

STREST

Stress Tests for Critical Infrastructures
against Natural Hazards

Wim Courage

TNO innovation
for life

STREST: WAKE UP CALL

- › Fukushima 2011
- › Low Probability
- › High Consequence



→EU:
Can a natural catastrophe cripple critical infrastructure (CI) in Europe, like power, water, transport or communication?

STREST: FP7 PROJECT

› Consortium



12 partners

7 countries

Coordinator Prof. D. Giardini (ETH)

<http://www.strest-eu.org>

STREST: FP7 PROJECT

- › Establish a common and consistent taxonomy of non-nuclear CIs;
- › Develop a rigorous, consistent modelling approach to hazard, vulnerability, risk and resilience assessment of LP-HC events;
- › Design a stress test framework and specific applications to address the vulnerability, resilience and interdependencies of CIs;
- › Enable the implementation of European policies for the systematic implementation of stress tests.

STREST: WP'S

WP1:Management

WP2:State of the Art

WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

WP7: Dissemination

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WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

STREST: WP6 CASES

WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

- › 3 Types (ref. K. Pitilakis et al.):
 - › (A) individual, single-site, high risk infrastructures
 - › (B) distributed and/or geographically extended infrastructures with potentially high economic and environmental impact
 - › (C) distributed, multiple-site infrastructures with low individual impact but large collective impact or dependencies

STREST: WP6 CI-S (USE CASES)

CI-A1 ENI/Kuwait oil refinery and petrochemical plant, Milazzo, Italy

WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's



CI-A2 Large dams of the Valais region, Switzerland



A) individual, single-site, high risk infrastructures

(B) distributed and/or geographically extended infrastructures with potentially high economic and environmental impact

(C) distributed, multiple-site infrastructures with low individual impact but large collective impact or dependencies

STREST: WP6 CI-S (USE CASES)

CI-B1 Major hydrocarbon pipelines, Turkey



WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

CI-B2 Gasunie national gas storage and distribution network, Netherlands



- A) individual, single-site, high risk infrastructures
- (B) distributed and/or geographically extended infrastructures with potentially high economic and environmental impact
- (C) distributed, multiple-site infrastructures with low individual impact but large collective impact or dependencies

STREST: WP6 CI-S (USE CASES)

CI-B3 Port infrastructures of Thessaloniki, Greece

WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's



CI-C1 Industrial district of Emilia, Italy



A) individual, single-site, high risk infrastructures

(B) distributed and/or geographically extended infrastructures with potentially high economic and environmental impact

(C) distributed, multiple-site infrastructures with low individual impact but large collective impact or dependencies

STREST: WP3 HAZARD

WP3: Hazard

› Focus on

WP4: Risk

WP5: Methodology

WP6: CI's

- › earthquakes,
- › tsunamis,
- › geotechnical effects
- › and floods

STREST: WP3 HAZARD

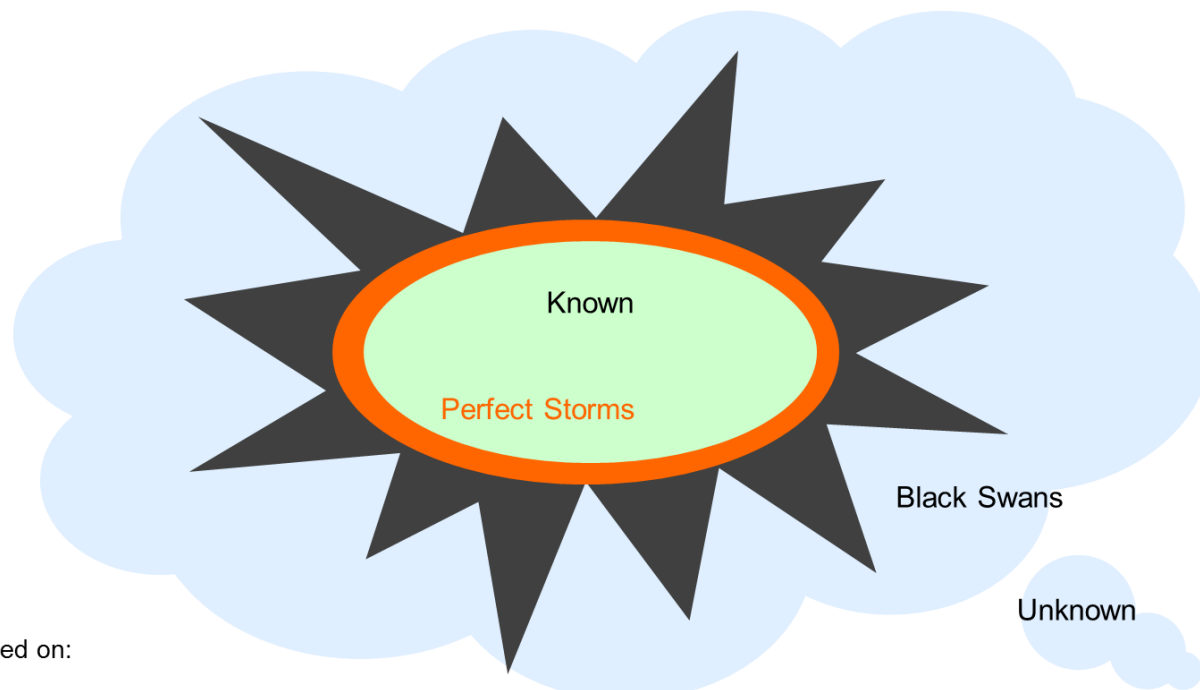
WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

