
IMPORTANT TOPICS

TG: RESISTANCE OF STRUCTURES TO EXPLOSION EFFECTS

Regulations and Testing Methods



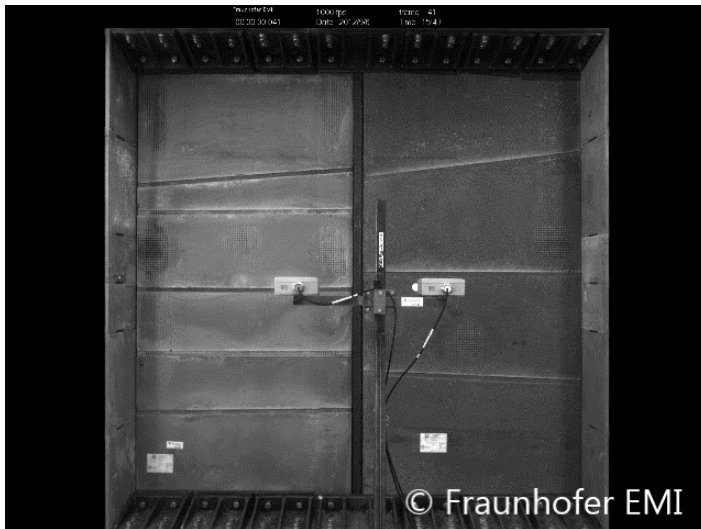
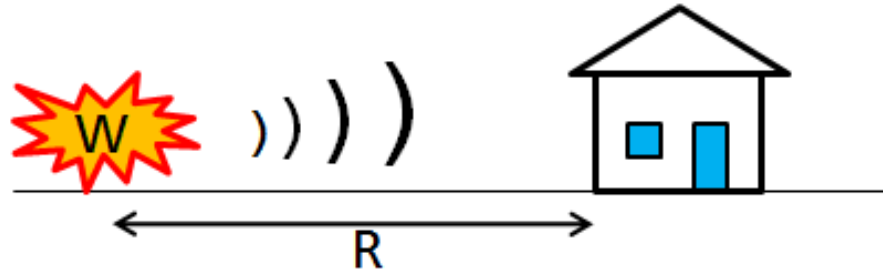
Wehrtechnische Dienststelle 1
Schutz- und Sondertechnik
(WTD 52)



JOINT RESEARCH CENTRE



What is: Resistance of structures to explosion effects



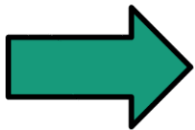
Starting Point

■ ERNCIP goals:

- ERNCIP aims at providing a framework within which **experimental facilities** and **laboratories** will share knowledge and expertise in order to harmonize test protocols throughout Europe, leading to better protection of critical infrastructures against all types of threats and hazards.
- Our mission is to foster the emergence of innovative, qualified, efficient and competitive security solutions, through the networking of European experimental capabilities

■ First Questions

- In which field (sub topic) of structural protection against/ to explosives / explosions / explosive effects the group will try to support the goal

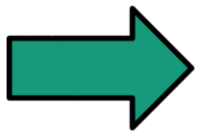


What do we like to investigate / harmonize
in general and in a first step?

Structural Resistance against Explosive Loading

Status

- In contrast to other topics relatively small group of experts
- Group members represents also competitors for testing, but have common sense in testing fundamentals
- Number of regulations very limited
 - EN 1991-7: Action on structures → Explosion in informative Annex
 - FEMA 426, 427, 428, 429, 430 and 452 → non- EU
 - Several national documents like e.g.
 - PAS (Public Available Specification)
 - KTA Guideline (Guideline for nuclear power plants)
"external loads"
- Regulations for material testing only available for glass



Integral design approach defining loading and resistance not available in building sector

IDENTIFIED TOPICS

RESISTANCE OF STRUCTURES TO EXPLOSION EFFECTS

Starting points for Improvements:

Creation of
Regulations
for design
concept

- Framework for extended **risk assessment**
- Definition of appropriate design **strategies and methods**
- Common (harmonized) safety concept with comparable **reliability**

Increase
Resistance
against
Explosions



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Modification
Regulations
for testing
methods

- **Guidelines** for choice and application of **testing methods**
- Common **interpretation** of test **results and analysis**
- **Regulations** for also loading bearing building materials
- **Numerical "testing" methods**

