Approach to a modified standard for testing windows under explosive loading

Findings of Thematic Group "Resistance of structures to explosion effects" of the European Reference network for Critical infrastructure protection ERNCIP

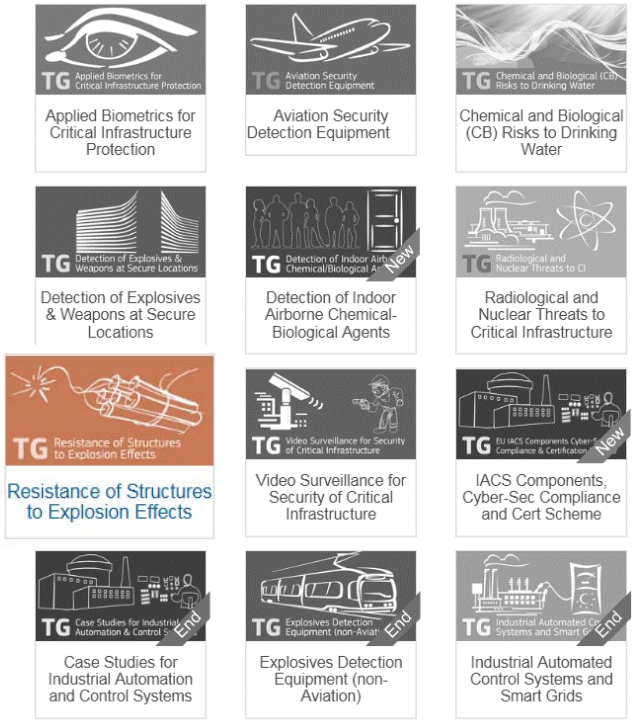
JRC

The ERNCIP Project

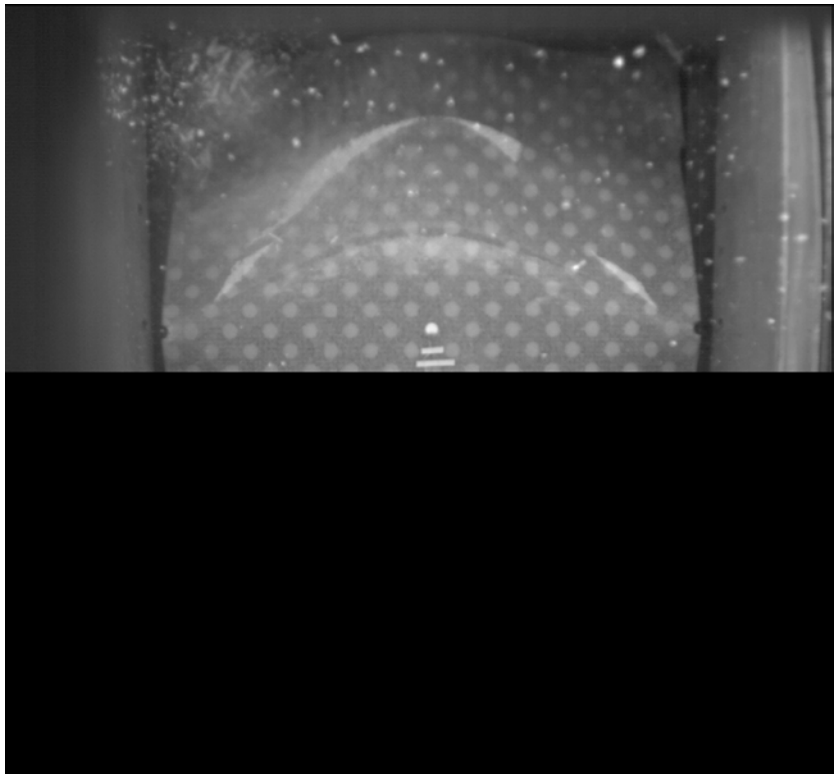
ERNCIP's mission is to foster the emergence of innovative, qualified, efficient and competitive security solutions, through networking of European experimental capabilities

