



20th International Symposium of MASE
"RESILIENT STRUCTURES"
September, 28th - 29th, 2023, Skopje, N. Macedonia

ERIES

ENGINEERING
RESEARCH
INFRASTRUCTURES
FOR EUROPEAN
SYNERGIES

European Research Synergies Towards Loss and Risk-driven Mitigation Approaches

Presenter: Gerard J. O'Reilly¹

1) Centre for Training and Research on Reduction of Seismic Risk (ROSE Centre)

Scuola Universitaria Superiore IUSS Pavia, Pavia, Italy

ROSE

CENTRE FOR TRAINING AND
RESEARCH ON REDUCTION
OF SEISMIC RISK



IUSS

Scuola Universitaria Superiore Pavia



PROJECT OVERVIEW



ENGINEERING
RESEARCH
INFRASTRUCTURES
FOR EUROPEAN
SYNERGIES

- The objective of ERIES is to provide transnational access (TA) to research infrastructures to conduct research that will advance frontier knowledge related to seismic, wind and geotechnical hazards

- Funding: European Commission Horizon Europe



- Total Budget: €11,616,118
 - €10,616,225 European Commission Contribution
 - €999,892 UKRI Contribution
- Duration: 4 years (01/06/2022 - 31/05/2026)

ERIES | ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES

About | Research | Transnational Access | Dissemination | News and Events | FAQ

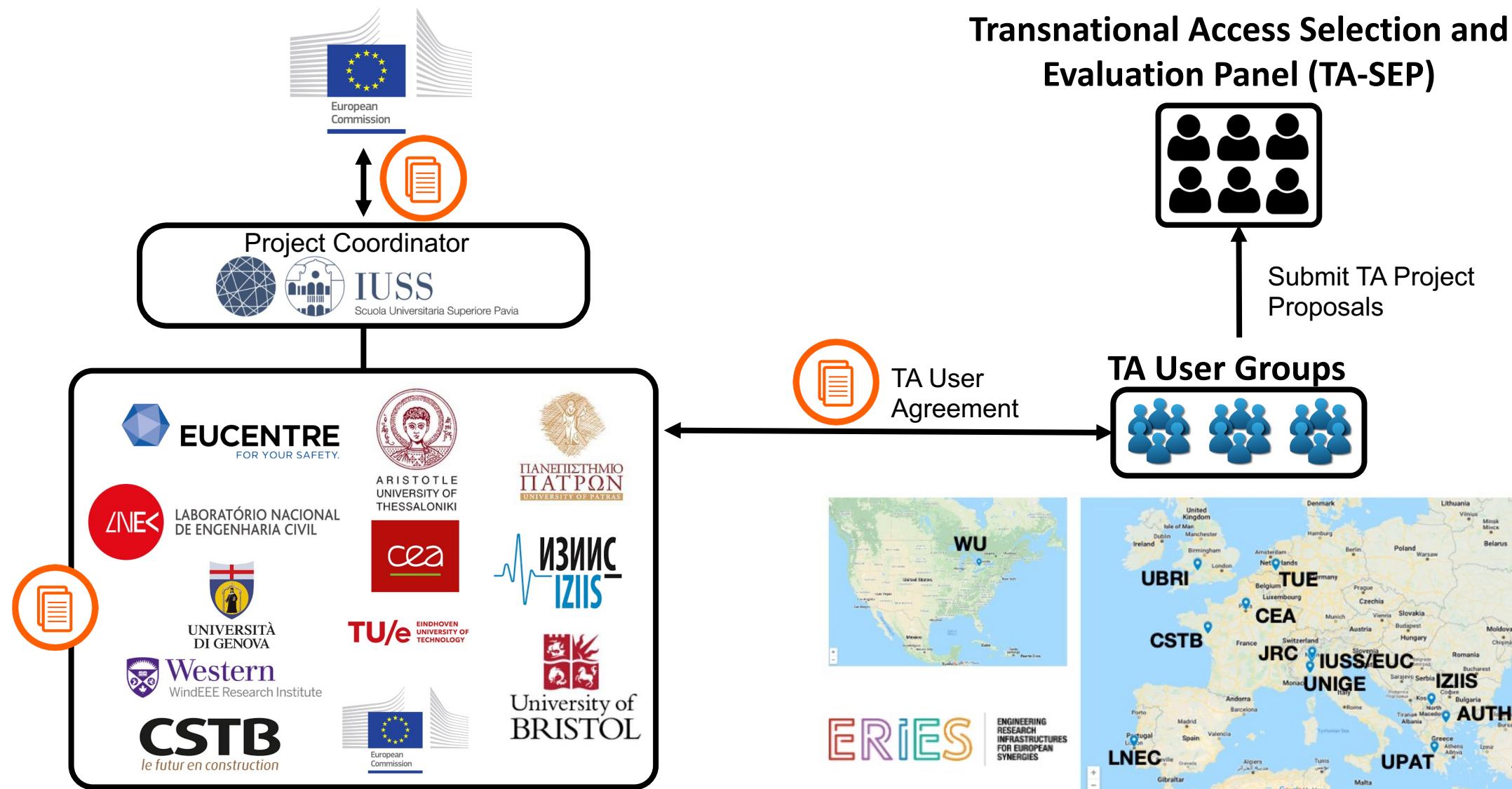
ERIES responds to the call INFRA-2021-SERV-01-07: Research infrastructure services advancing frontier knowledge with the overall objective of providing transnational access (TA) to advanced research infrastructures in the fields of structural, seismic, wind and geotechnical engineering. This project, together with the research infrastructure team assembled, provides access to leading experimental facilities that permit users to advance frontier knowledge and conduct curiosity-driven research towards: the reduction of losses and disruption due to these hazards; the management of their associated risk; and the development of innovative solutions to address them that will contribute to a greener and more sustainable society.

To this end, ERIES offers TA to the best European experimental facilities in each field, with new and unique infrastructures available for the first time in this programme, along with the provision of key infrastructure in Canada. It integrates past infrastructure projects' successful results and implementation, such as SERIES and SERA, and expands access capabilities to new communities and disciplines not yet focused on. It will provide authoritative input for diverse stakeholders, from Civil Protection agencies to the European seismic building code. It will help develop future standards for experimental techniques in earthquake, wind and geotechnical engineering. It will provide a platform from which European researchers can create innovative solutions and testbed applications of next-generation technologies.

With 13 partners from 8 countries, ERIES builds an essential element toward reducing losses, managing risk, and overall a greener and more sustainable engineering future in Europe.

NEWS

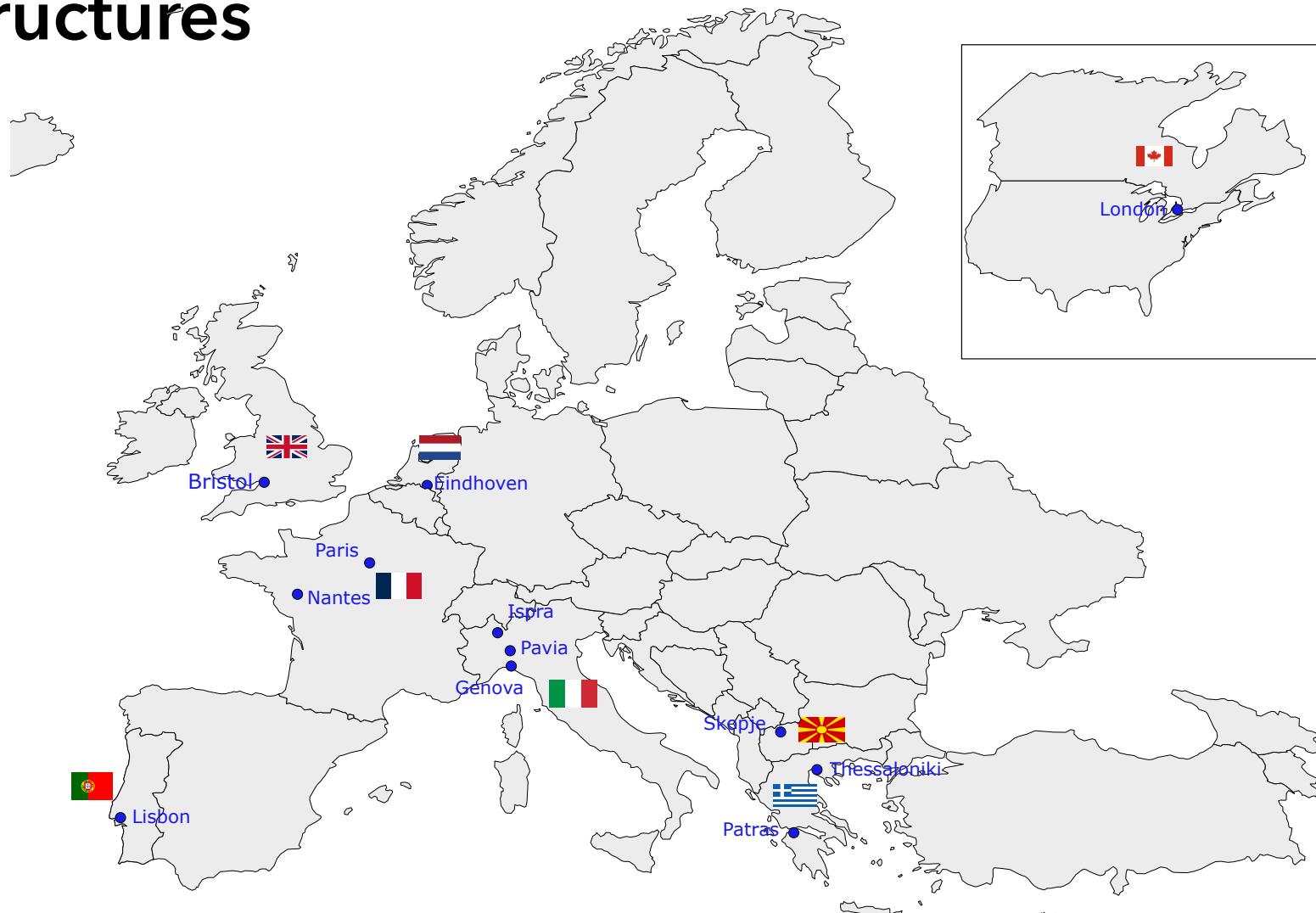
Website: www.eries.eu
Email: eries@iusspavia.it