Increase
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IDENTIFIED TOPICS

RESISTANCE OF STRUCTURES TO EXPLOSION EFFECTS

Creation of Regulations for design concept

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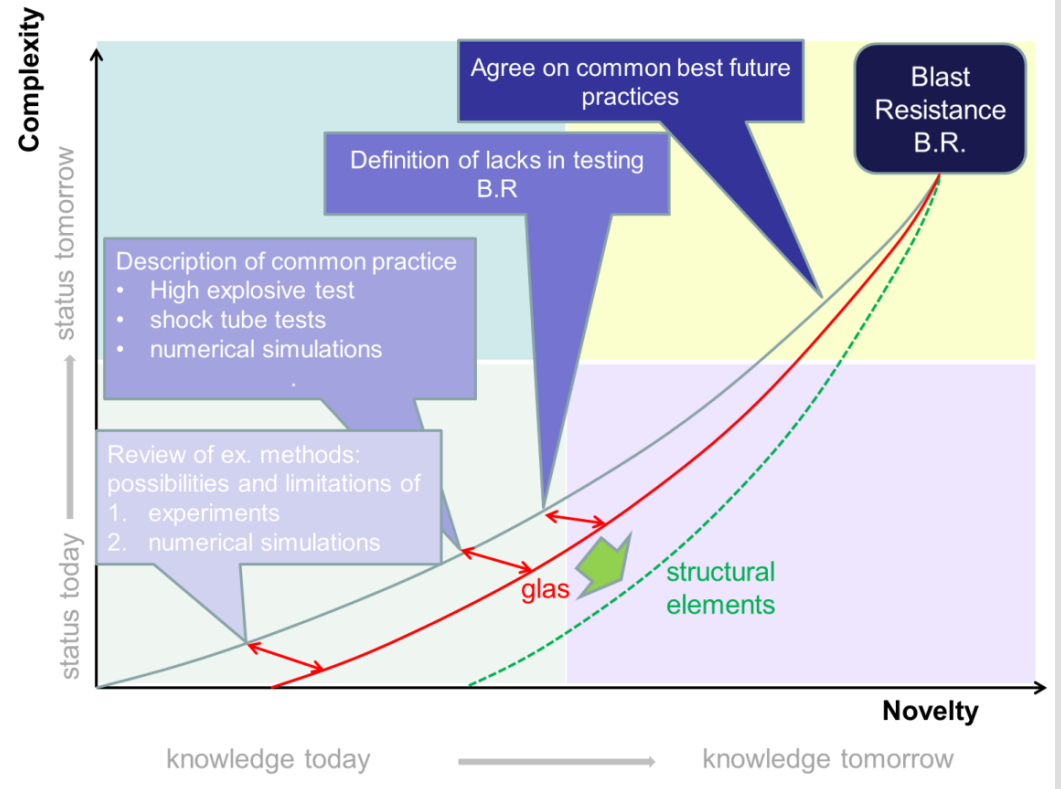
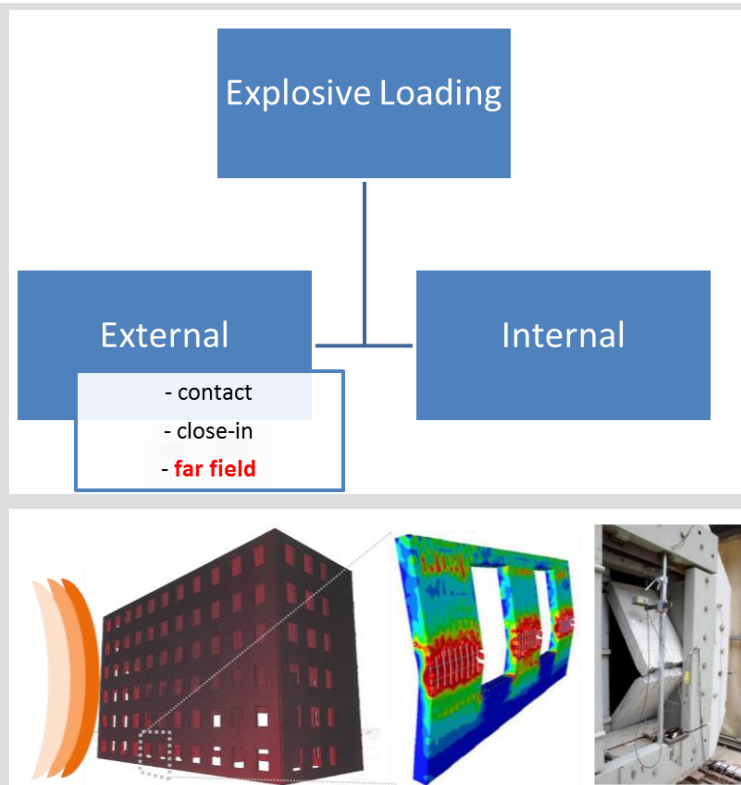
Increase Resistance against Explosions



