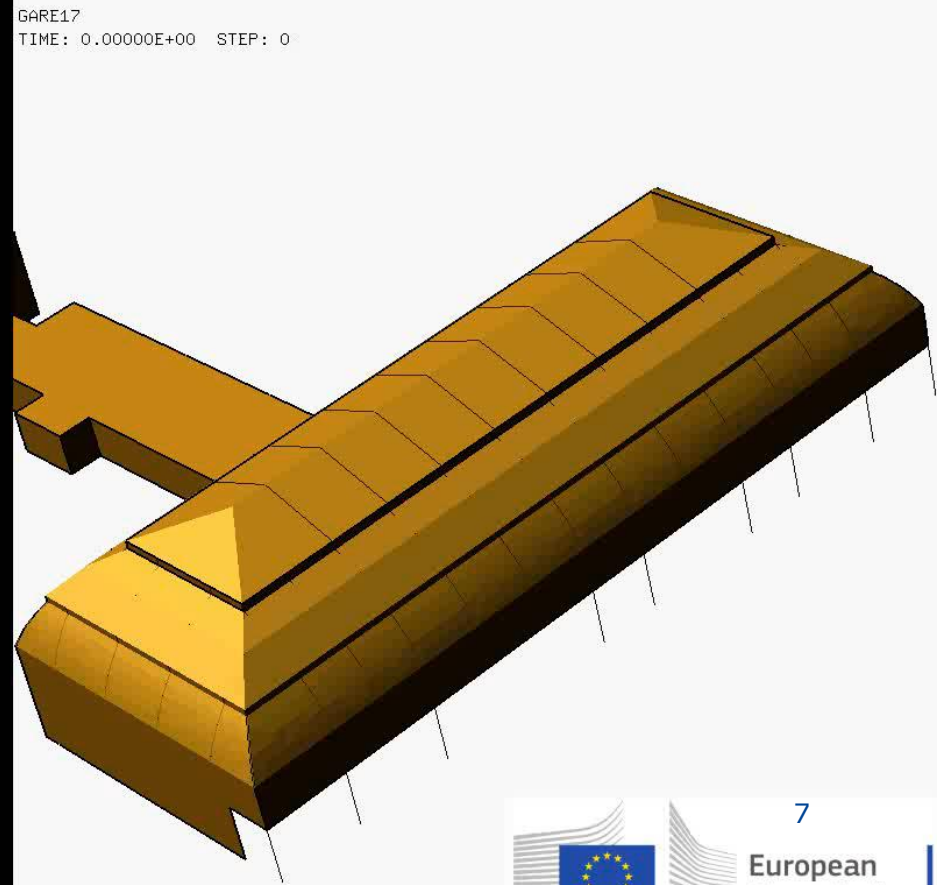
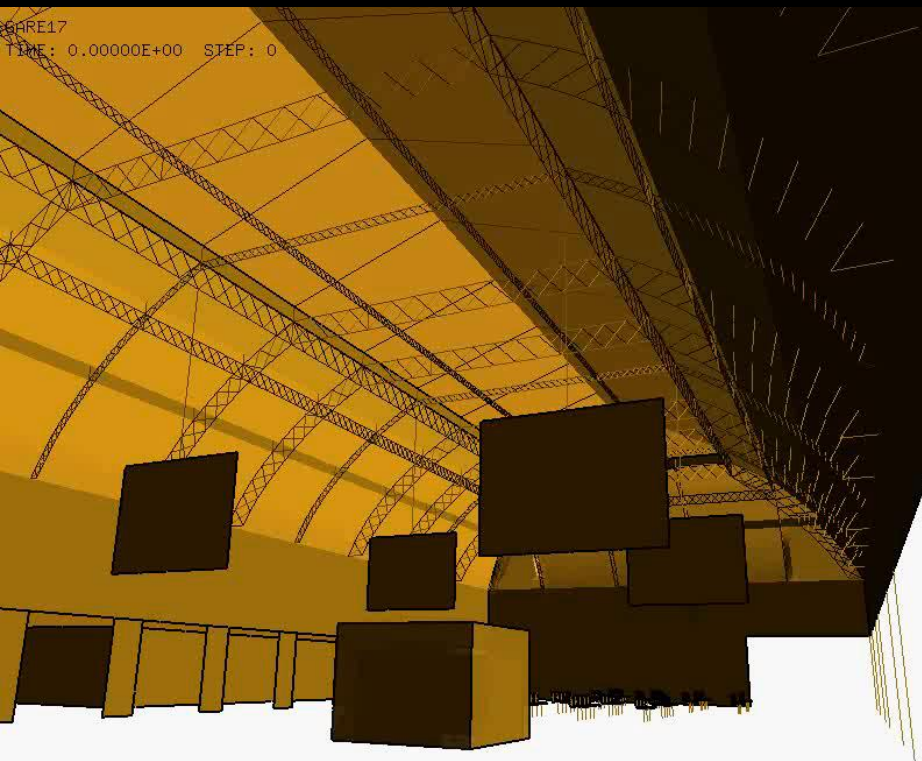
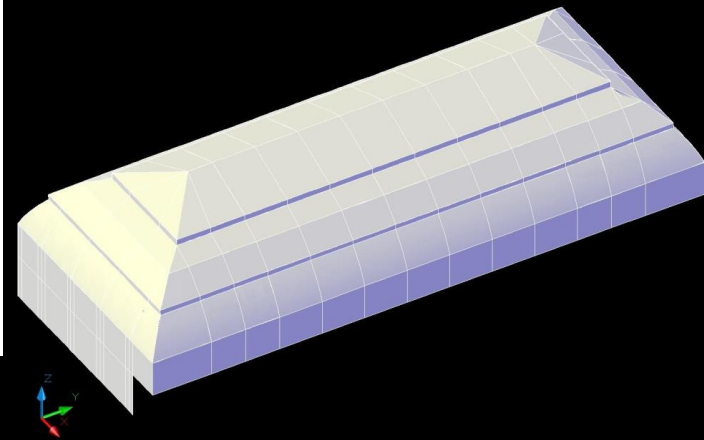