Scenario-based exploration



Based on:

E. Pate-Cornell, Risk Analysis, Vol. 32, No. 11, 2012

STREST: WP3 HAZARD

WP3: Hazard

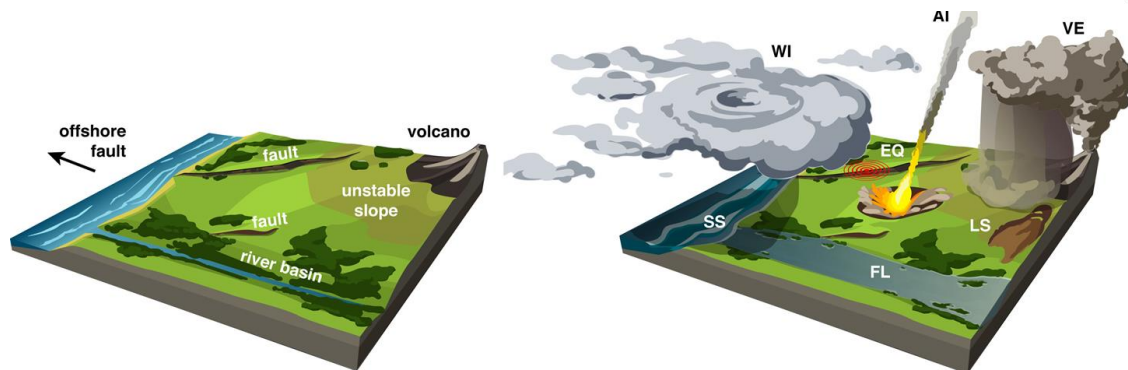
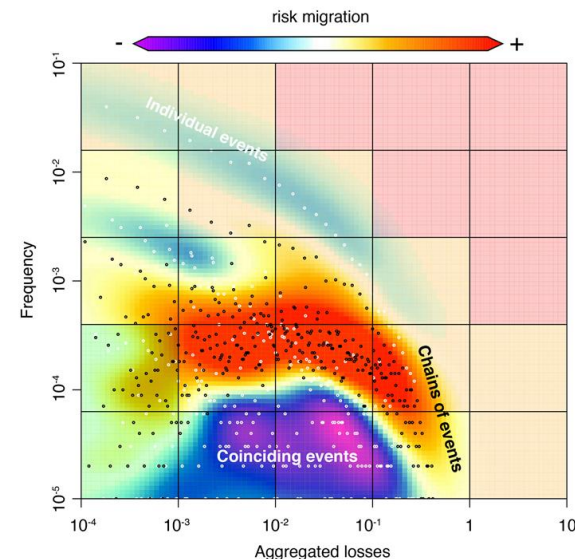
WP4: Risk

WP5: Methodology

WP6: CI's

› Multi-hazard assessment & cascading effects

› (ref. MATRIX, Mignan et al.)