Identified Topics

Regulations for testing methods

Types of Explosive Loading and WP Approach

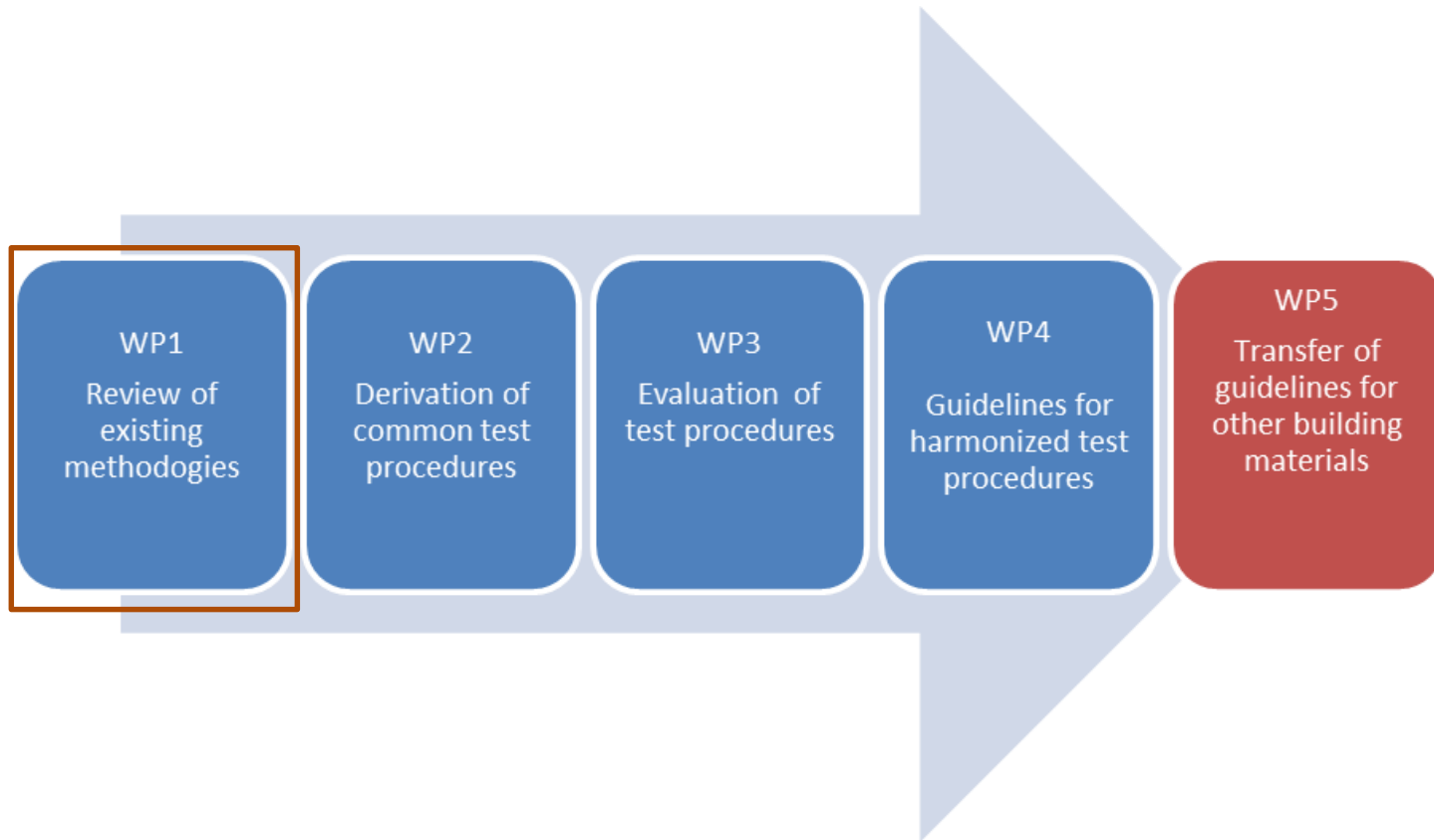


Review and guidelines for existing testing methods for glass under far field loading and transfer to other building materials

Work Programm

Regulations for testing methods

Structure : (completed and accepted December 2012)



Identified Topics

Regulations for testing methods

Existing Test Methods and Analysis Approach

High Explosives

Shock Tube

Numerical Simulation

In order to assess and choose testing methods (especially as a CI-operator) knowledge about:

- Properties formation and propagation of shock waves
- The impact of shock waves on the test specimen
- Possibilities and limitations in measurements
- The interpretation of measurements and test results

will be presented in a guideline document

Identified Topics

Regulations for testing methods

Existing Test Methods possible Pro's and Cons's

High Explosives

- + most appropriate loading profile
- + minor limitations in test specimen size
- Deviation in loading amplitude
- Consideration of clearing effects and robust measurements

Shock Tube

- + reproducibility of loading amplitude
- + less disturbance in measurements
- Limitations to end section size
- Consideration of possible reflections

Numerical Simulation

- + application range for arbitrary loadings
- + cost effectiveness
- Derivation of dynamic material properties
- Validation required

WP1
Review of
existing
methodologies

+ more detailed design regulation very desirable

Work Programm

Deliverables

Regulations for testing methods



Resistance of structures to explosion effects: Review report of testing methods

ERNCIP thematic area
Resistance of structures
to explosion effects
Deliverable D1

Kevin C., Ans van Doormaal, Christof Haberacker,
Götz Hüskens, Martin Larcher, Arja Saarenheimo,
George Solomos, Alexander Stolz, Laurent Thame,
Georgios Valsamos

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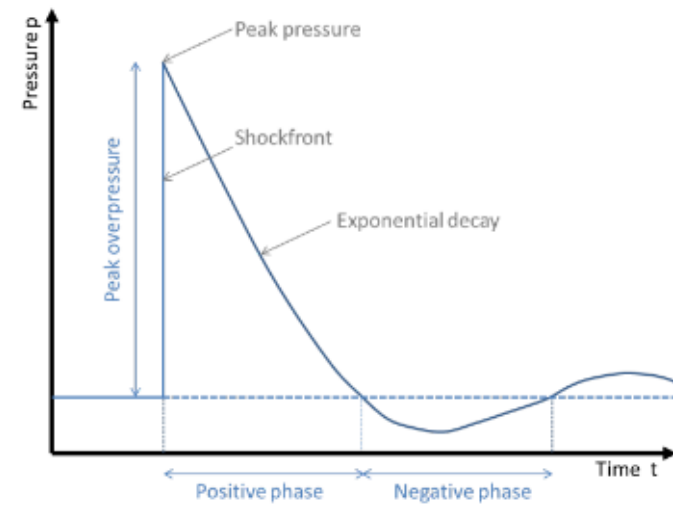
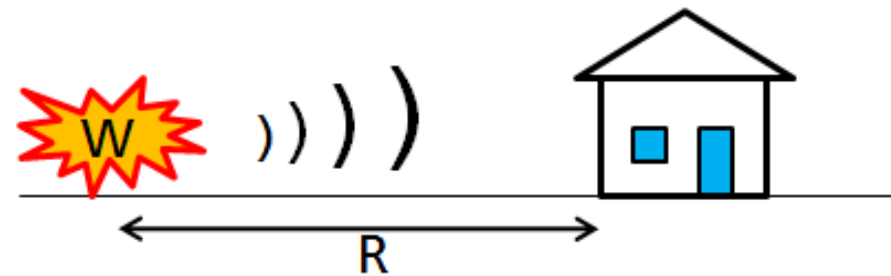