EUROPLEXUS code, developed in collaboration with CEA

- **Explicit** finite element code for fast dynamic response of structures (**explosions, impacts**, crashes, etc.)
- Specialized in modelling of **Fluid-Structure Interaction** phenomena
- **Free** version available **for research and education**



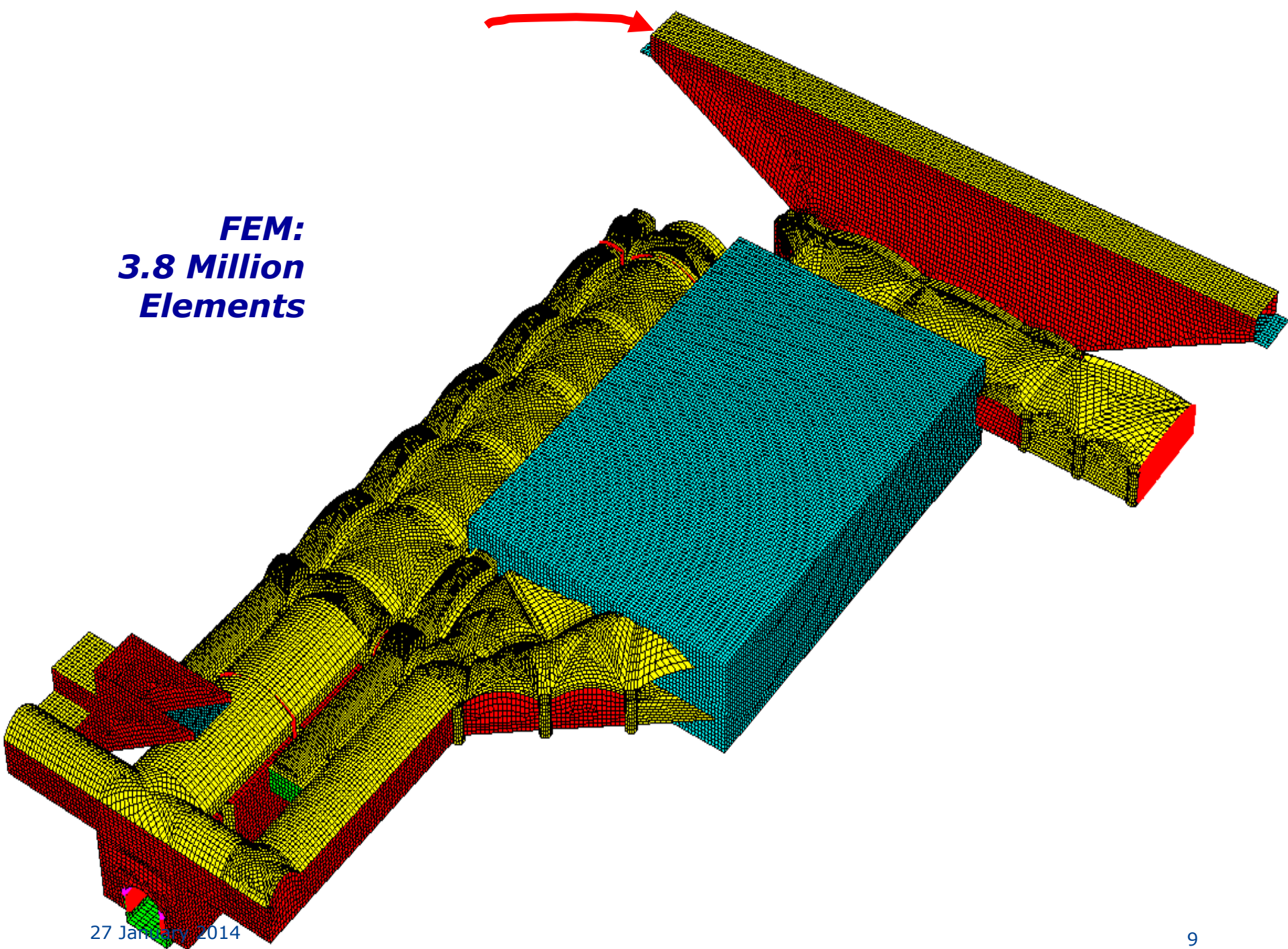
Explosion inside a station





FP7 Project : SECUR-ED
Secured Urban Transport – European Demonstration

FEM:
3.8 Million
Elements



Simulation of explosion scenario

- Example: Real metro station
- Data for calculation and post treatment:

Number of finite elements	Memory peak for the calculation [GB]	Memory peak for the post treatment [GB]	Size of the output data [GB]	CPU needed for the calculation [s]	CPU needed for the post treatment [s]
3,800,178	10.07	24.44	253.51	828771 (9.59 days)	46577 (0.54 days)

- **Parametric studies** increase output data and calculation time
- Parallelization reduces calculation time
→ Parameter studies are possible in reasonable time
- **BUT: e.g. 10 runs with different parameters: 2.5 TB data**