ERIES Research Infrastructures

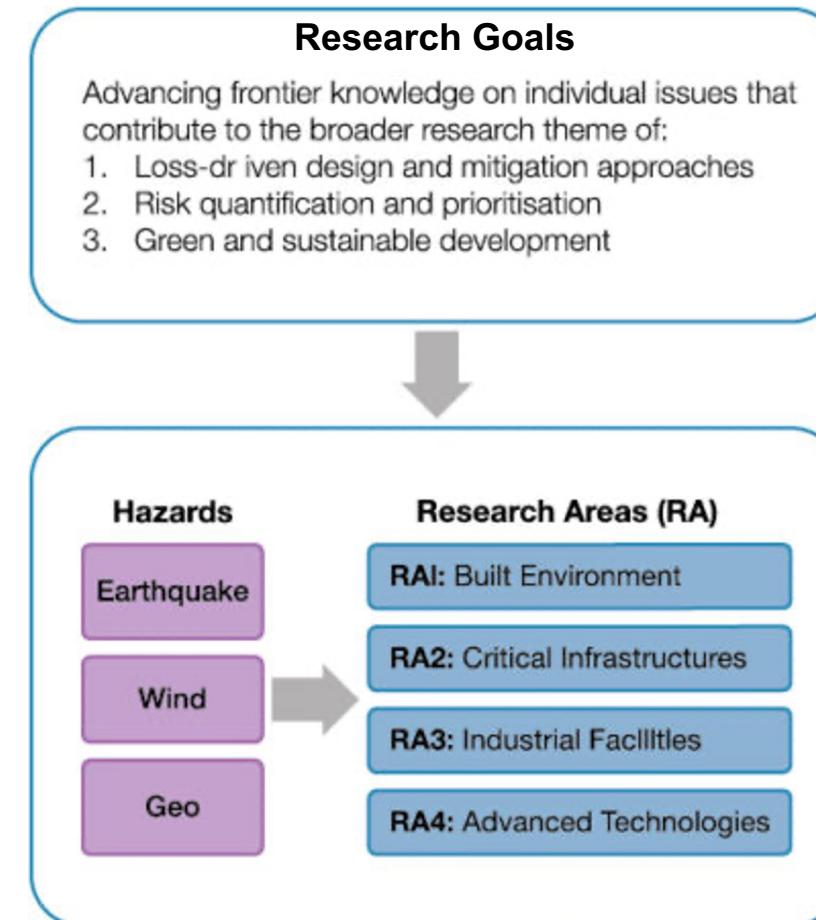
1. IUSS-EUC – Pavia, Italy
2. UPAT – Patras, Greece
3. UBRI – Bristol, UK
4. AUTH – Thessaloniki, Greece
5. LNEC – Lisbon, Portugal
6. CEA – Paris, France
7. IZIIS – Skopje, North Macedonia
8. UNIGE – Genova, Italy
9. WU – London, Canada
10. TUE – Eindhoven, Netherlands
11. CSTB – Nantes, France
12. JRC – Ispra, Italy





RESEARCH GOALS

- It comprises three main research goals shown which TA user projects shall strive to address
- ERIES will advance frontier knowledge related to seismic, wind, and geotechnical hazards
- Research will be carried out with respect to these three hazards and in one of the four research areas listed





Research Goals

Research Goal 1:
Loss-driven design
and mitigation
approaches

Research Goal 2:
Risk quantification
and prioritisation

Research Goal 3:
Green and
sustainable
development



Research Goals

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development

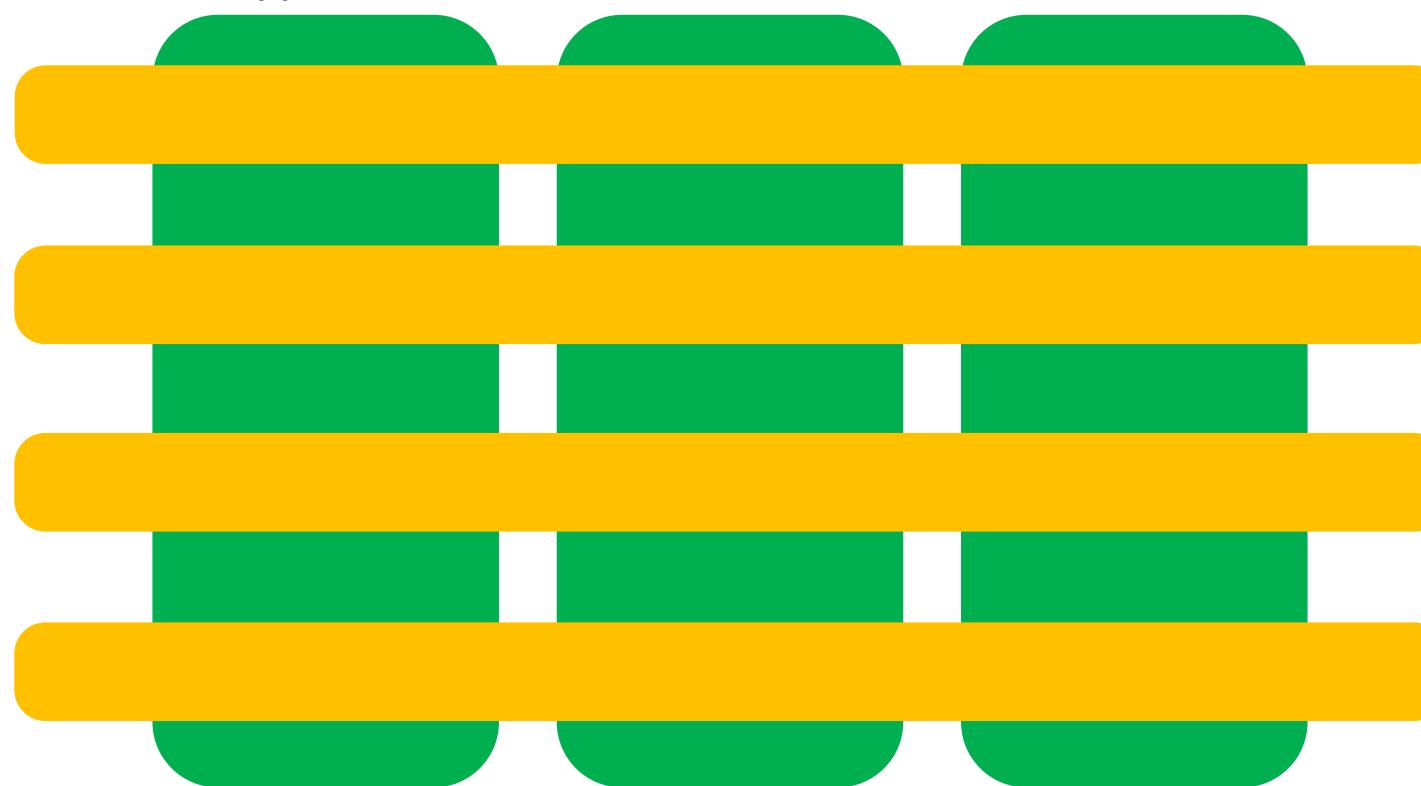
Research Area 1
(RA1): Built
Environment

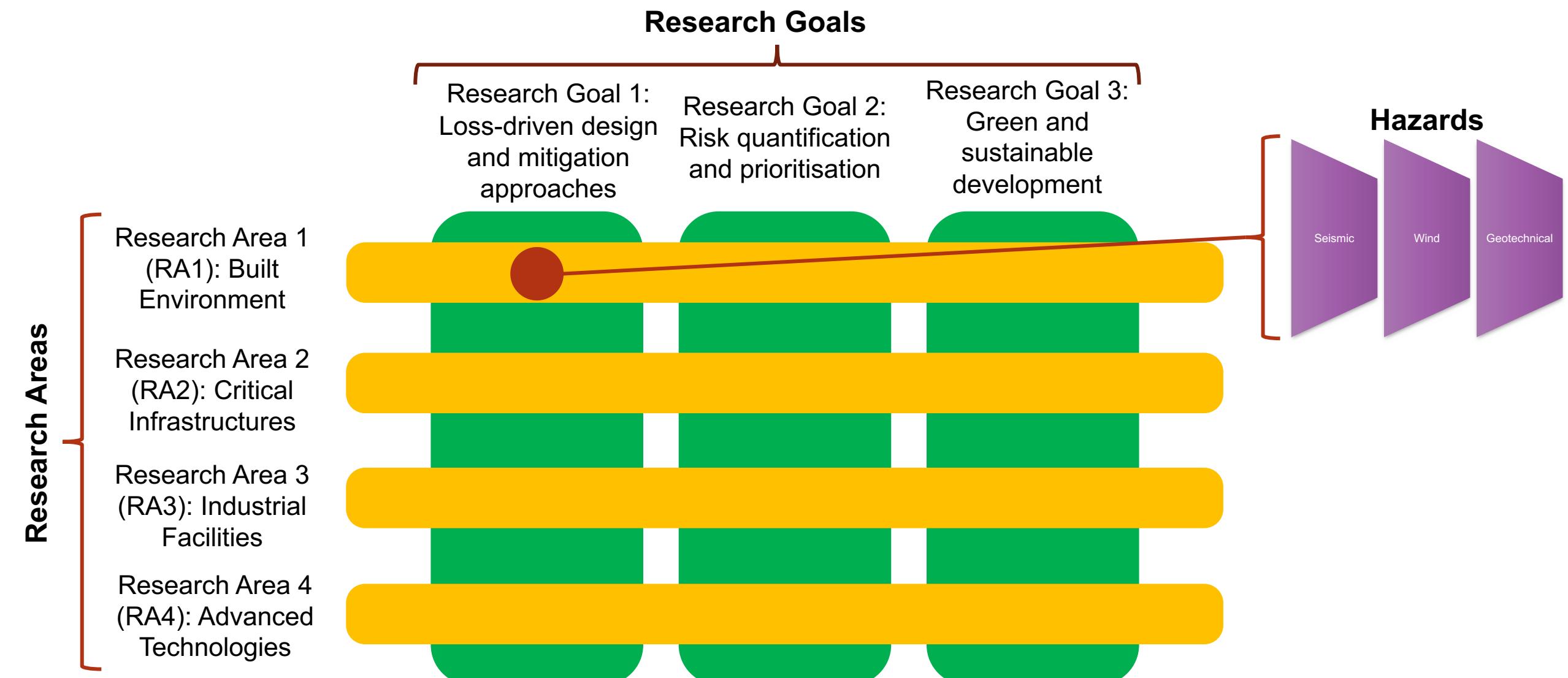
Research Area 2
(RA2): Critical
Infrastructures