Figure 1: Simplified sketch of a blast wave with its characteristic properties

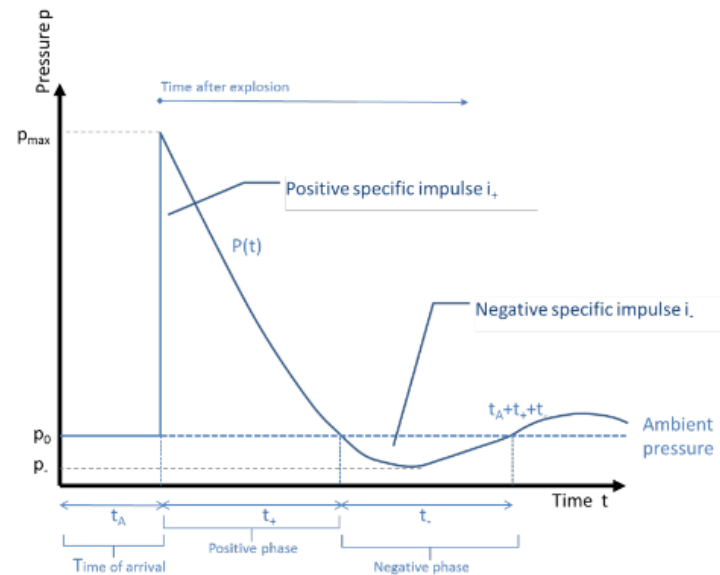


Figure 7: Description of a blast wave as an ideal pressure-time history according to the European standard EN 13123-1

Deliverables

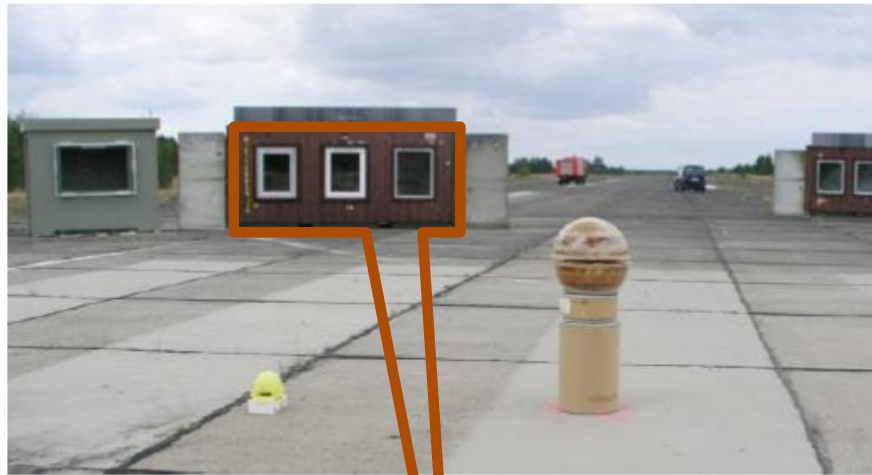


Figure 8: Typical arena test set-up for rating window systems.