ERNCIP Strategic Goals:

- Improve protection of CIP in EU
- Support development of single EU market for security products
- Identify gaps in EU security product testing capabilities



Resistance of structures to explosion effects



Resistance of Structures to Explosion Effects

Wehrtechnische Dienststelle für Schutz- und Sondertechnik (WTD 52)

ENSTA Bretagne

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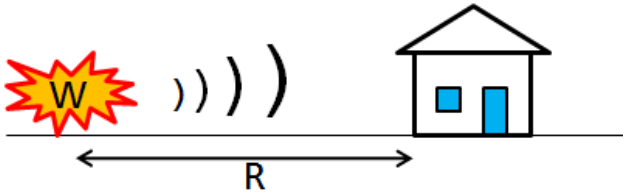
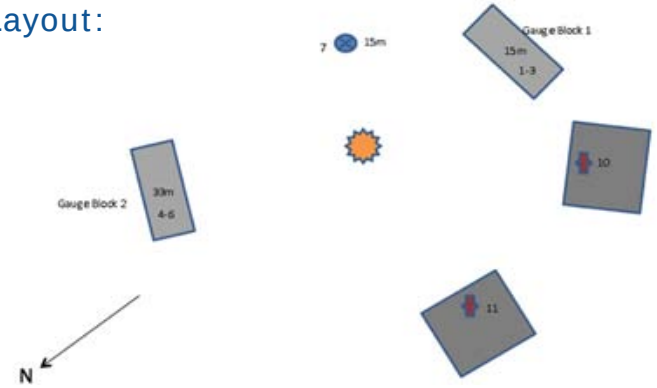
Resistance of structures to explosion effects
Experimental Testing: Arena Tests

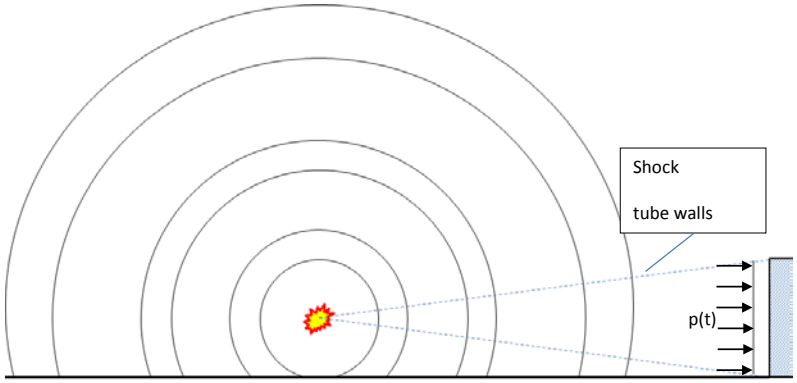


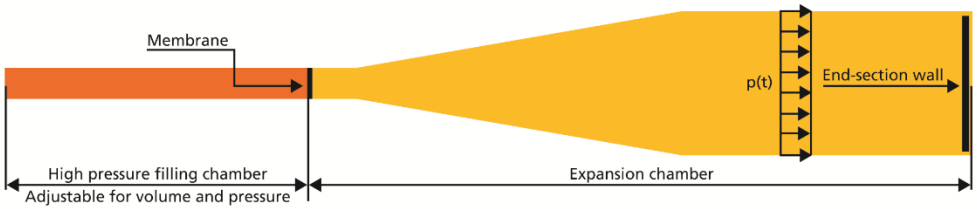
Loading parameters:
- Charge weight W
- Distance R