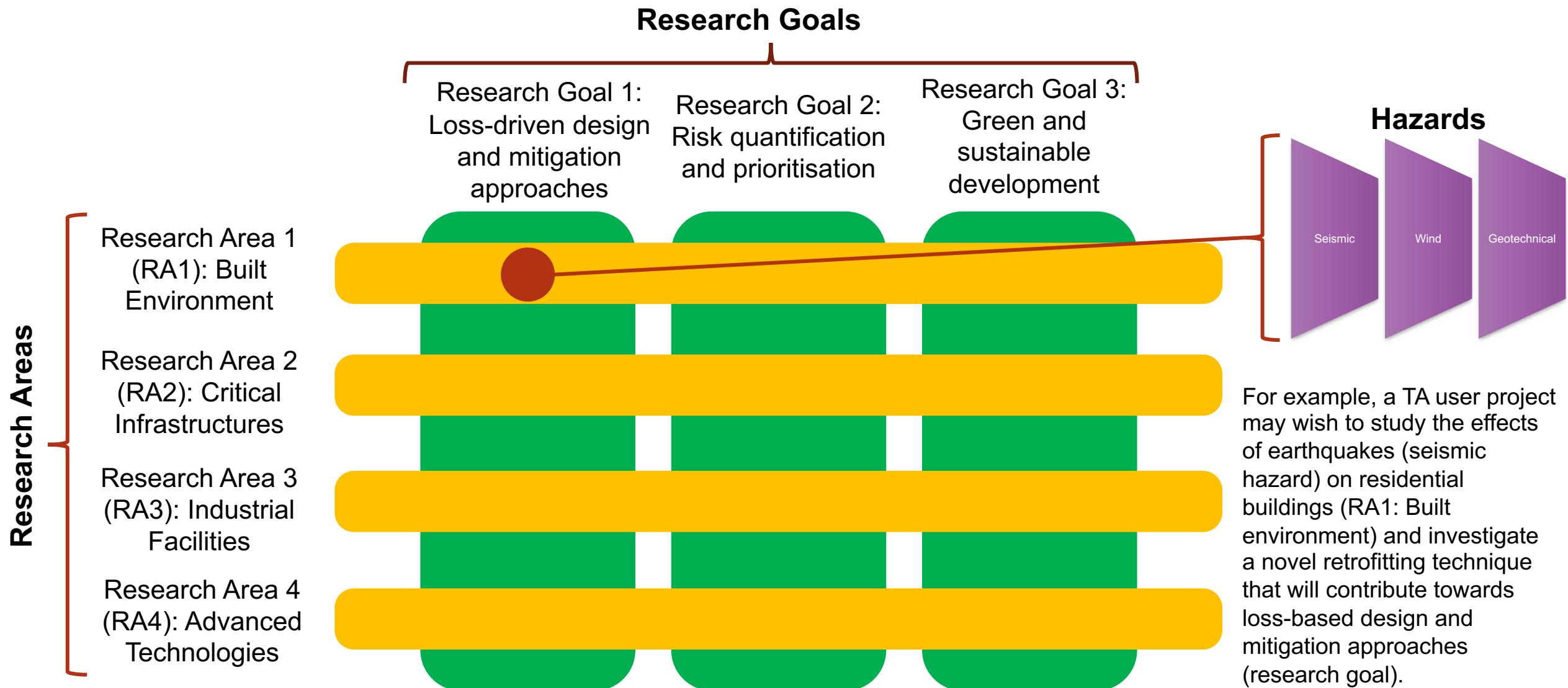
Research Area 3
(RA3): Industrial
Facilities

Research Area 4
(RA4): Advanced
Technologies

Research Areas





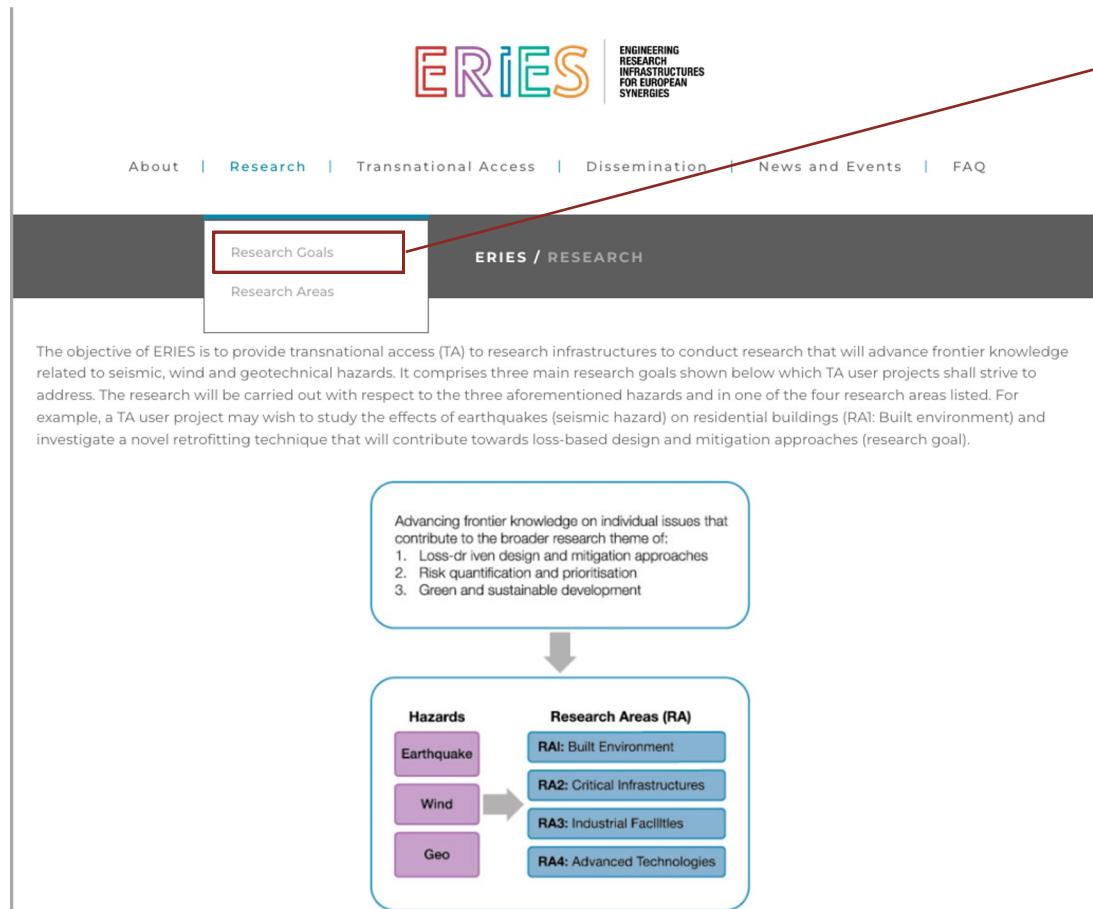




RESEARCH GOALS

<https://erries.eu/>

- Specific details can be found on the project website



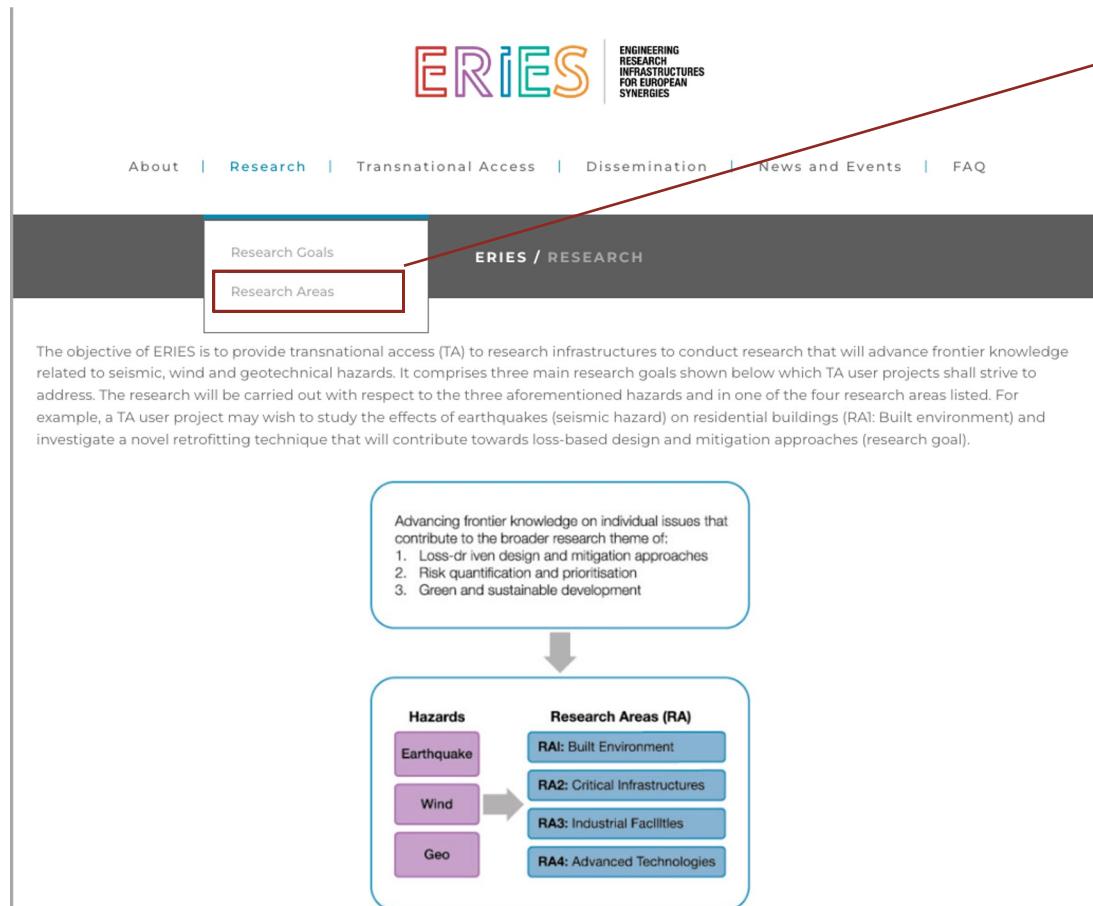
The screenshot shows the ERIES project website's research goals page. At the top, there is a navigation bar with links for About, Research, Transnational Access, Dissemination, News and Events, and FAQ. Below the navigation bar, there is a main header with the ERIES logo and the text "ERIES | ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES". Underneath the header, there is a secondary navigation bar with links for ERIES / RESEARCH GOALS. A large section titled "Research Goals" is present. Within this section, there is a sub-section titled "Research Goal 1: Loss-driven design and mitigation approaches". This sub-section contains text about the importance of loss-driven design and mitigation approaches in the design and retrofit of structures against natural hazards. Another sub-section titled "Seismic Hazard" is also present, containing text about the challenges and opportunities in seismic hazard research, mentioning the need for better performance and technical know-how, and the role of ERIES in addressing these issues through its TA activities.