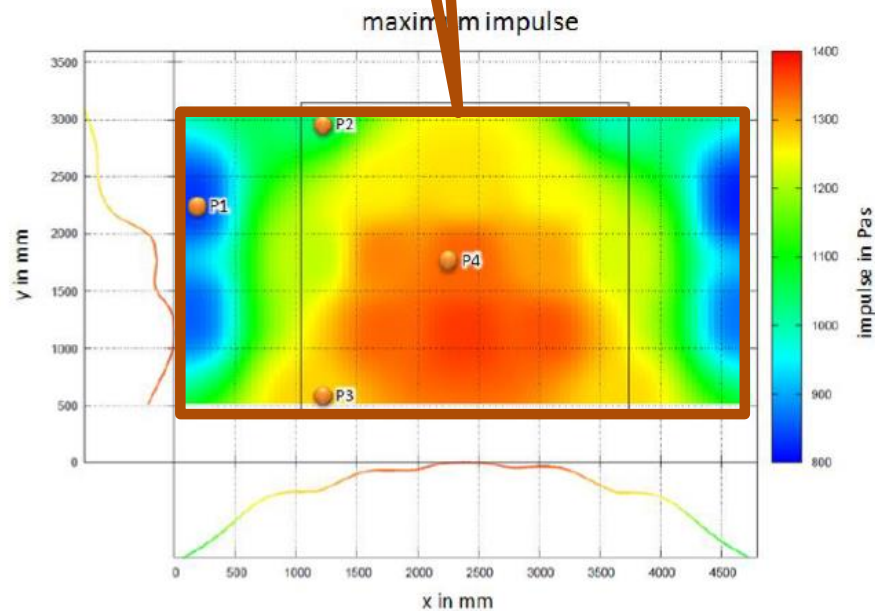


Figure 24: Pressure distribution on a test surface

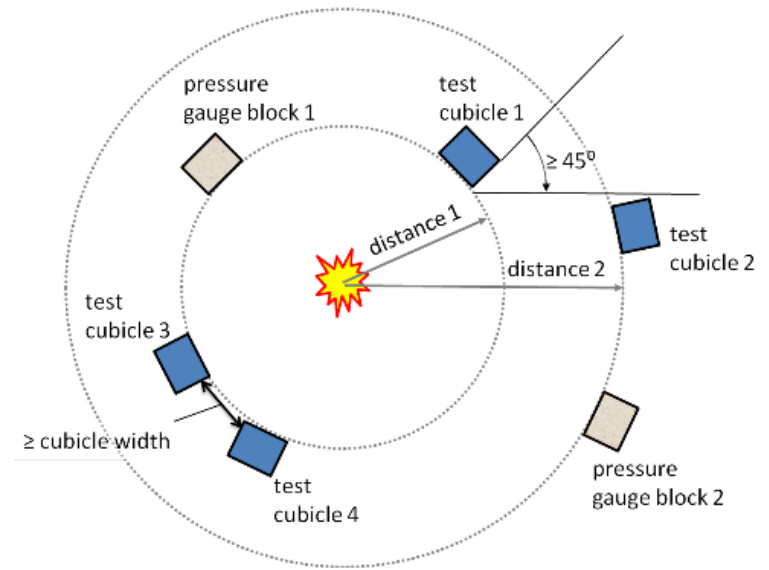


Figure 9: Typical arena test set-up

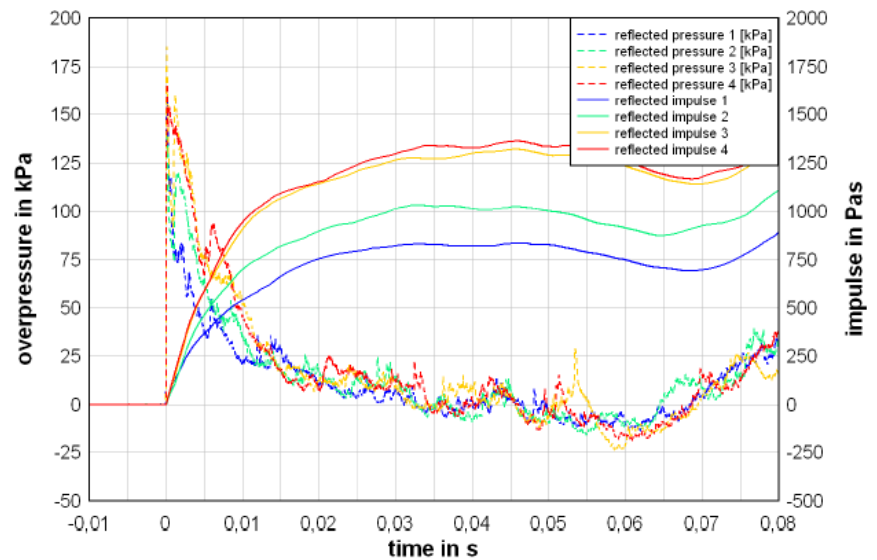


Figure 25: Impulse-time histories referring to the figure above

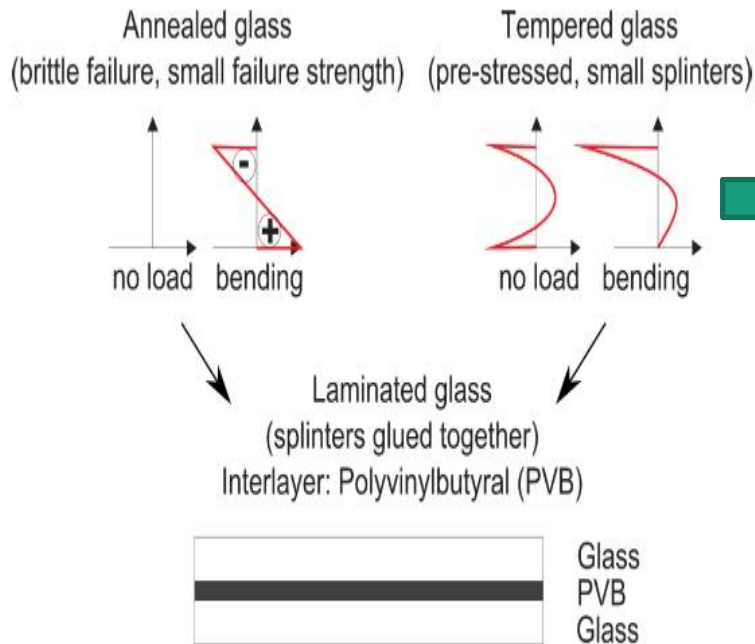


Figure 31: Main types of glass

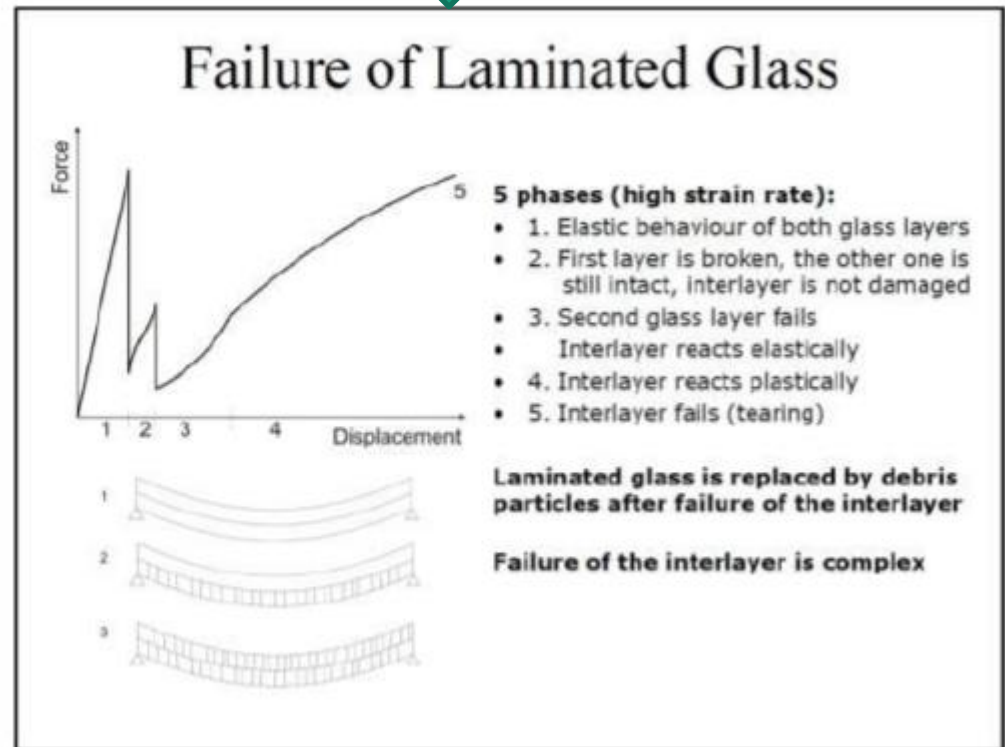