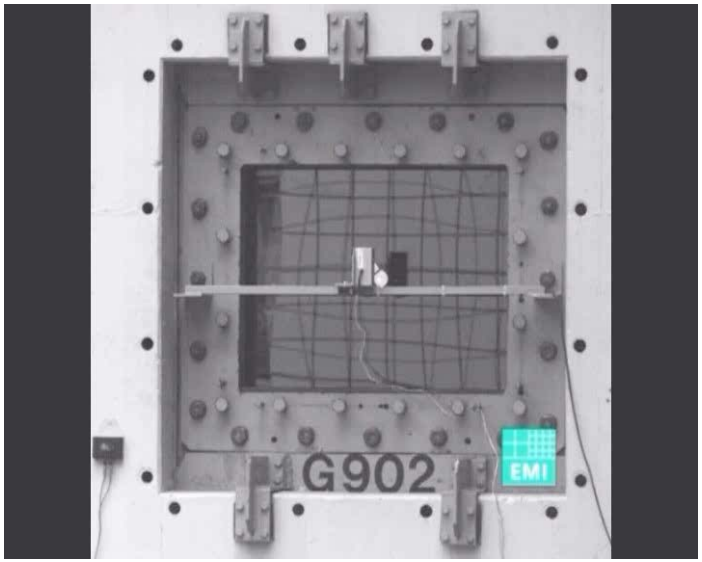
Layout:



Resistance of structures to explosion effects
Experimental Testing: Shocktubes







Why we

Members of the group…

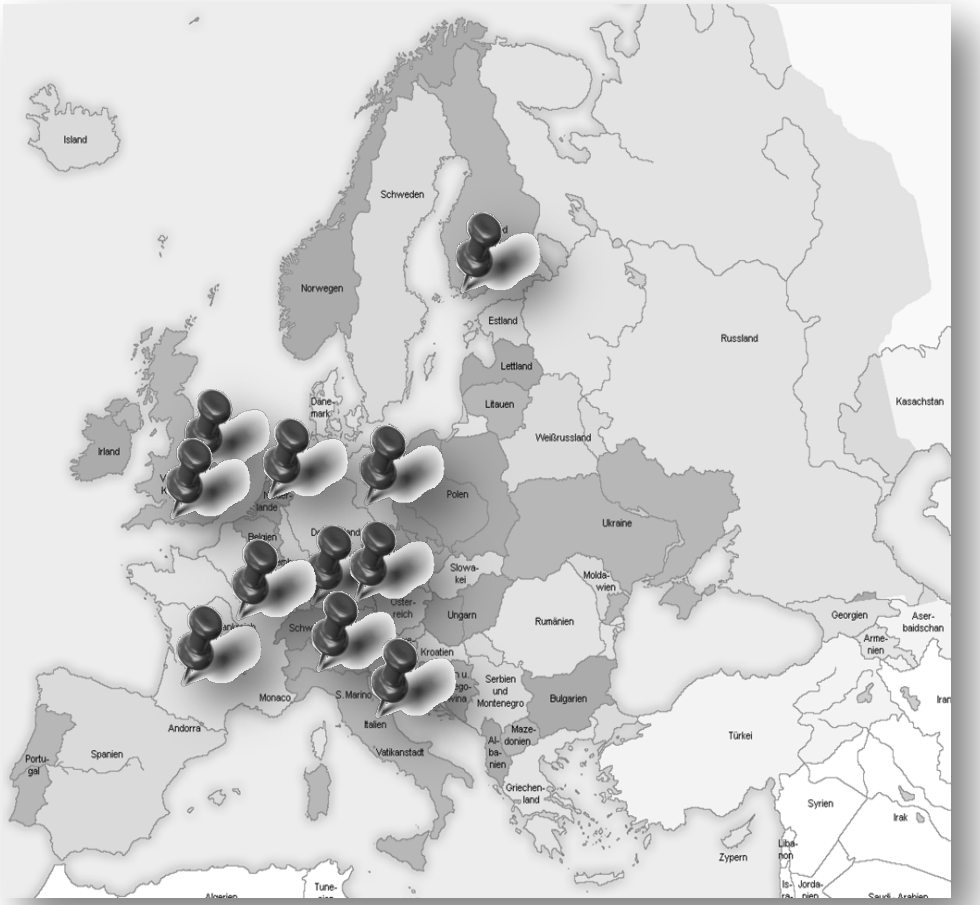
… define threat scenarios and the protection levels