STREST: WP3 HAZARD

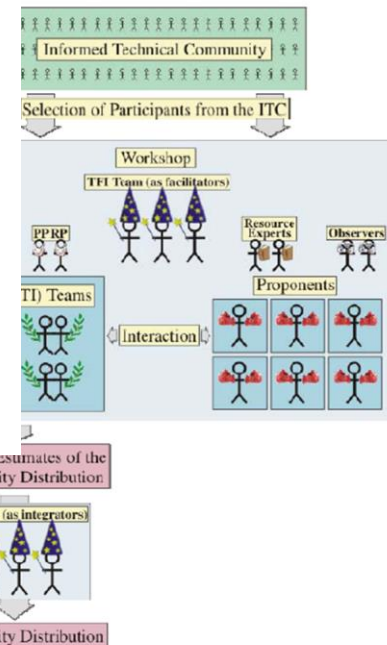
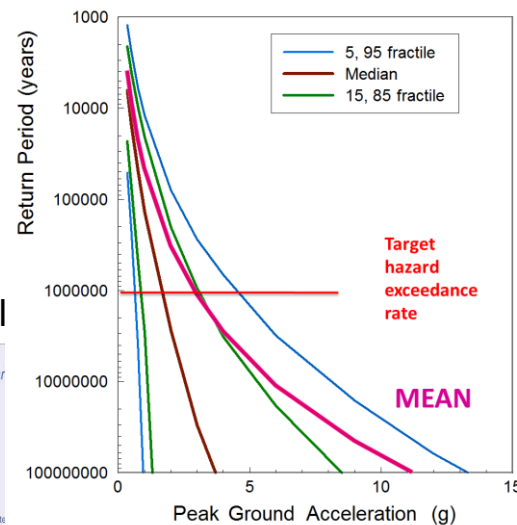
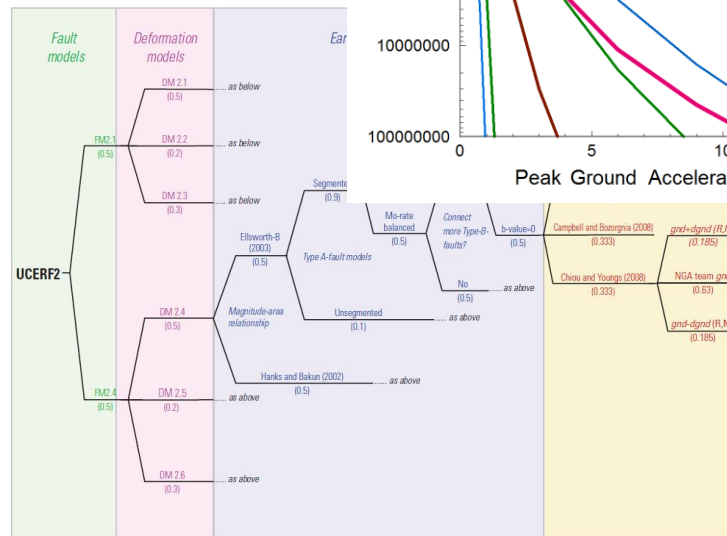
WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's

- › Epistemic uncertainties
 - › (Ref. Silva et al)
 - › (Ref. Fabrice et al)



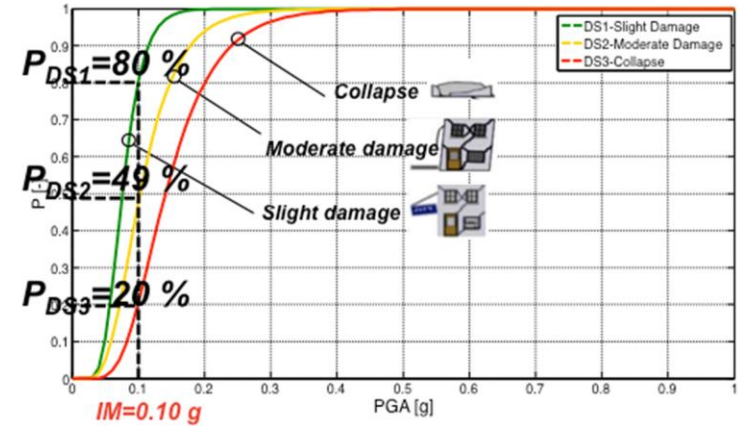
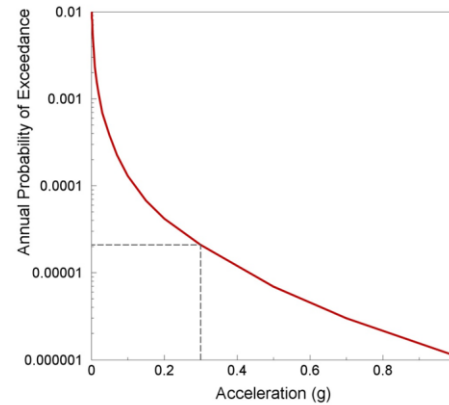
STREST: WP4 RISK