Emerging Areas in Container Security Research

- Composites Technology
- Wireless Sensor Networks

Eugenio Gutiérrez
European Commission
Joint Research Centre

Presented at the
ISO TC104 SC2 WG2 Meeting
30/09/13-02/10/13, Atlanta, GA, USA



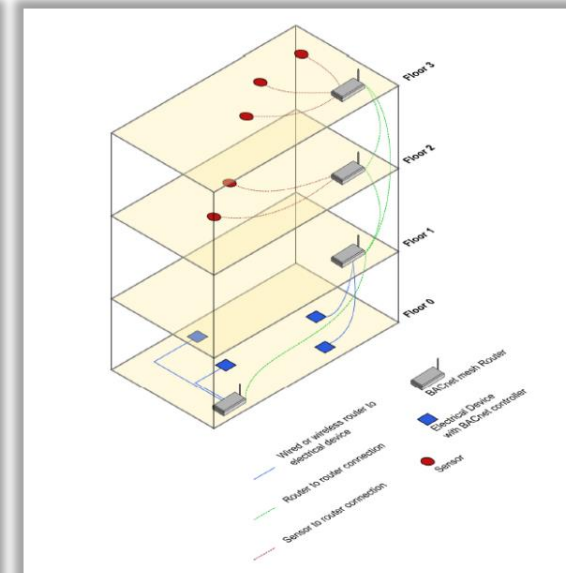
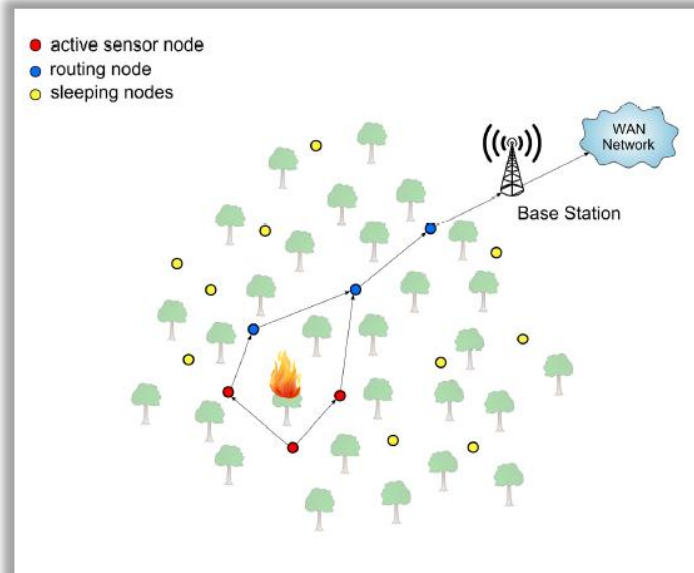
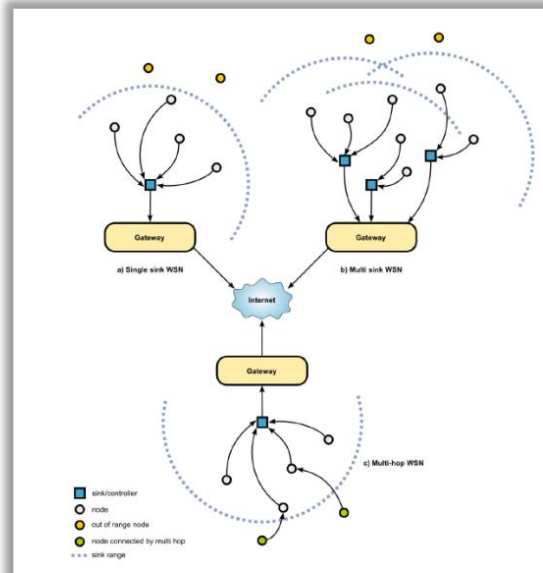
STEC
SMART TAMP-EVIDENT CONTAINER

Wireless Sensor Networks

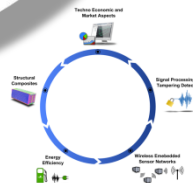
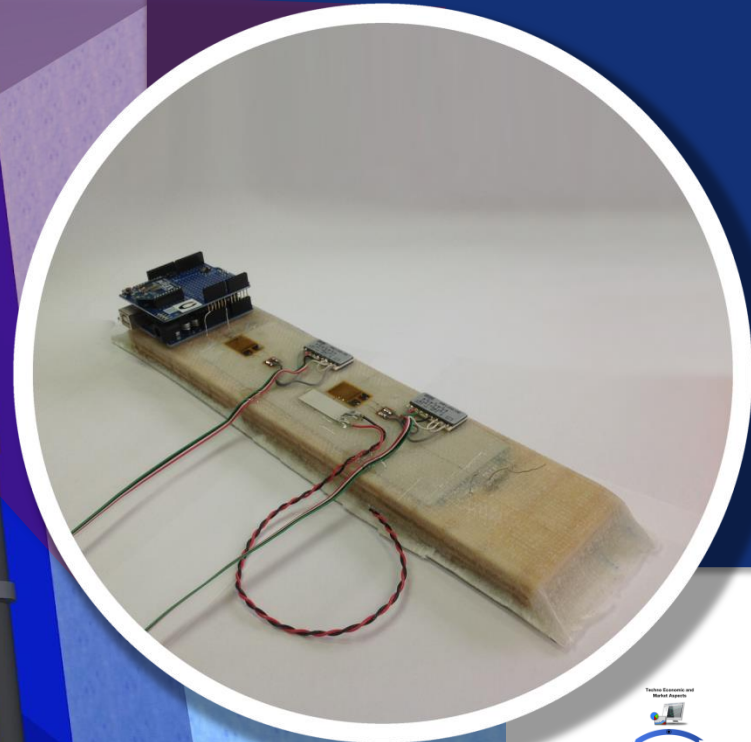
HOW?



Wireless Network Topologies and Functionalities



Comprehensive Full Scale Testing



Summary

	Volume (Disk)	Processing (Memory + Parallelization)	'Next'
Laboratory Photogrammetry	100 TB	High	GPU +Cluster
Blast Simulation	100 TB	Very High	Cluster
Containers Wireless Networks	PB>?? -->	Very High →	Big Data ??