… do blast consultancy

… interpret test requirements

… are impartial from the market

… do actually test the elements



Why we

11 Members from 6 countries

Organization	Country	Focus in TG (Testing / Modelling / Both)	Type of org.
BAM	Germany	Both	R&D, consultancy
CEA	France	Both	R&D
CPNI	United Kingdom	Testing	policy support, consultancy
ENSTA Bretagne	France	Both	R&D
Fraunhofer EMI	Germany	Both	R&D, consultancy
UK Home Office	United Kingdom	Testing	policy support, consultancy
JRC	European Commission	Modelling	R&D, policy support
TNO	Netherlands	Both	R&D, consultancy
University Trieste	Italy	Modelling	R&D
VTT	Finland	Modelling	R&D
WTD 52	Germany	Testing	R&D

Motivation I

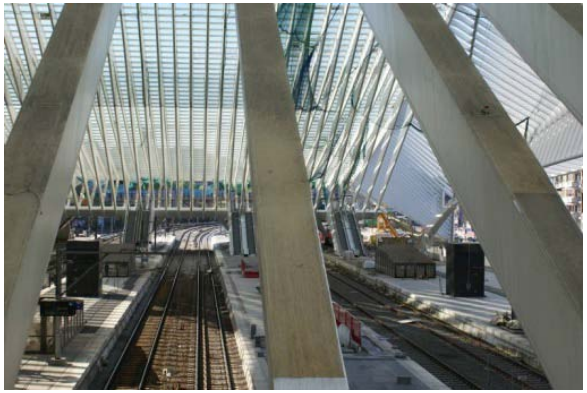
Glass panel in
standard test frame

?

?

Window system

European Parliament,
Strasbourg



Railway station Liège

[wikipedia.org]

Motivation II

- Changed threat scenarios (standard 100 kg in certain distances)
- Existing test sizes do not reflect actual sizes of real windows.
- Different standards available but not consistent and harmonized (all have good points)

VBIED in Iraq

[Wikimedia commons]

Newcastle Library

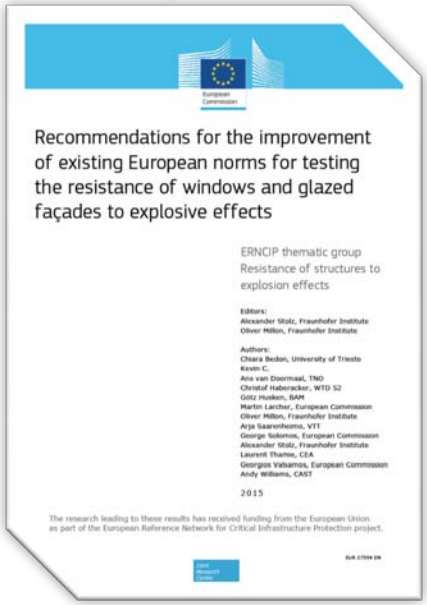
Approach

Review/ comparison of existing methodologies / standards

Derivation of common test procedures / best practices

Identify gaps and conflicts

Recommendation for modifications



Main Results

Review

- • Different sample numbers required
- • Different test specimen sizes

Best practices

- • Support structure and boundary conditions may influence results
- • Lack of detailed definition of support conditions