Figure 32: Phases of failure of laminated glass

Deliverables



Resistance of structures to explosion effects:
Review report of testing methods

- Reports gives comprehensive overview over

- Theoretical background
- Testing basics
- Expectable test results and interpretation
- Verification and validation of results

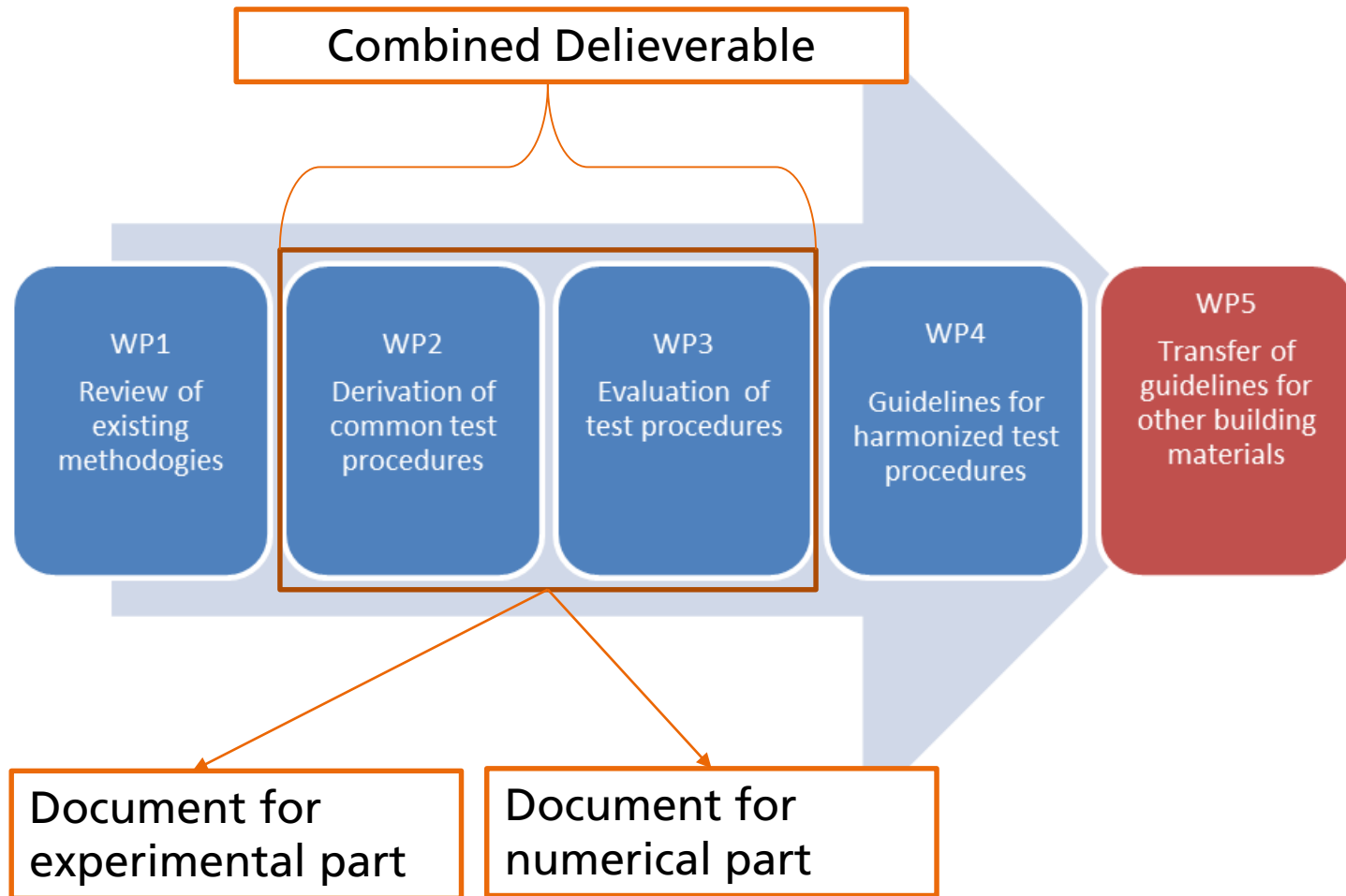
Ready to use for costumers, manufacturer, and building planners.