Optical Measurements during Large Structure Reference Tests

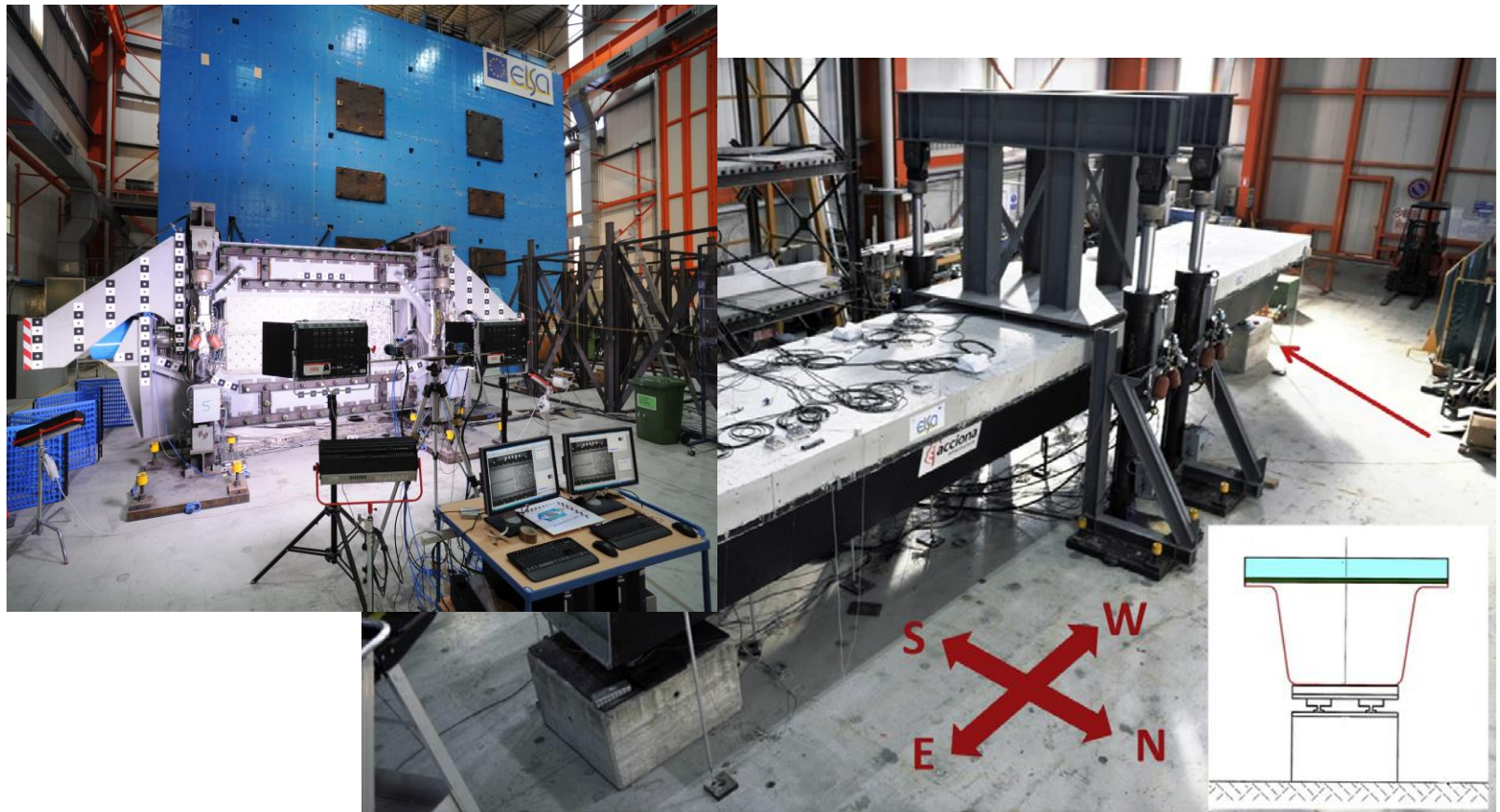
Aim:

- Provide accurate data field for validating numerical simulation

Requirements:

- “Temporal” resolution: 2000-13000 images/run, x20 when oversampling
- Large displacements: ~ 20 cm
- Small deformation: $5e-5$ or less
- **Cracks:** $\sim 10 \mu\text{m}$ resolution (pixel scale 1.5-3 mm)
- Large dimension of the specimen: from 3 to 16 m, 3D

Experimental Settings



Data Acquisition

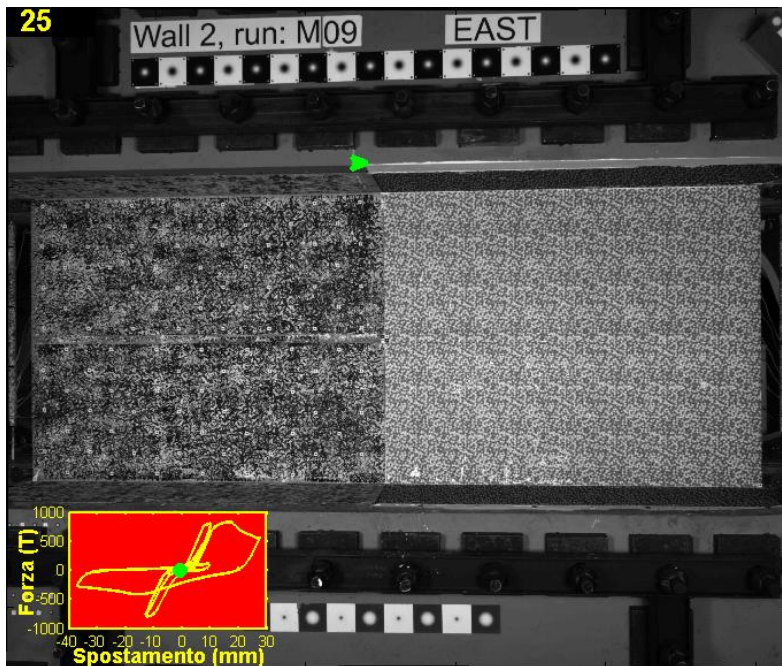
Data Processing

Data Quality?