RESEARCH AREAS

<https://erries.eu/>

- Specific details can be found on the project website

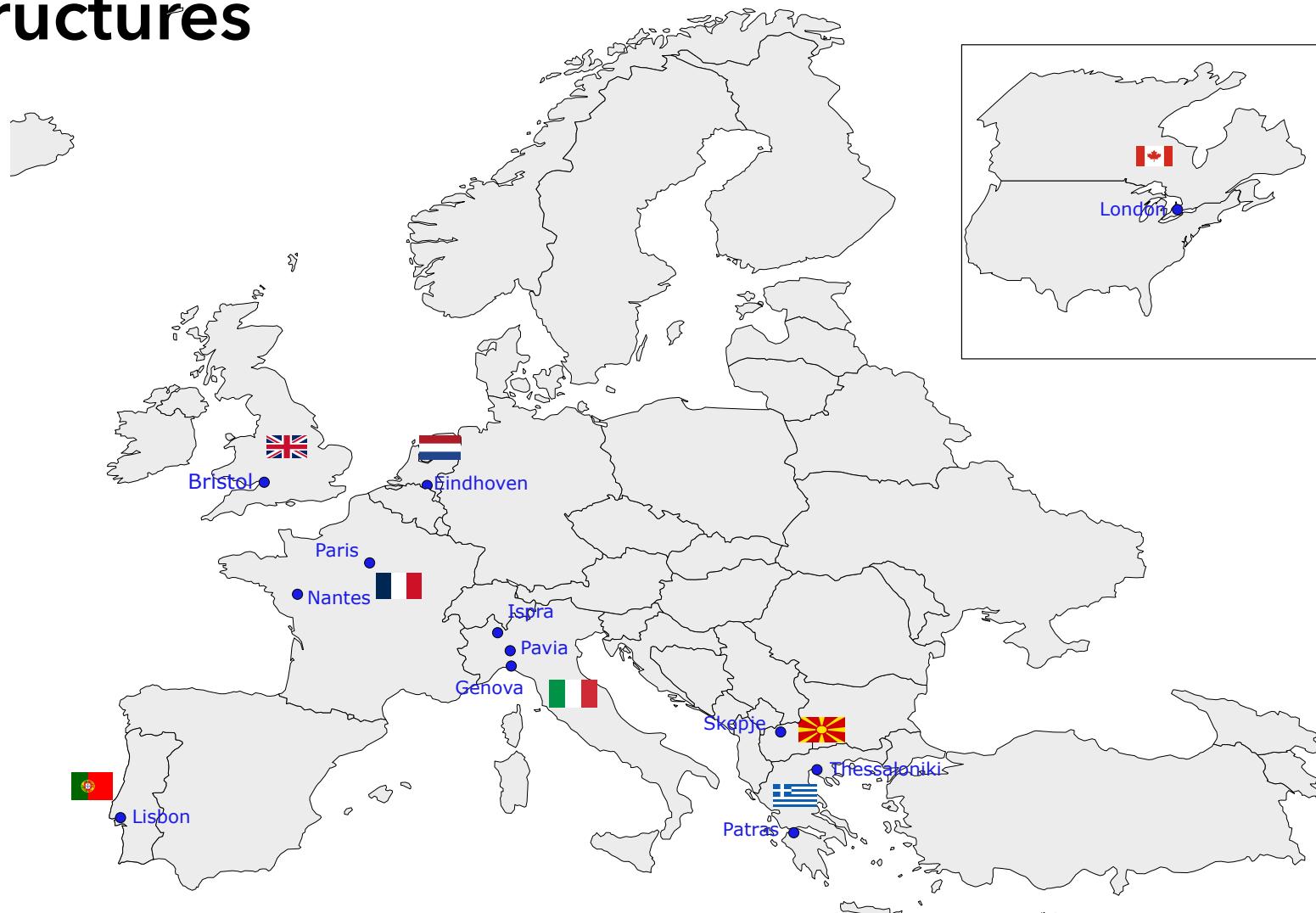


The screenshot shows the ERIES project website's research areas details page. At the top, there is a navigation bar with links for About, Research, Transnational Access, Dissemination, News and Events, and FAQ. The main content area is titled "ERIES / RESEARCH AREAS" and contains four sections: "Research Areas", "Research Area 1 (RA1): Built Environment", "Research Area 2 (RA2): Critical Infrastructures", "Research Area 3 (RA3): Industrial Facilities", and "Research Area 4 (RA4): Advanced Technologies". Each section has a brief description and a detailed explanation. The "Research Areas" section is the first one listed. The "Research Area 1 (RA1): Built Environment" section is the second one listed. The "Research Area 2 (RA2): Critical Infrastructures" section is the third one listed. The "Research Area 3 (RA3): Industrial Facilities" section is the fourth one listed. The "Research Area 4 (RA4): Advanced Technologies" section is the fifth one listed. The "Research Areas" section is highlighted with a red box. A red line connects this box to the corresponding section on the left. Below these sections, there is a diagram illustrating the relationship between Hazards and Research Areas. The diagram shows three boxes: a blue box labeled "Advancing frontier knowledge on individual issues that contribute to the broader research theme of:" with a list of three items; a purple box labeled "Hazards" containing "Earthquake", "Wind", and "Geo"; and a blue box labeled "Research Areas (RA)" containing "RA1: Built Environment", "RA2: Critical Infrastructures", "RA3: Industrial Facilities", and "RA4: Advanced Technologies". An arrow points from the "Hazards" box to the "Research Areas (RA)" box.



ERIES Research Infrastructures

1. IUSS-EUC – Pavia, Italy
2. UPAT – Patras, Greece
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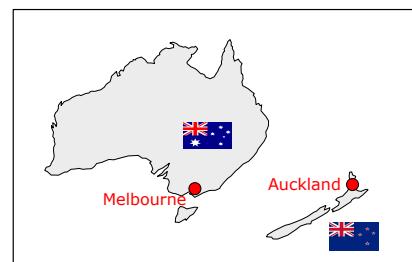


User Group Distribution (1st- and 2nd Call)

- Geographical diversity

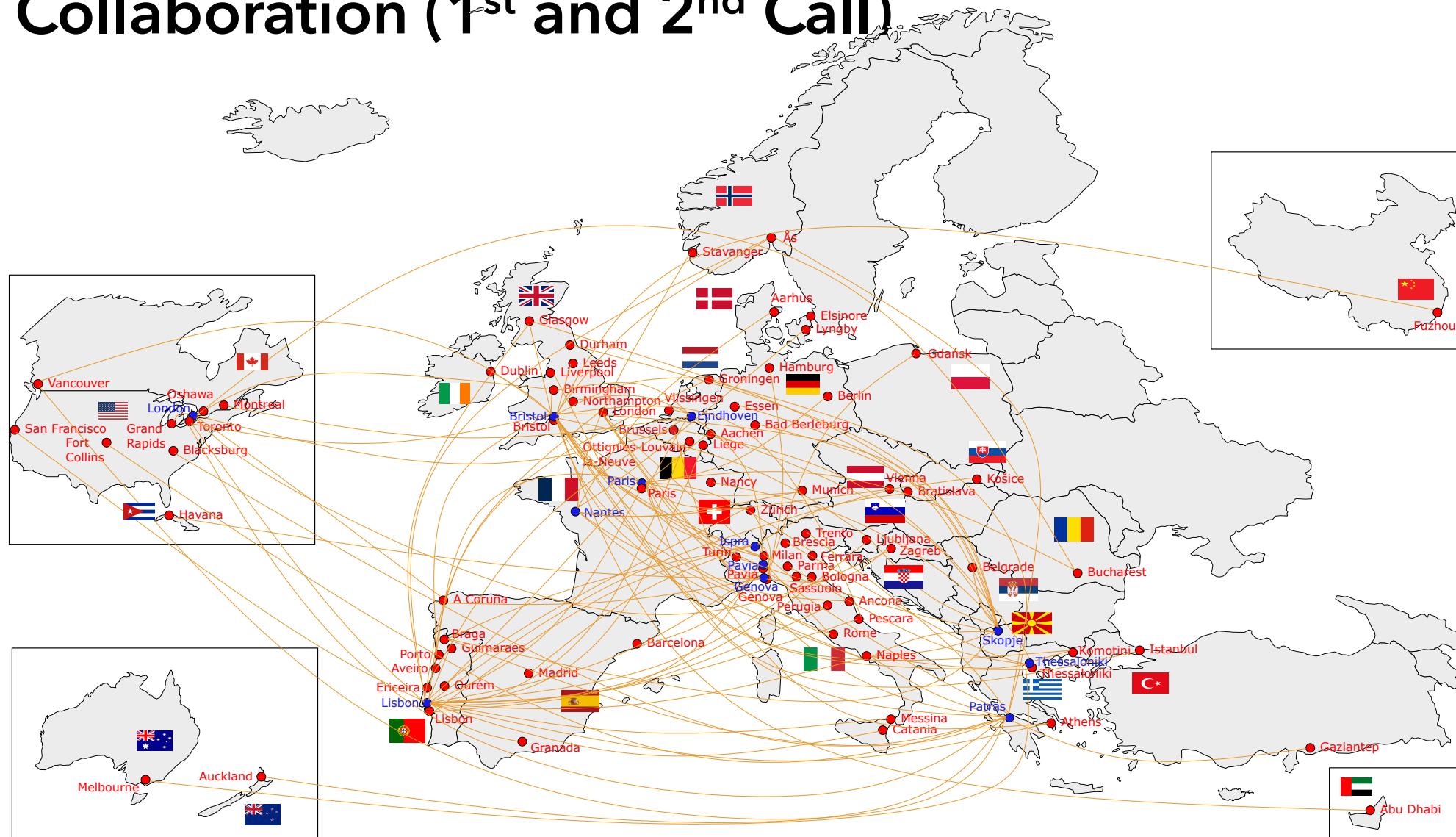
Users from:

- Europe
- North America
- Oceania
- Asia





User Group Collaboration (1st and 2nd Call)