Gaps

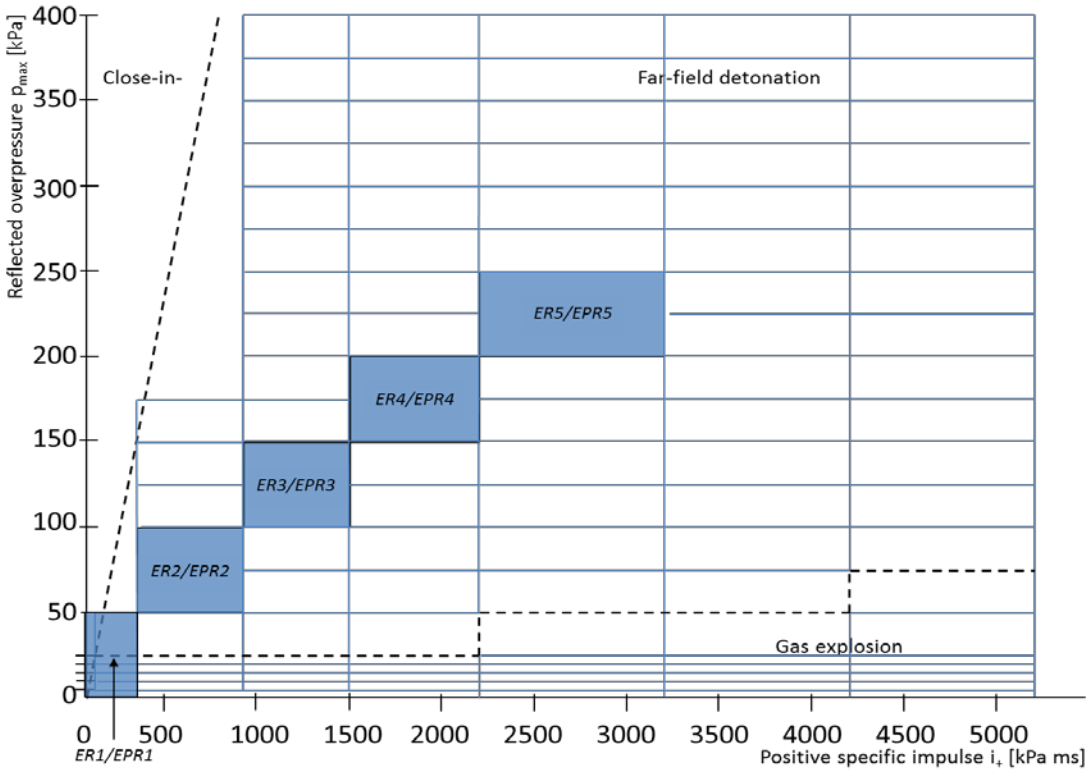
- • Standards not applicable to both windows and facade systems

Modification

- • Harmonization of hazard classes and hazard levels required
- • Derivation of different EPR classification (for additional threats such as petrochemical loading)