WP3: Hazard

WP4: Risk

WP5: Methodology

WP6: CI's



$$P(\text{Failure}) = P(\text{Acceleration}) * P(\text{Failure} | \text{Acceleration})$$

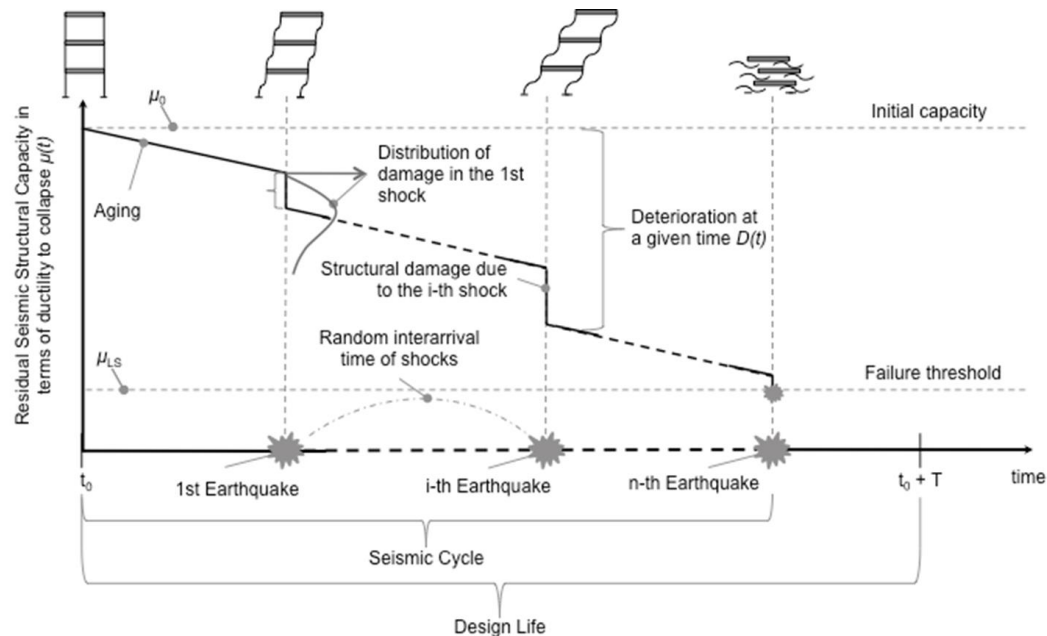
STREST: WP4 RISK

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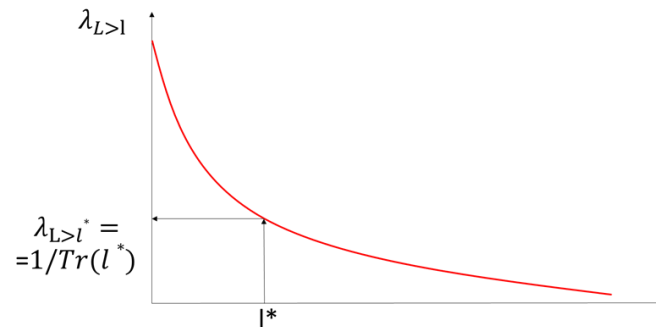
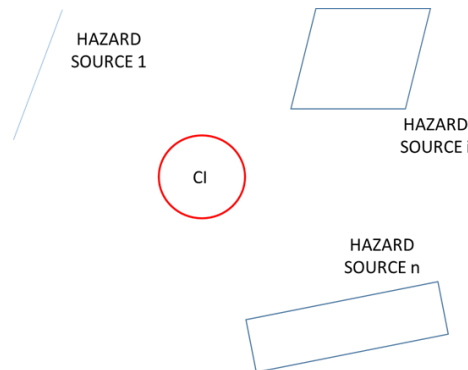
STREST: WP4 RISK