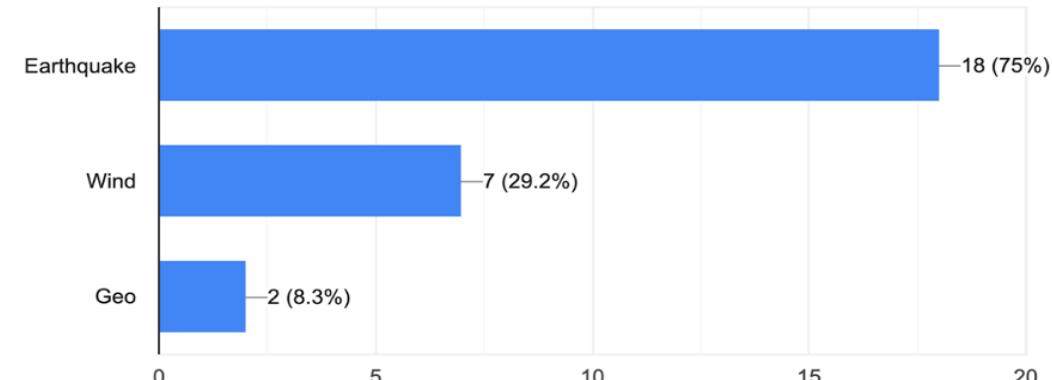




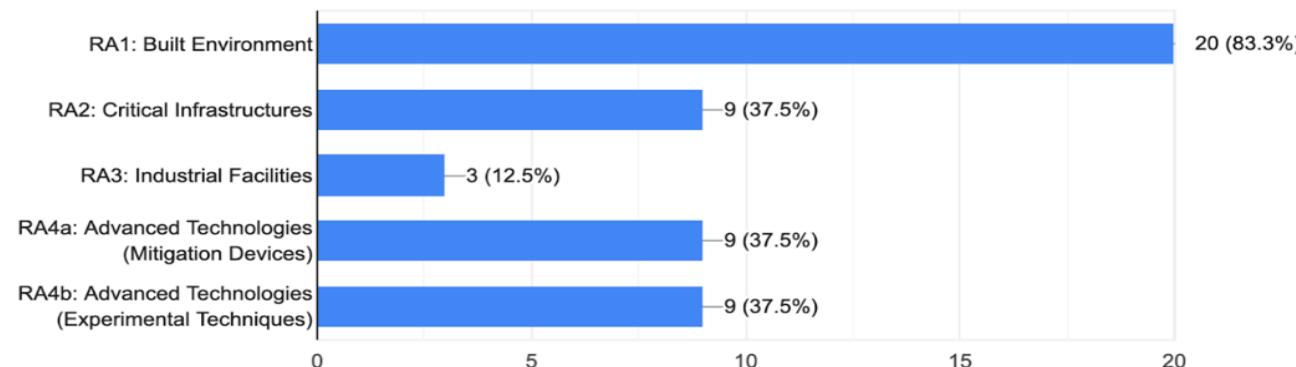
Transactional Access - 1st call

- 24 applications from 10 different countries around Europe
- Transactional access (TA) to infrastructures in the fields of structural, seismic, wind, and geotechnical engineering
- Majority of proposals focus on earthquake related research areas
- 5 research areas where the proposal focuses on with the majority related to Built Environment

Which of the three hazards addressed in ERIES does the proposal focus on?
24 responses



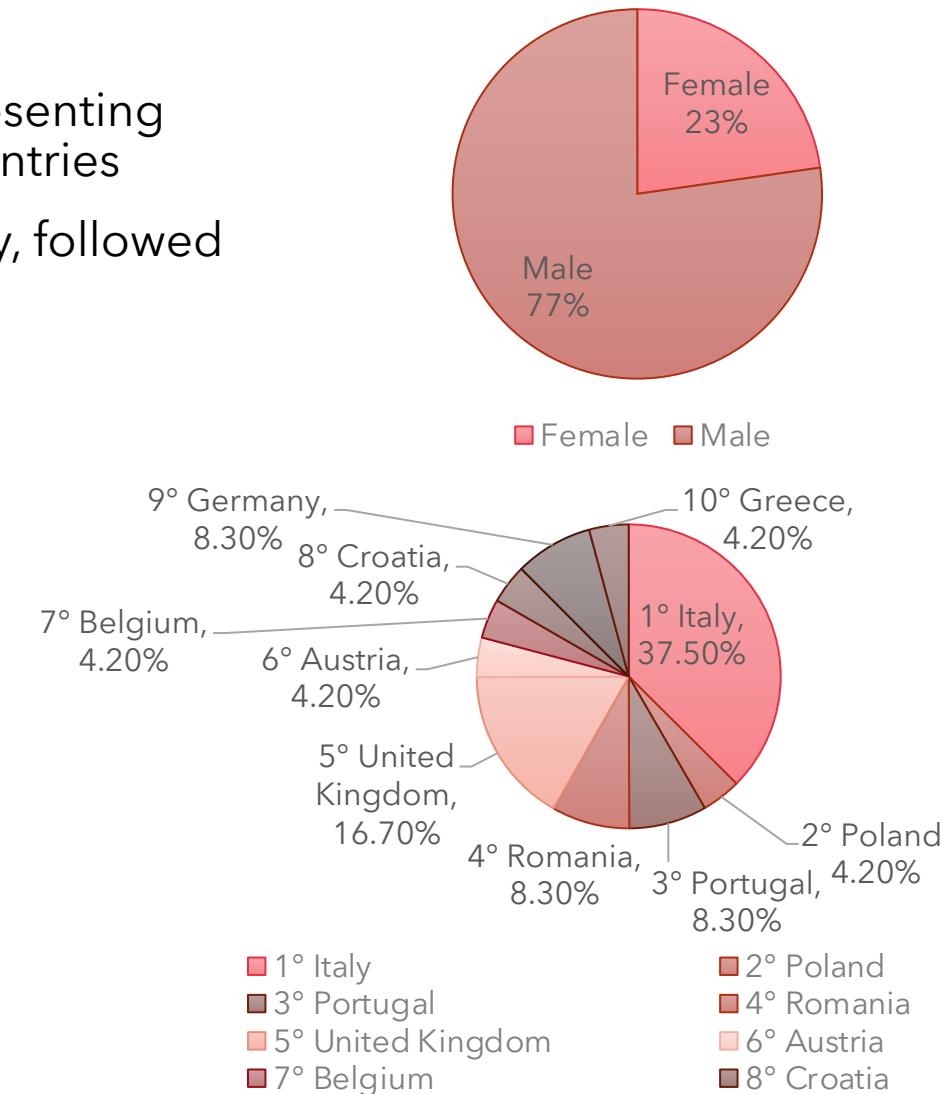
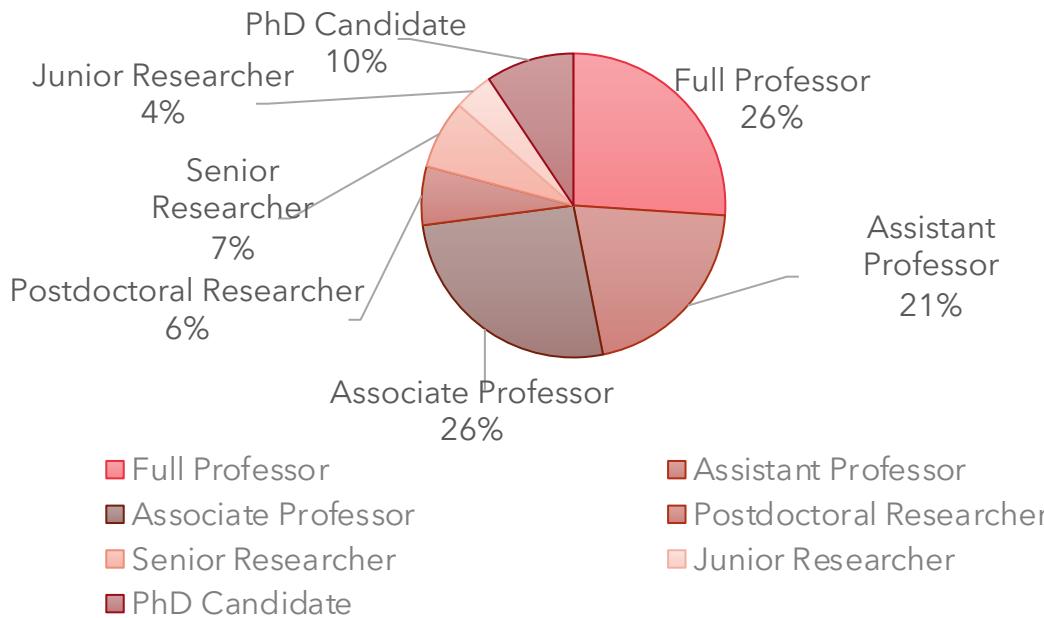
Which of the four ERIES Research Areas does the proposal focus on?
24 responses