- Group members which also compete for appointments defined common fundamentals available for end-users!
- Document informs potential costumer in advance about:
 - What to expect
 - How do deal with data and results

Work Programm

Deliverables

Regulations for testing methods



**European Reference Network for Critical Infrastructure
Protection (ERNCIP) thematic group**

Work package 2

**A comparison of existing standards
for testing blast-resistant glazing and
windows**

Thematic group:

**Resistance of structures to
explosion effects**

**Coordinator: Dr Alexander Stolz, Fraunhofer Institute for
High-Speed Dynamics, Ernst Mach Institute (EMI)**

**Deputy Coordinator: Christof Haberacker, Bundeswehr
Technical Centre for Protective and Special Technologies
(WTD 52)**

**European Reference Network for Critical Infrastructure
Protection (ERNCIP) thematic group**

**Numerical simulations for
classification of blast-loaded
laminated glass:
possibilities, limitations and
recommendations**

Thematic group:

**Resistance of structures to explosion
effects**

**Coordinator: Dr Alexander Stolz, Fraunhofer Institute for
High-Speed Dynamics, Ernst Mach Institute (EMI)**

Table 19: Comparison of standards for testing blast resistance of glazing.

Item	EN 13541:2012	EN 13123-1:2001/ EN 13124-1:2001	EN 13123-2:2004/ EN 13124-2:2004	GSA-TS01:2003	ASTM F 1642:2004	ISO 16933:2007	ISO 16934:2007
Application	Glass	Windows, doors, shutters	Windows, doors, shutters	Windows	Glass, windows	Glass, windows	Glass, windows
Test method	Shock tube	Shock tube	Arena test	Shock-tube or arena test	Shock-tube or arena test	Arena test	Shock tube
Standard loading	Large charge VBIED	Large charge VBIED	Small charge PBIED	Large charge VBIED	Small PBIED and large charge VBIED	Small PBIED and large charge VBIED	Large charge VBIED
User defined loading	No	No	No	Yes	Yes	No	Yes without certification
Petrochemical loading	No	No	No	No	No	No	No
Sample dimension	Fixed, vision size 1 000 × 800 mm	User defined	User defined	1650 × 1200 mm specified other size are permitted	User defined	Fixed, vision size 1 000 × 800 mm	Fixed, vision size 1 000 × 800 mm
Number of samples	3	1	1	1	Minimum 3	Minimum 3	Minimum 3
Tests of partially opened windows or doors	No	No	No	No	No	No	No
Testing glazed facades	No	No	No	No	No	No	No
Mounting of samples	Well defined	General description only	General description only	Outline description only	Outline description only	Well defined for glass; general description for windows	Well defined for glass; general description for windows
Number of pres. transducers	2	Not specified; at least 1	Not specified	≥ 2 outside; 1 inside	Shock tube: 3 Arena test: 4	≥ 3	≥ 1; not specified