Data Flow (Flood?)

Data Acquisition

IRIS



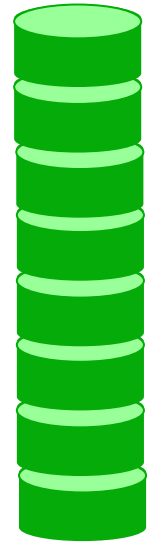
One Stereo rig
One run

270 MB/s

1.6 TB/run

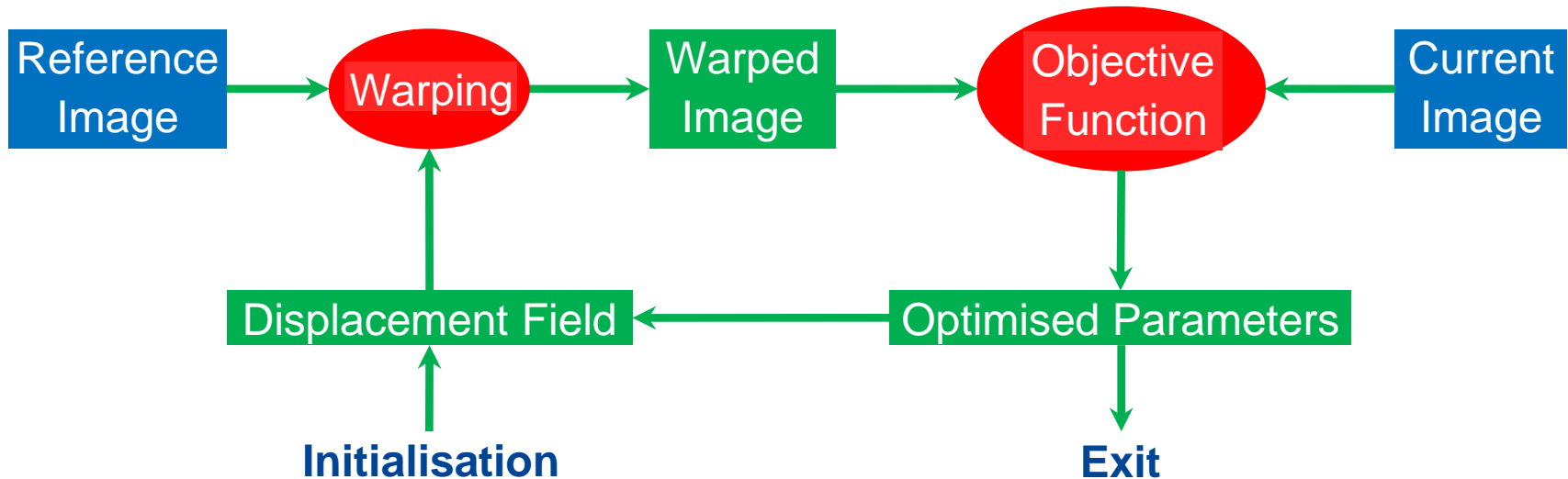
14 MB/s

80 GB/run



14 MB/s → → → → → 270 MB/s when oversampling

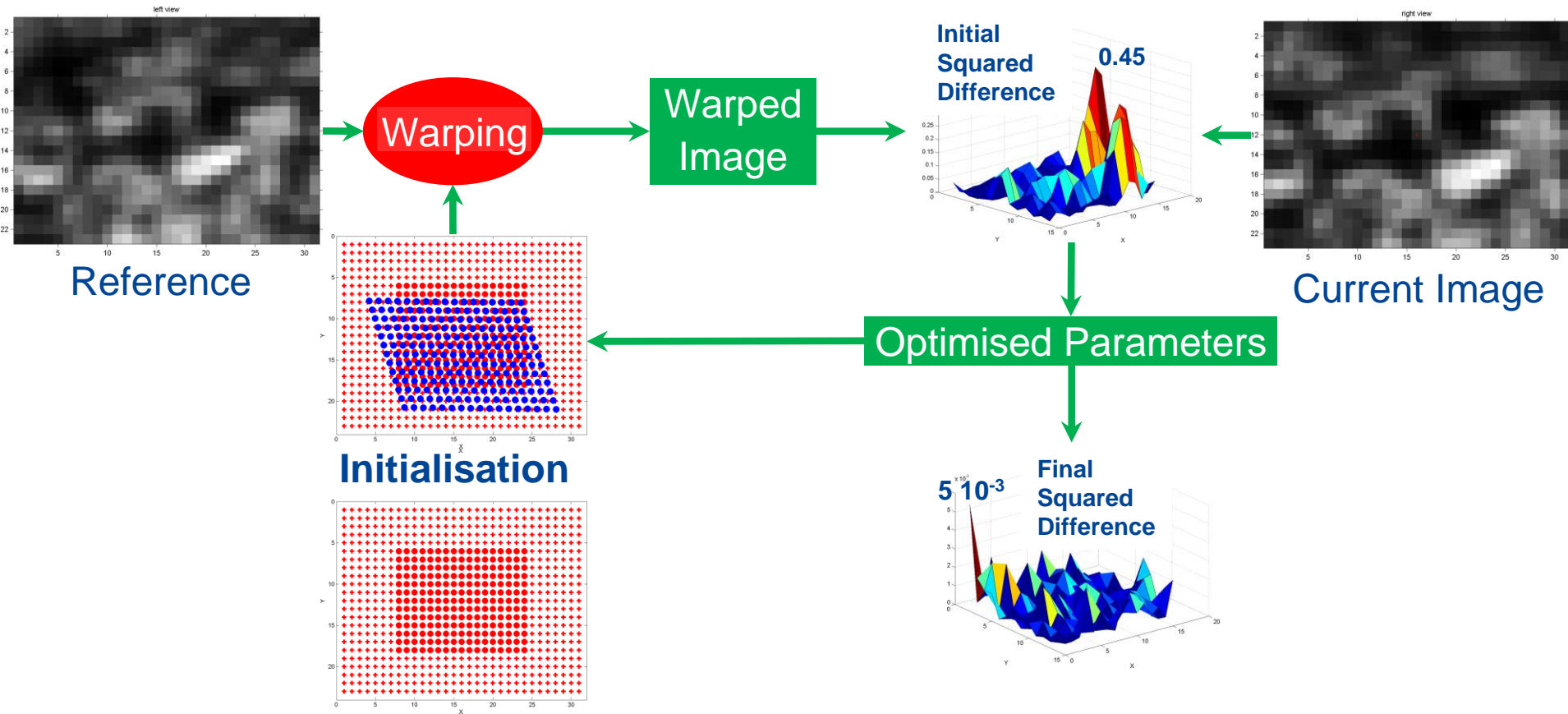
Processing: Local Tracking & Optical Flow