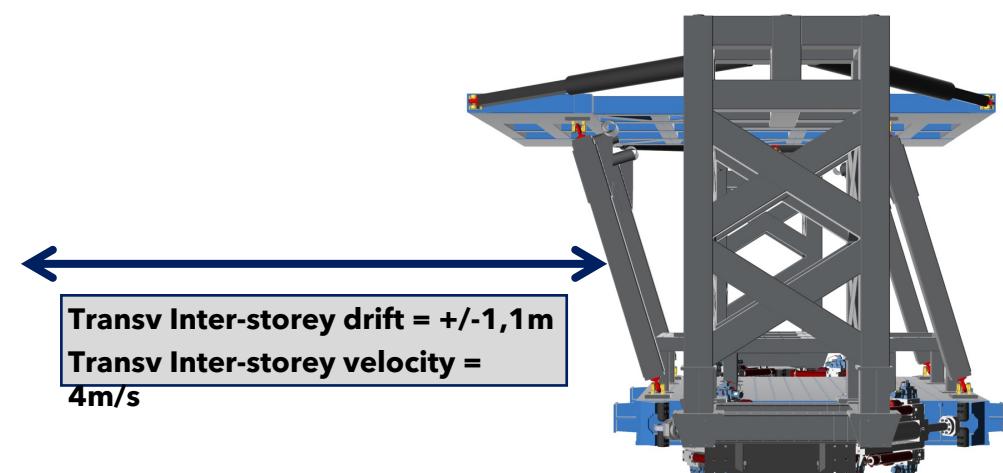
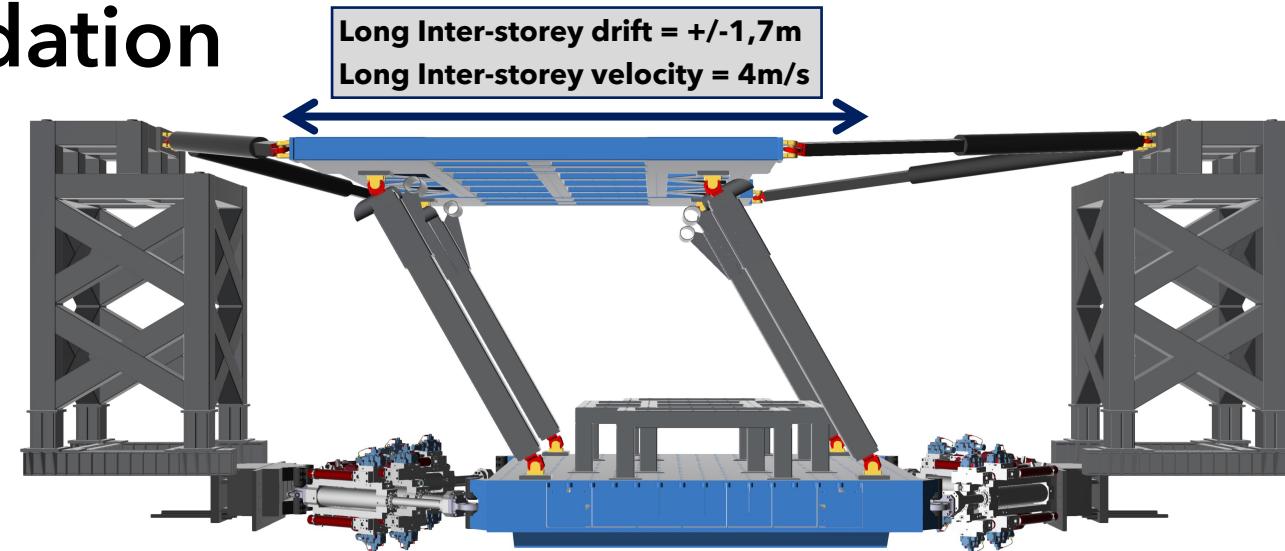
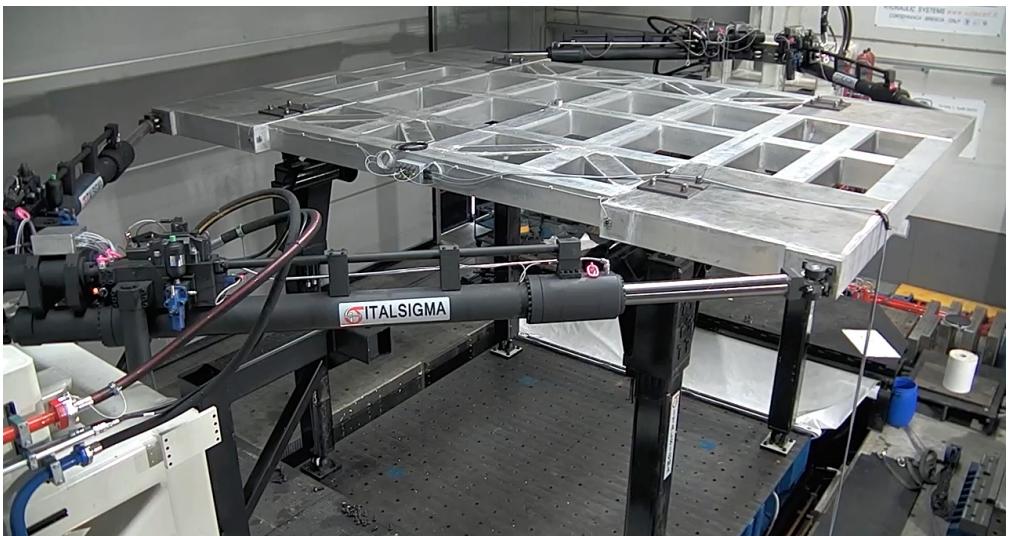
User groups - 1st call

- Diverse group of people of different profiles representing universities, research institutions and different countries
- Highest number of applications received from Italy, followed by United Kingdom and Portugal
- 10 different countries





9DLAB at EUCENTRE Foundation

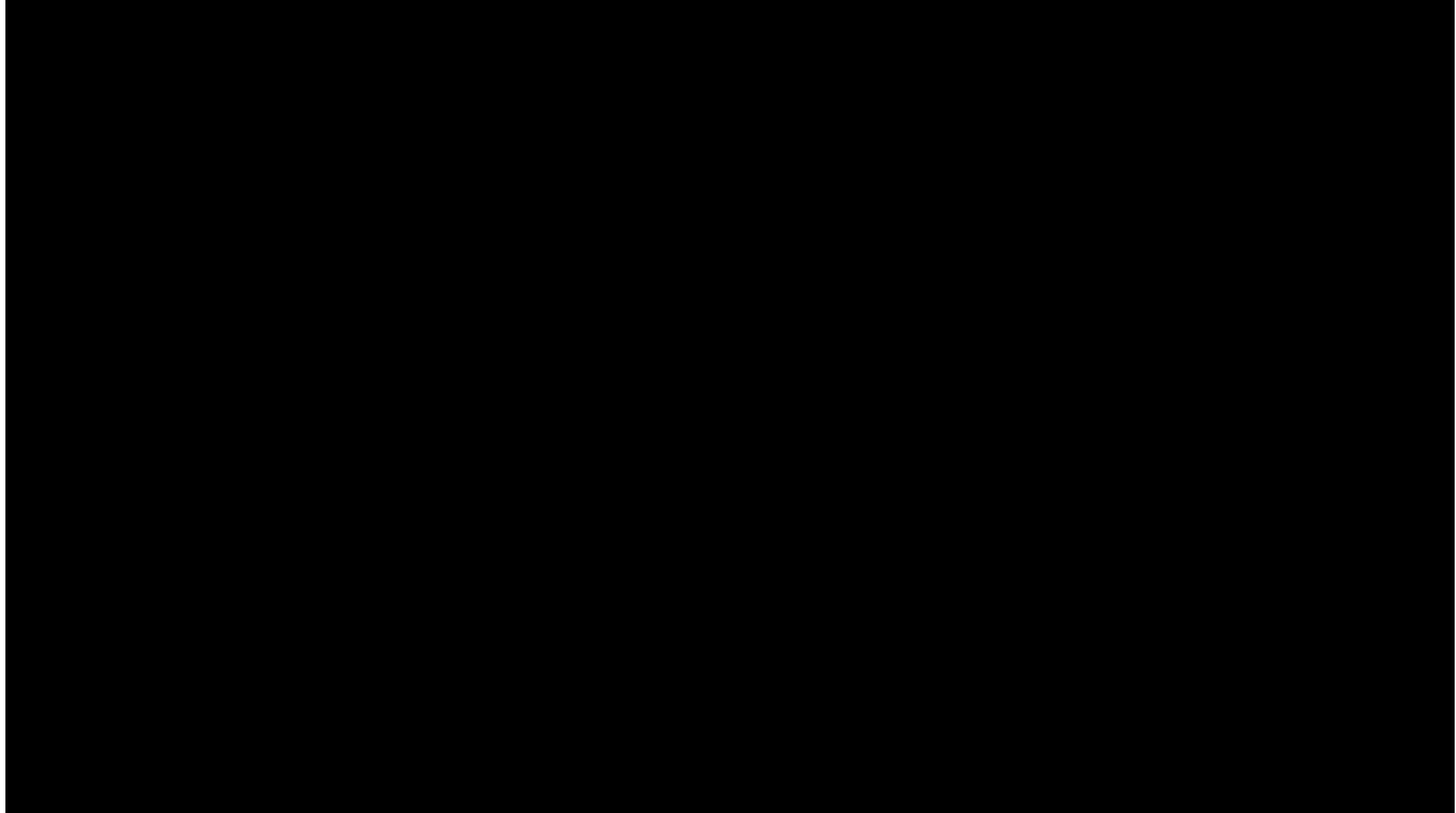




MASE 20 - "RESILIENT STRUCTURES"

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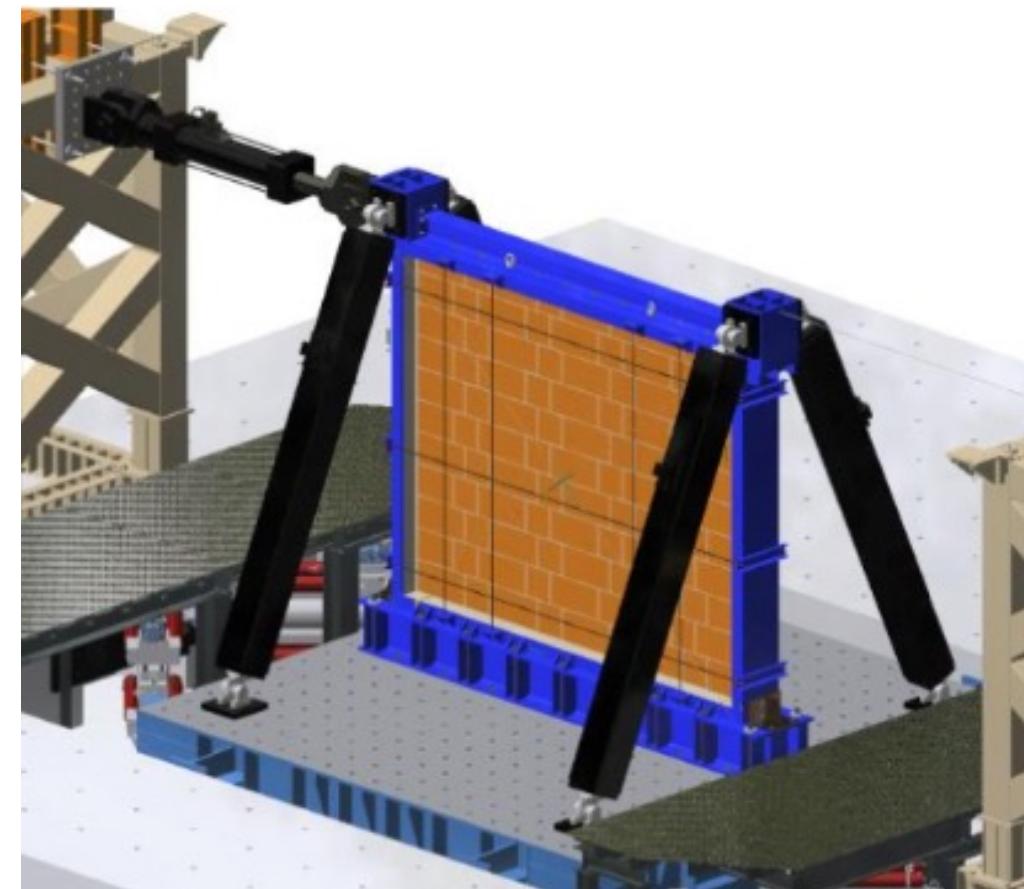
European Research Synergies Towards Loss and Risk-driven Mitigation
Approaches - Gerard J. O'Reilly





Case-Study Project: ENFRAG

- A case study example is described to illustrate the types of projects and how they address the research goals and areas outlined previously
- The project is ENFRAG (ENhancing state-dependent FRAGility through experimentally validated Energy-Based Approaches)
- It is led by the University College London, UK alongside Sapienza, Rome and is accessing the 9DLAB facilities at the Eucentre Foundation in Pavia, Italy