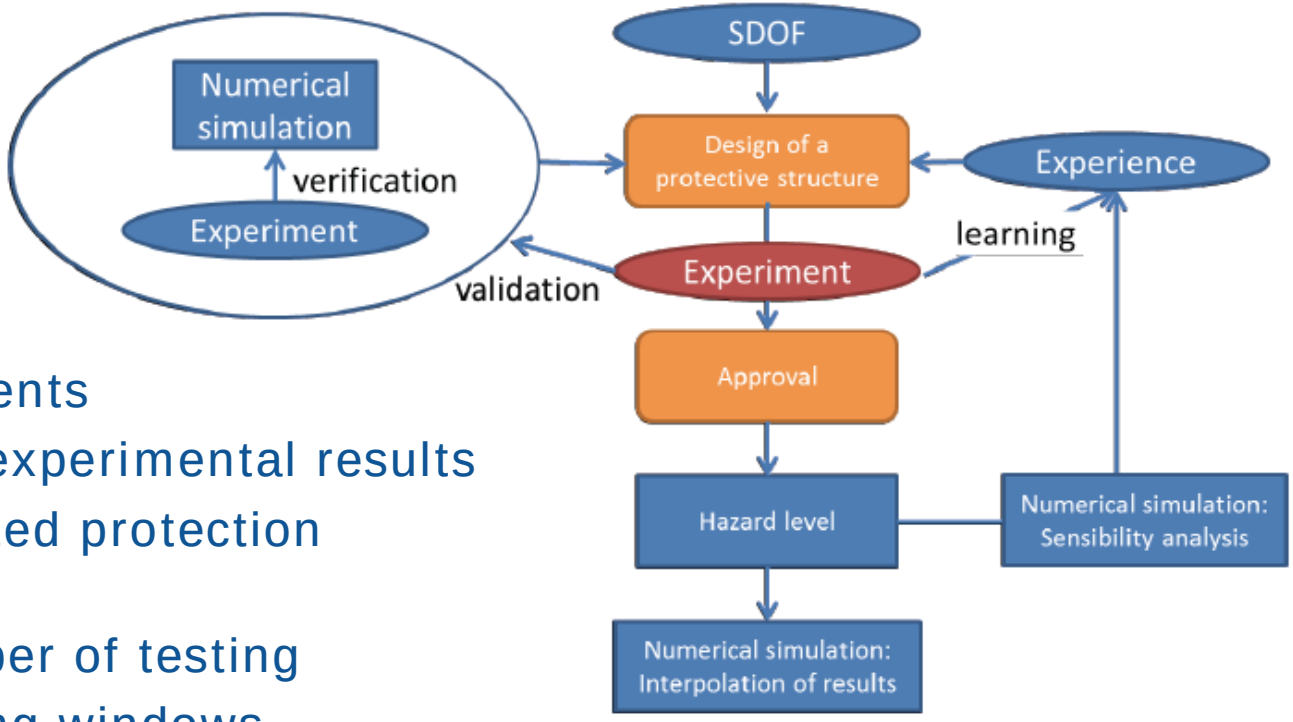
- • Lack of standards for numerical modelling

Main Results



Proposed definition of loading levels by using a pressure-impulse diagram for application in shock-tube tests

Motivation for numerical simulations *)

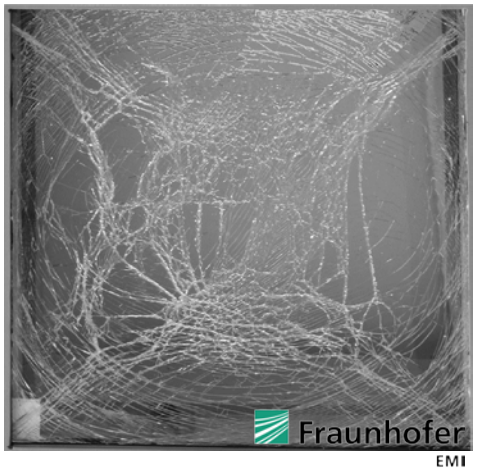


- Support experiments
- Extrapolation of experimental results
- Design of optimized protection (also facades)
- Reduce the number of testing
- Support classifying windows

*) Single degree of freedom method, explicit finite element method

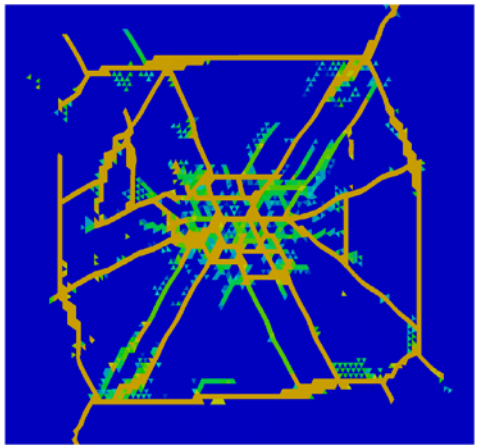
Example numerical simulation: glass + windows