Local Tracking: on Sub-Windows, Objective Function + Warping Model, e.g. (Minimize $\int \text{Squared Difference} [\text{Linear Deformation} + \text{Light Correction}]$)

Optical Flow: on Full Window, Objective Function (e.g. $\int \text{Squared Difference}$, $\int \text{Absolute Difference}$) + Regularization Term controlling smoothness

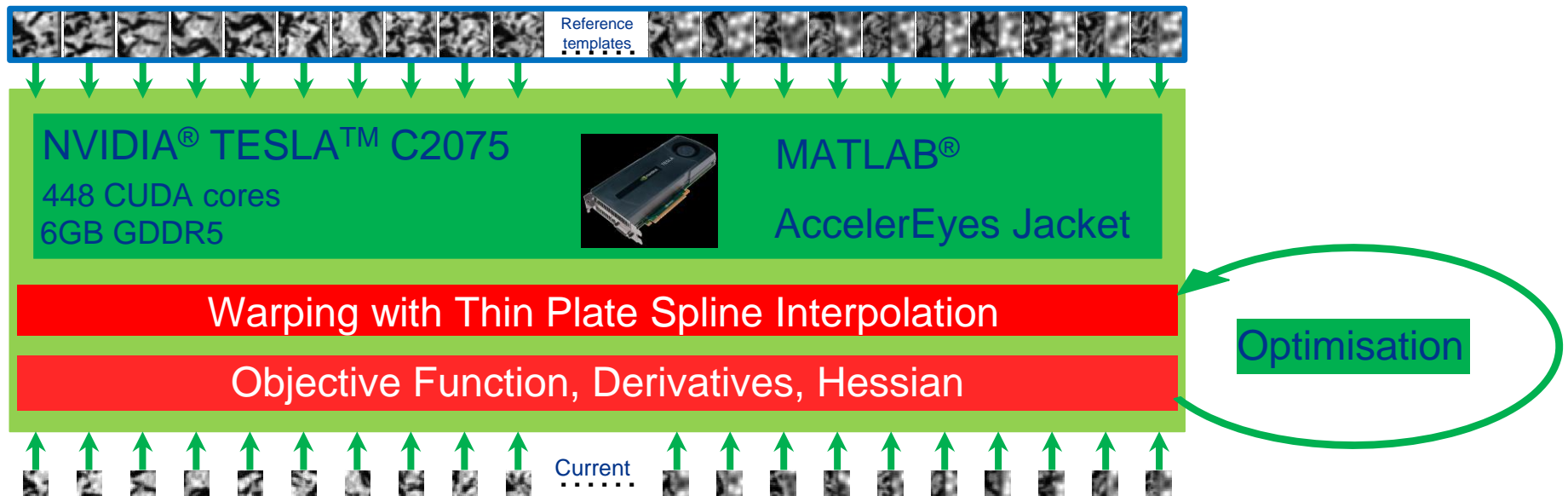
Local Tracking



Present Data Flow

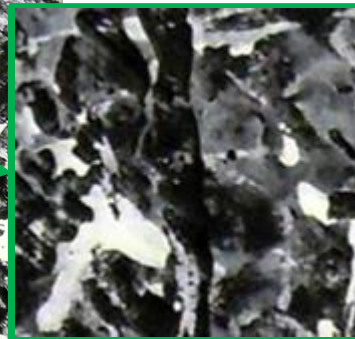
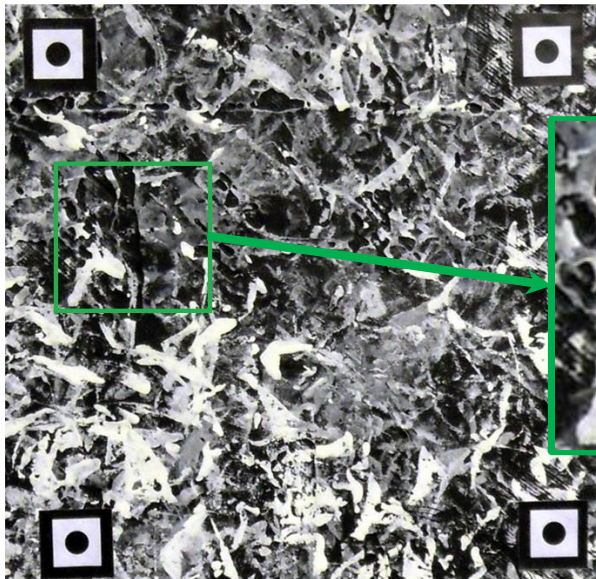
Simultaneous Tracking on N templates through use of GPU C2075:

Acceleration by a factor 10 to 30 depending on the templates size and number

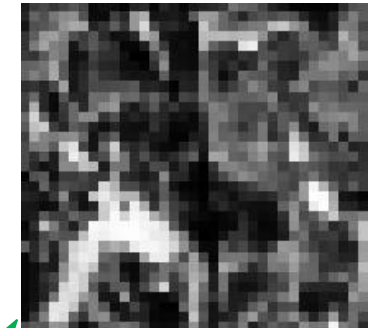


Texture Quality

Lagrangian Tracking: following material points from reference to current state

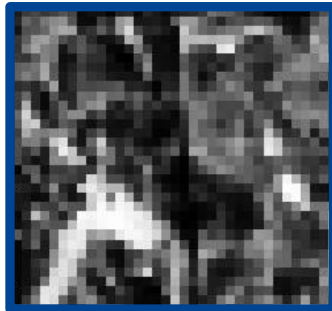


Camera Sampling:
Optical Blurring
Grey level Rounding
Pixelisation→Aliasing



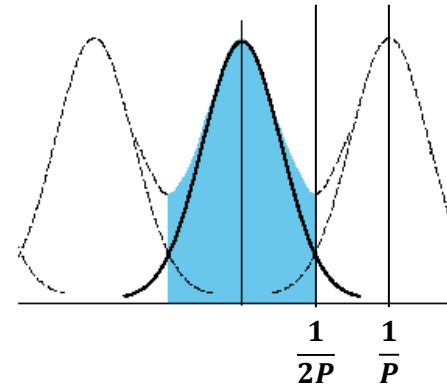
Texture Quality {
Density
Characteristic Scale
Smoothness
...Spectrum

“Hardware Brush”



Caliper
Template
Gauge

Our reference

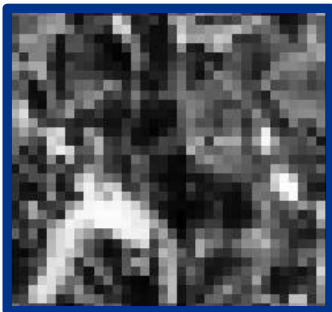


Warping

Bias

Aliasing

INTERPOLATOR Thin Plate Spline



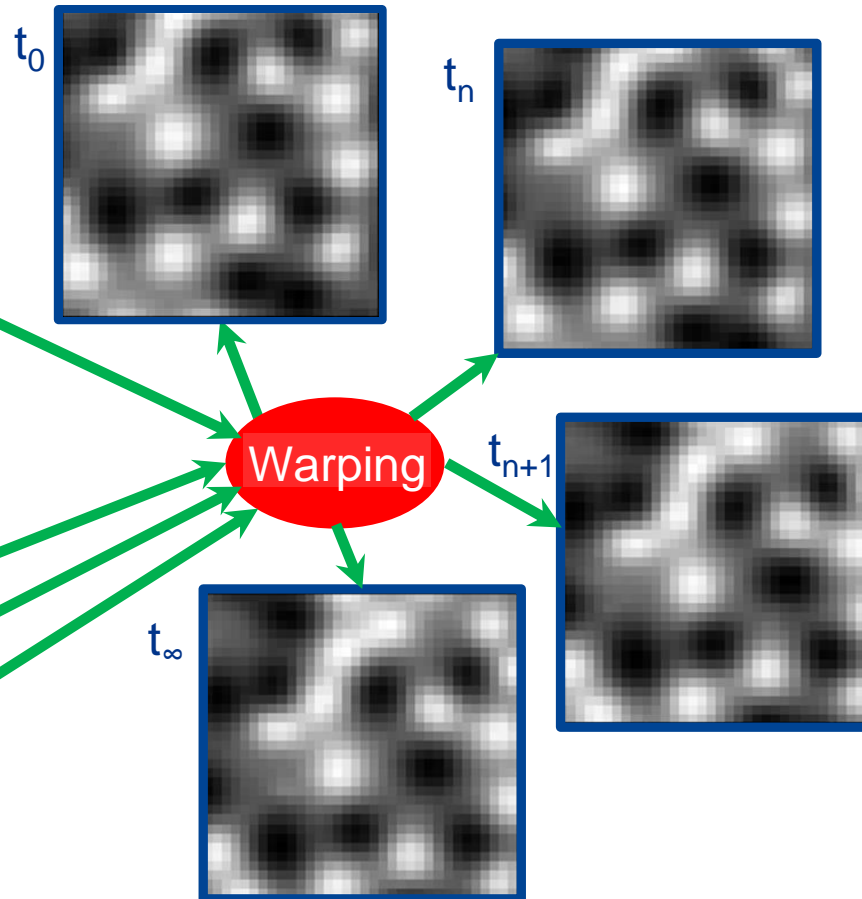
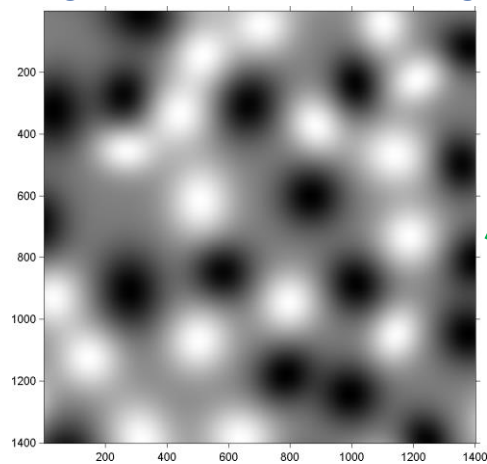
Our Current State