SAPIENZA
UNIVERSITÀ DI ROMA

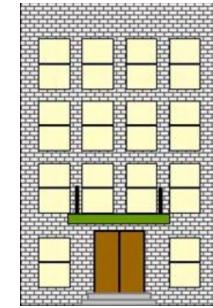


Background

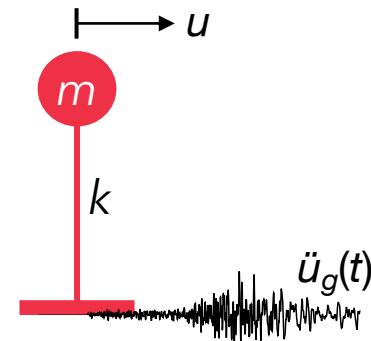
- The aim is to investigate the impact of energy dissipation in buildings on the seismic response and damage estimation
- If we test two identical structures (A and B) with the same earthquake scaled to $\text{PGA}_A=0.2\text{g}$ and $\text{PGA}_B=0.5\text{g}$



Structure A



Structure B



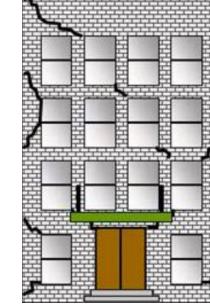


Background

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Structure A



Structure B

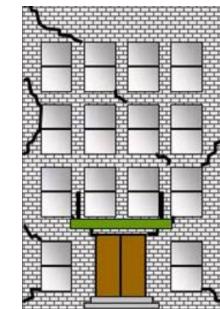


Structure B is
damaged
more



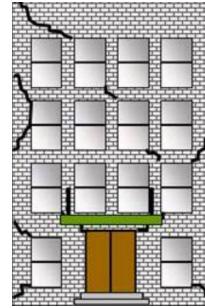
Background

- If we run a second earthquake on them at PGA=1g, specimen B will be more damaged than A
- This is because of the damage it suffered accumulated previously
- Most numerical modelling and seismic fragility models used in risk assessment don't account for this



Same
damage?

Structure A

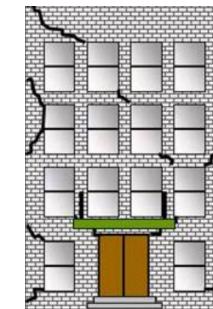


Structure B



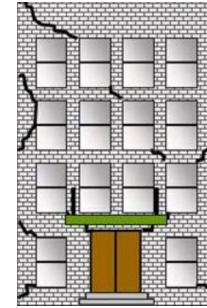
Background

- If we run a second earthquake on them at $PGA=1g$, specimen B will be more damaged than A
- This is because of the damage it suffered previously
- State-independent fragility functions would say they have the same damage state
- We know this is not the case
- Most numerical modelling and seismic fragility models used in risk assessment don't account for this

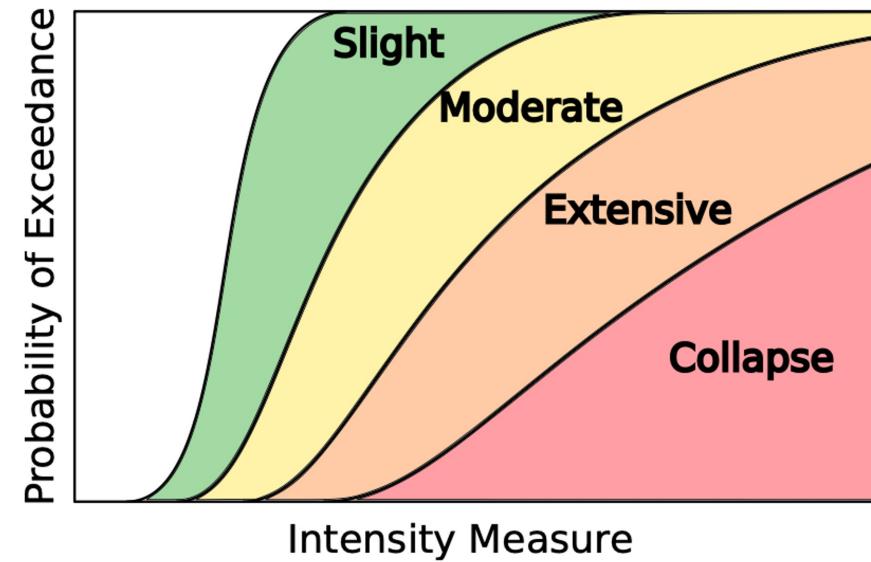


Same
damage?

Structure A



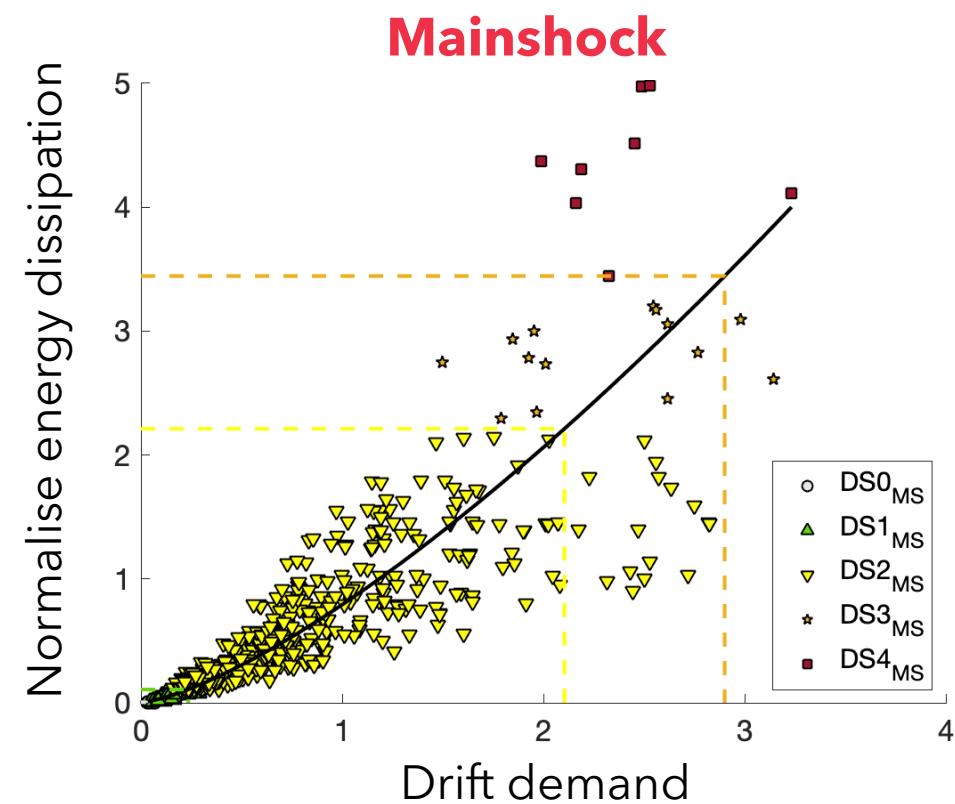
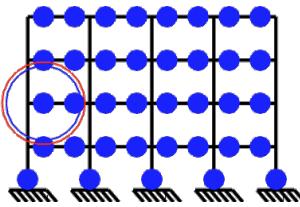
Structure B





Objectives

Aim to perform experimental research on peak drift vs. hysteretic energy

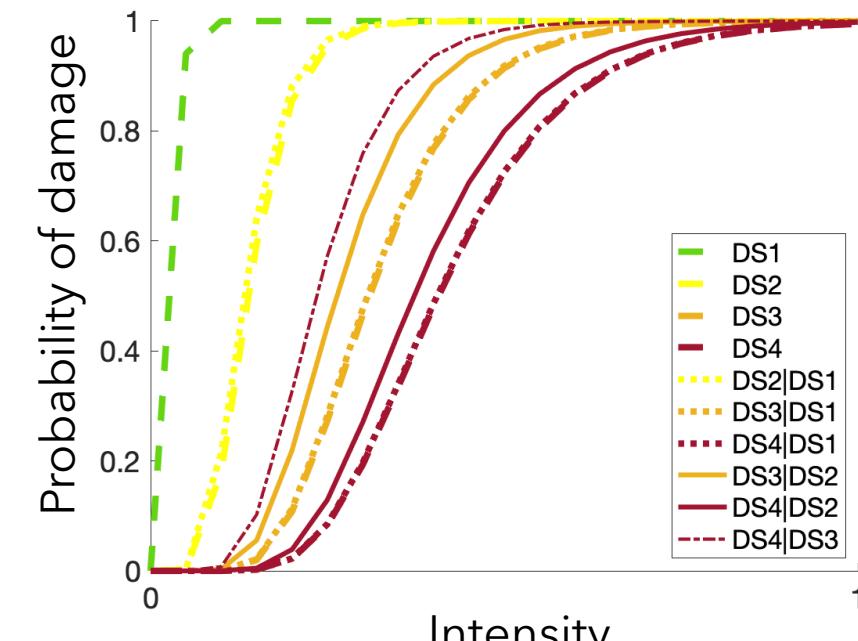
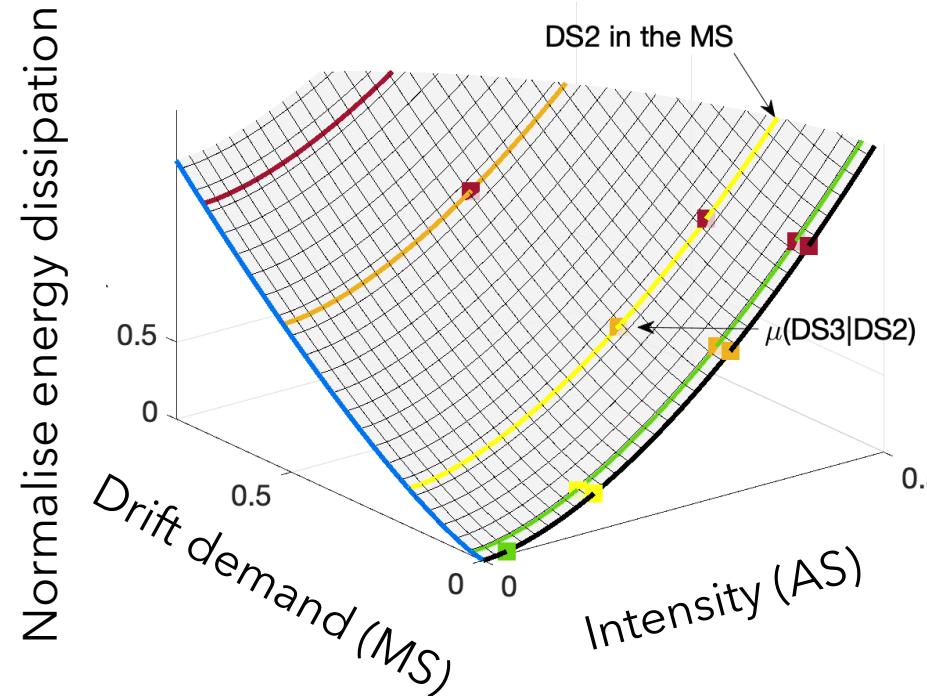