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Losses

(ref. I Iervolino et al)

Loss rate

$$\lambda_{L>l} = \sum_i v_i \cdot \int \int_{IM\ ER} P[L > z | ER = y] \cdot f_{ER|IM_i}(y|x) \cdot f_{IM_i}(x) \cdot dy \cdot dx$$

Loss exceedance probability given response

Response probability depending on event intensity

Hazard

STREST: WP4 RISK

WP3: Hazard

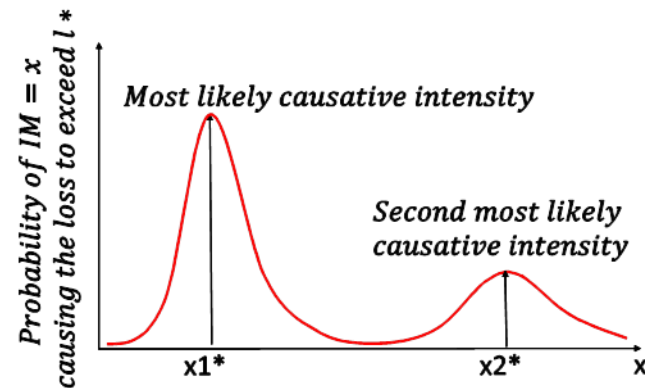
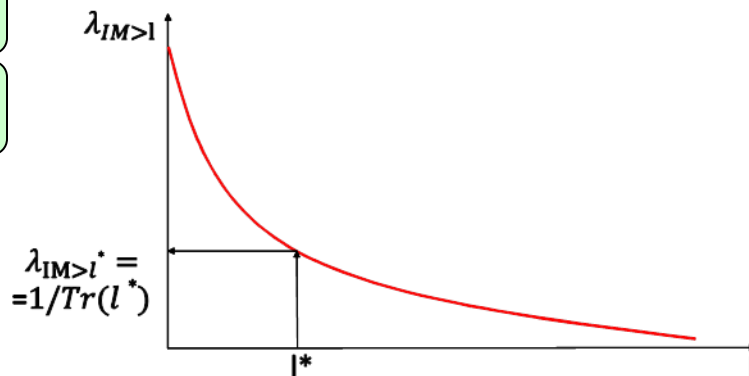
WP4: Risk

WP5: Methodology

WP6: CI's

› Losses

› (ref. I Iervolino et al)