Nota-Bene:

The pixel scales to [1 : 3] mm in our experiments

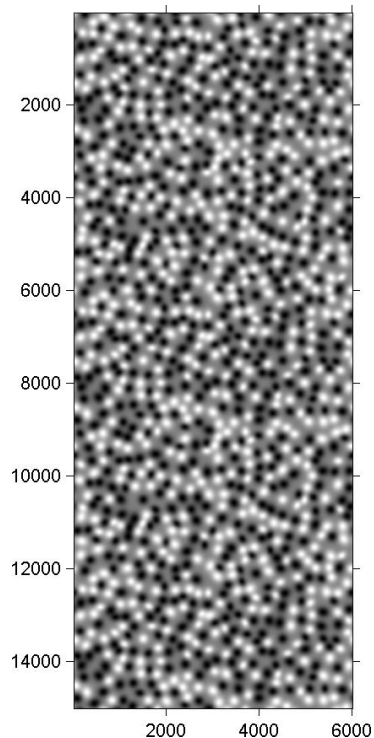
Dream: “Software Brush”

High Resolution Gauge



Practical application: “Software Brush”

High resolution
“Gauge” Design

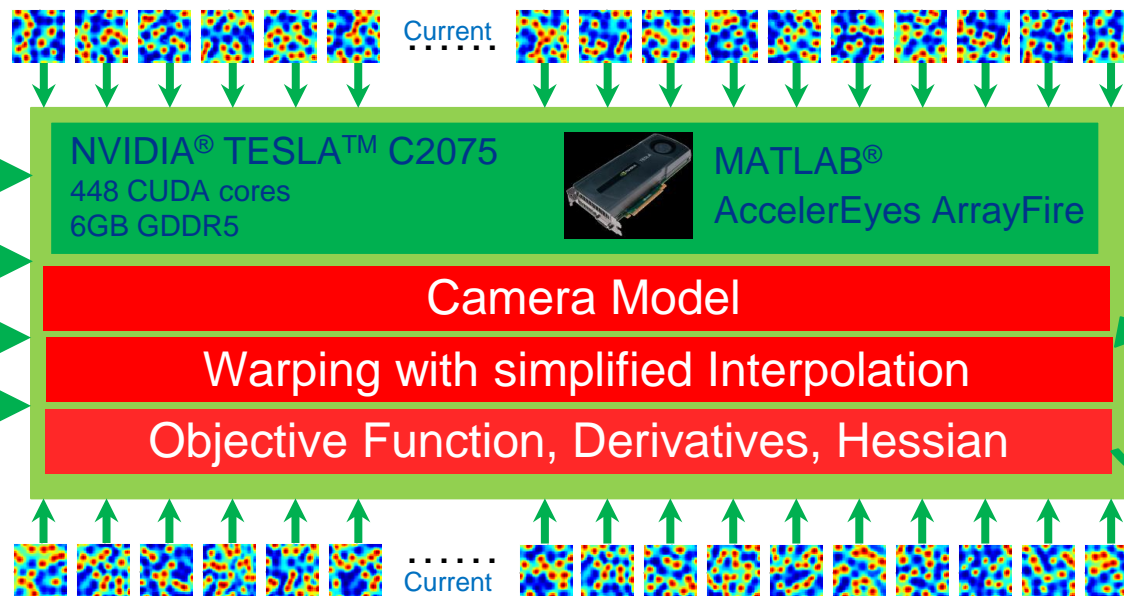
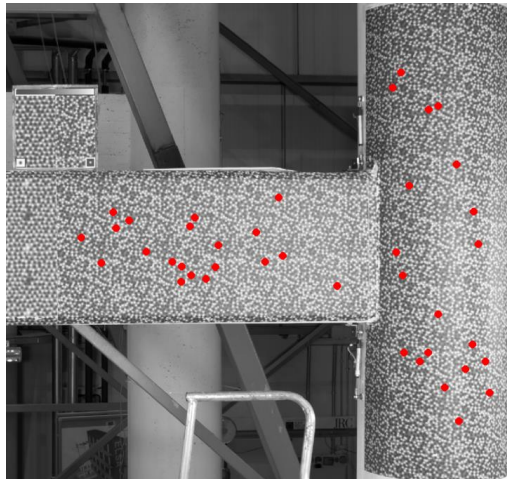


“Gauge” fresco applied on
the structure



Future Data Flow

Simultaneous Tracking on N sub-windows, using the high resolution template as reference:



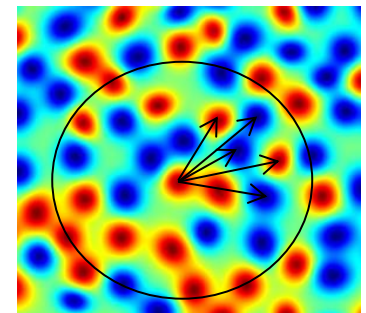
Conclusion

Data Volume:

- Large primary data volume per experiment, with complex secondary results generating 3D displacement fields, deformation field and 3D cracking network and aperture as function of time.
- Primary and secondary data need to be archived in a reference data repository.

Data Processing:

- Parallelisation of processing,
- Use of “digital brush” to reduce processing burden and increase accuracy.
- E.g. use internal invariants of the digital pattern to recognise the corresponding points on the structure and their orientation in space



Thank you for your attention

IRIS: Cracks Mapping

vertical displacement i21-OF-0-3368-to-max-3