Experiment

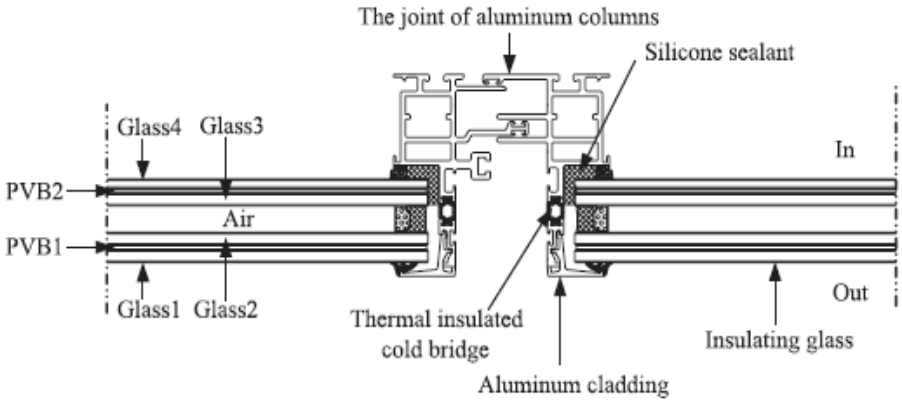


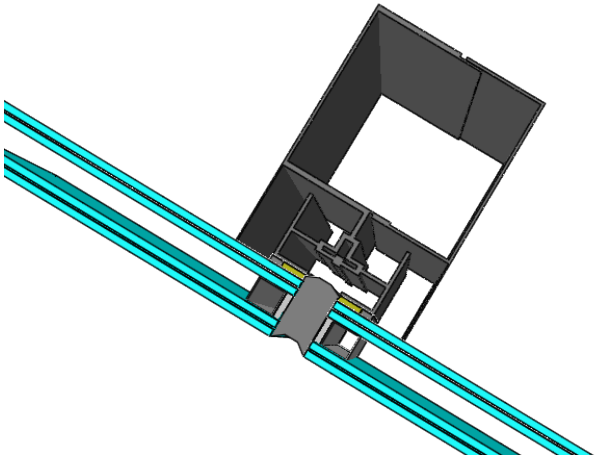
[Kranzer et al. 2005]

Numerical Simulation



Including windows frame system

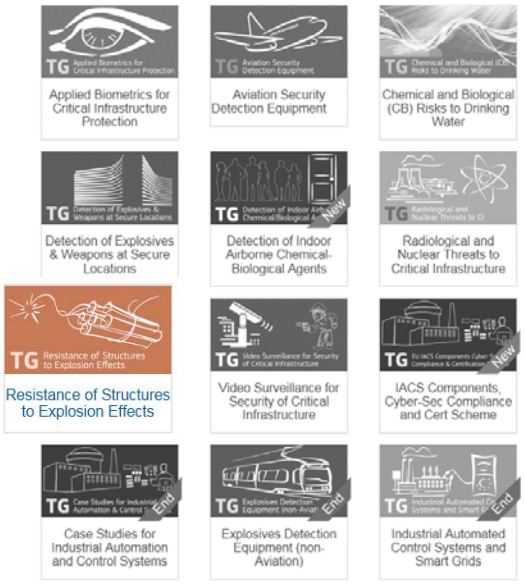




Simulation: Scope of a possible standard

- Modelling requirements (method, mesh size, materials)
- Loading (fluid-structure interaction, pressure-time history)
- Application range (first cracks, panel damage, shear failure, frame resistance)
- Validation process of the computational tool
- Interpretation of the numerical results and corresponding classification

References:



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https://erncip-project.jrc.ec.europa.eu/networks/tgs/buildings

Summary:

- Review and amend existing test standards to address the issues identified in ERNCIP studies.
  - Harmonize EN and ISO standards
  - Extend the test standards to cover glass facades
- Develop a new standard for numerical modelling for the performance of windows and glass façades under blast loading
  - Set-up a CEN Workshop with the aim of developing a CEN Workshop Agreement