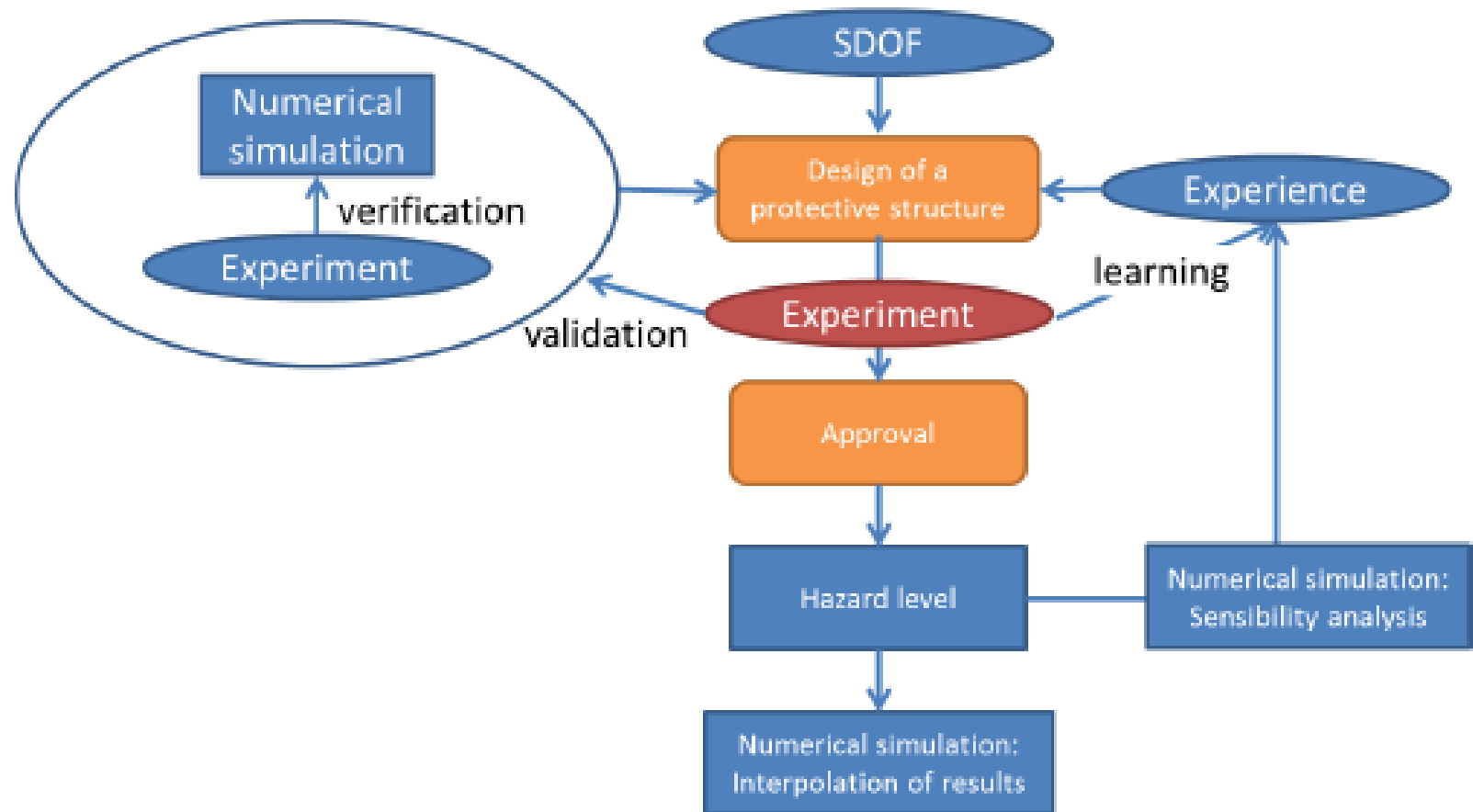
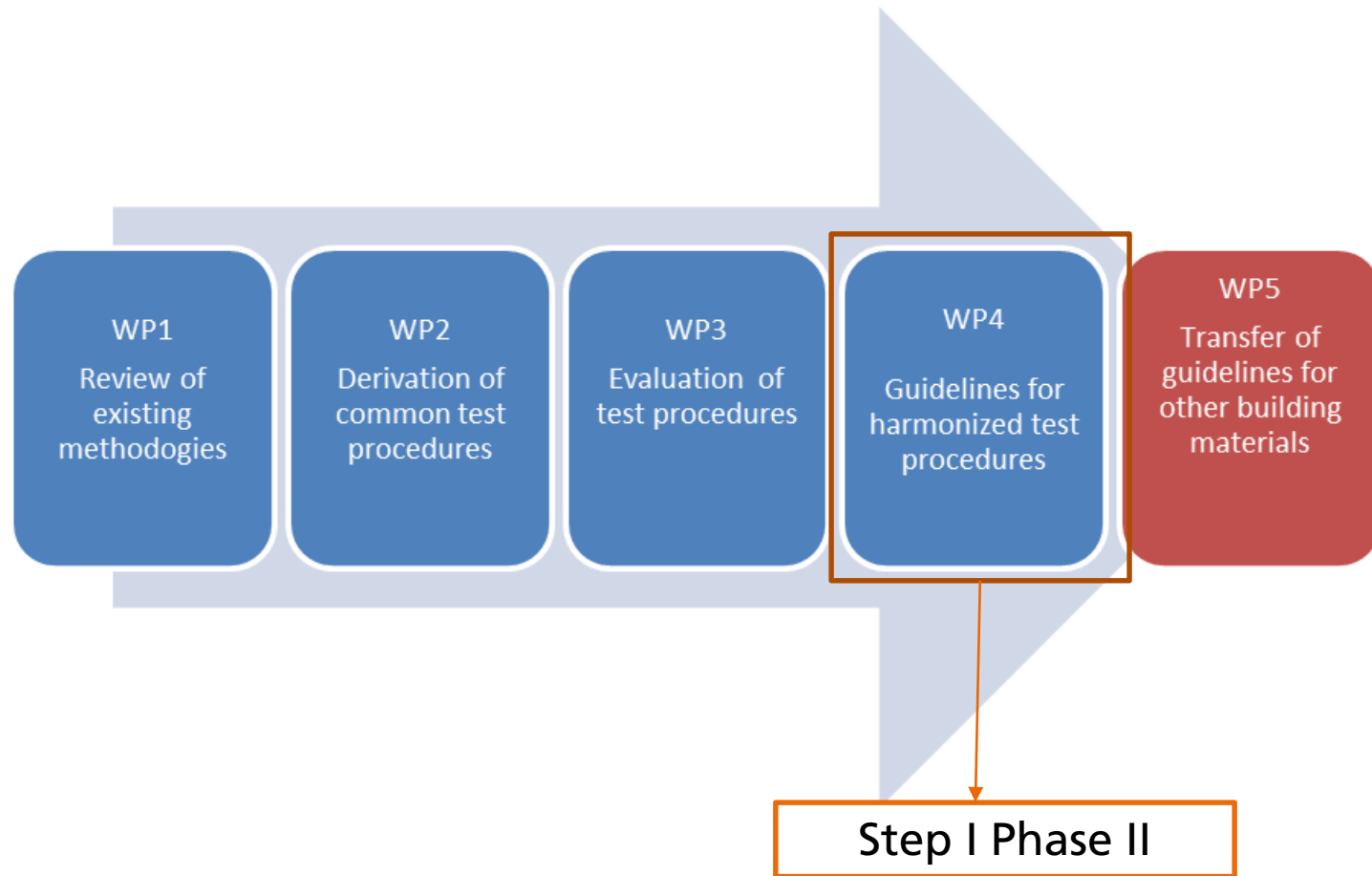


Figure 1: Interaction between numerical simulations and experiments for the approval of protective structures using laminated glass

Work Programm Structure

Regulations for testing methods



Work Programm

Outlook

Regulations for testing methods

Objectives

2.1 **Recommendations to the EU standardisation community** for the future development of the existing European norms for testing the resistance of windows and glazed facades to explosive effects (October 2015).

2.2 A report/draft proposal that provides the basic elements to launch the appropriate standardisation process for shock tube considering glass panes and windows.

The background of the image is a green, perforated metal surface, likely part of a scientific instrument. A small white circular sensor is mounted in the center, with two yellow tape strips and thin wires attached to it. The text "Thank you" is overlaid in a teal color at the top, and "Questions ?" is overlaid in black at the bottom.

Thank you

Questions ?