STREST: WP4 RISK

WP3: Hazard

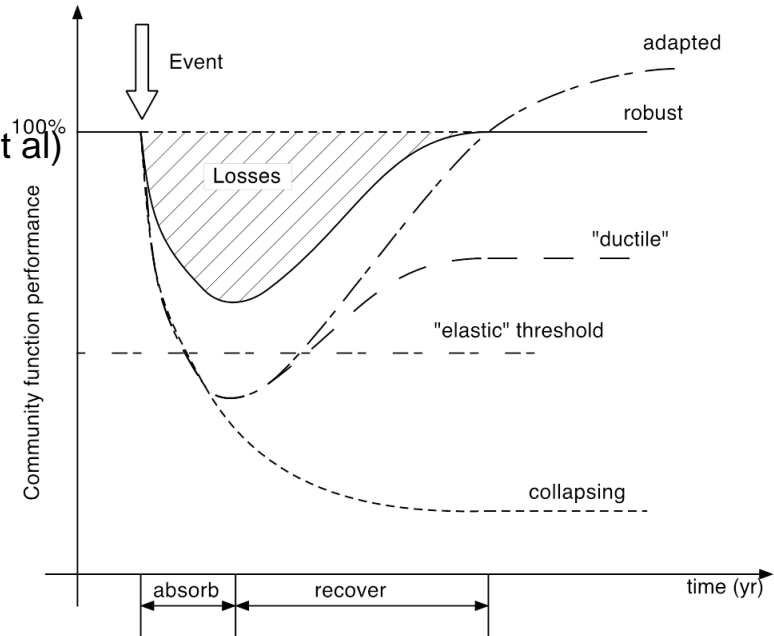
WP4: Risk

WP5: Methodology

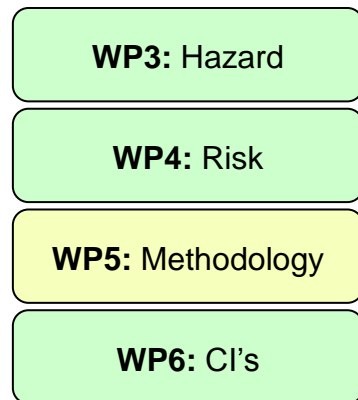
WP6: CI's

› Resilience

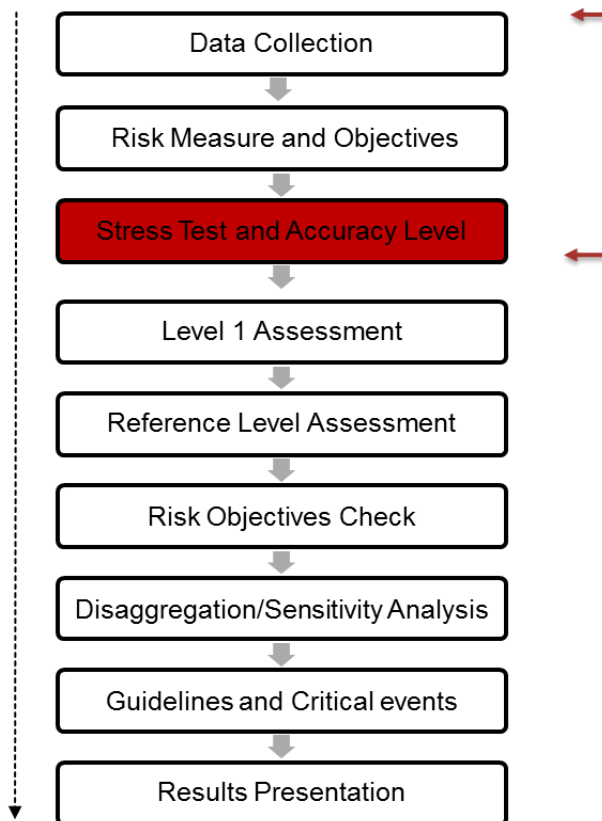
› (Ref. Stojadinovic et al)



STREST: WP5 METHODOLOGY



- › Workflow
 - › (Ref. Stojadinovic et al)
 - › (Ref. S. Esposito et al)
- › Multi level
- › Quantitative and probabilistic
- › Transparent
- › Efficient
- › Dynamic and Iterative



STREST

- › Methods to harmonize the treatment of uncertainties and the mechanics of hazard assessment, with focus on the quantification of epistemic uncertainties and its effects on LP-HC hazard, the integration of regional versus site- specific hazards and near-source effects;
- › Consistent quantification of the occurrence of LP-HC events (extremes, cascading effects) and schemes to introduce them in hazard and risk evaluations;
- › Definition of appropriate measures to express aggregated probabilities of exceeding limit values across an extended footprint, taking into account the spatial correlation characteristics;
- › Consistent taxonomy of different classes of CIs, to classify them in terms of common characteristics of vulnerability, possible consequences and resilience;
- › Probabilistic models for the vulnerability and consequence assessment, designed to enable transferring from hazard to risk and evaluating the consequences of system failures extending much beyond direct damages to equipment and structures, involving cascading effects;
- › Improvement of the present understanding and assessment of losses and resilience, at the level of single CI, CI system or society;
- › Probabilistic structural and systemic performance models (stress tests) to determine the losses in CIs, and their susceptibility to cascading effects that may amplify these losses, as well as interdependencies among different CIs;
- › European Reference Reports concerning the assessment and protection of CIs;
- › Interactions with practitioners via the involvement of CI owners and stakeholder workshops

STREST

› Ongoing

- › WP 5 being finalised
- › STRESS tests being applied to CI cases

› Next

- › *14-15 September 2016*
STREST Final Meeting, Ljubljana

<http://www.strest-eu.org>

An aerial photograph of a city, likely Amsterdam, featuring a large railway station with numerous tracks and platforms. Modern glass skyscrapers are prominent, particularly in the foreground and center. The city is surrounded by greenery and older buildings. The text "THANK YOU FOR YOUR ATTENTION" is overlaid in large, white, bold, sans-serif capital letters.

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