Gentile R, Galasso C. (2020) Hysteretic energy-based state-dependent fragility for ground motion sequences. *EESD*.
<https://doi.org/10.1002/eqe.3387>



Objectives

Energy-based state-dependent fragility curves



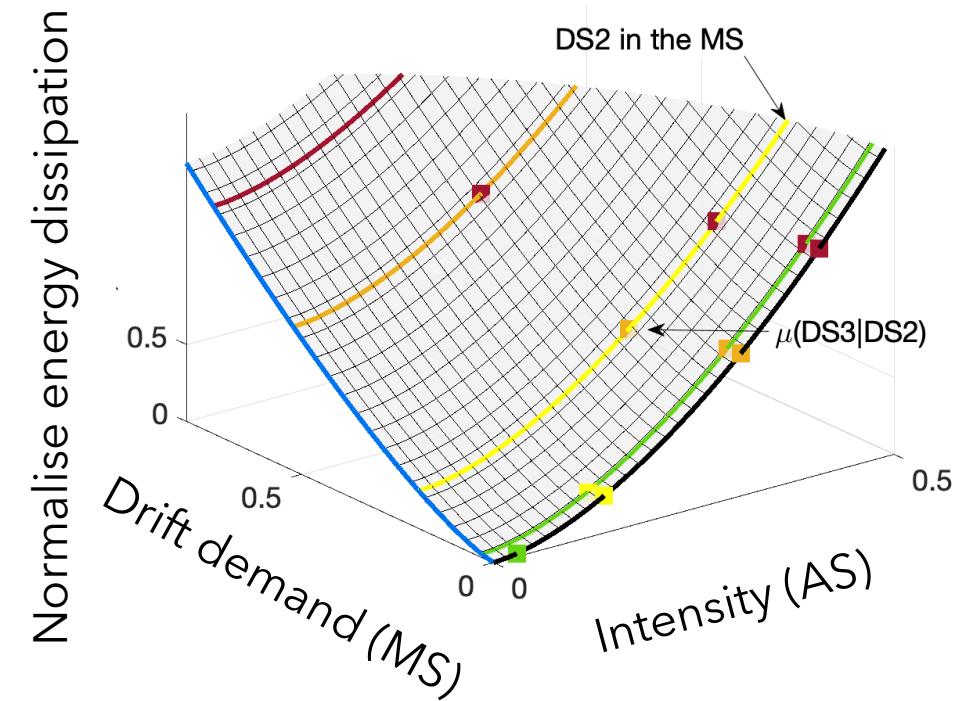
Line colour represents DS(AS)
Line type represents DS(MS)



Experimental test programme

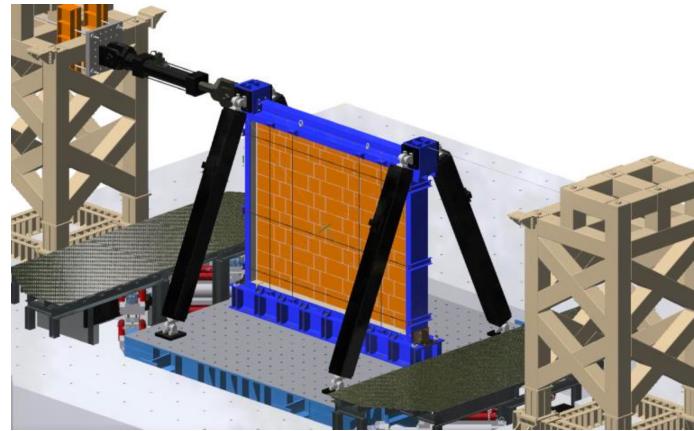


- Four nominally-identical masonry infill walls:
 - quasi-static cyclic displacement-controlled IP tests
 - and sequential shaking-table dynamic OOP tests
- Those are tested with different load protocols
- This will induce the same values of peak-based EDPs while modulating the energy-based demand conditional to the above peak quantities ($Eh|EDP_{IP}$ and $Eh|EDP_{OOP}$)

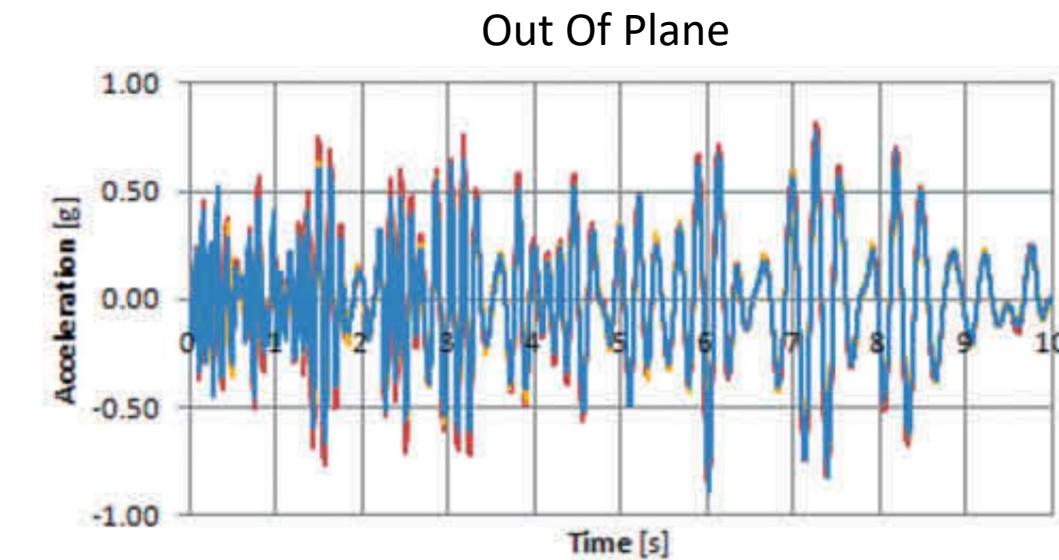
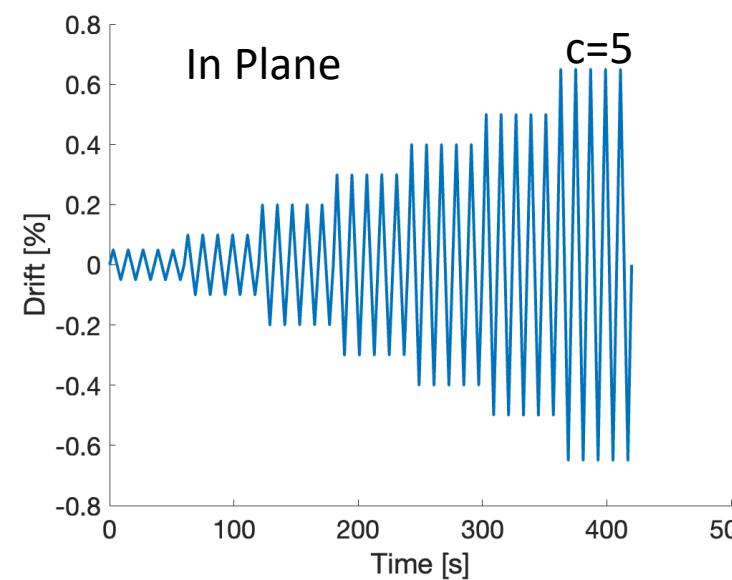




Experimental test programme



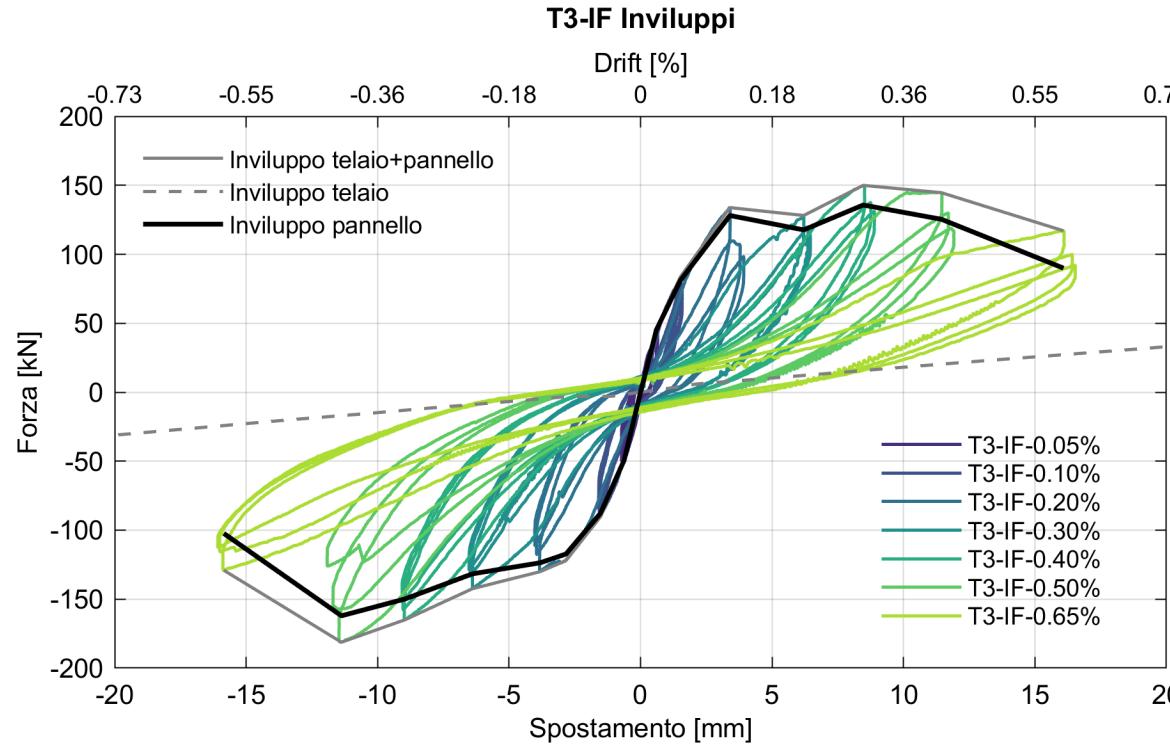
	θ_{max}	d	c	a(t)	ΔPFA	Notes
Test1	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	<u>5</u>	AC156	0.10g	<u>more</u> $E_h EDP_{IP}$ increasing EDP_{IP} cycles
Test2	[0.05, 0.3, 0.65]%	<u>3</u>	3	AC156	0.10g	<u>less</u> $E_h EDP_{IP}$ decreasing EDP_{IP} levels
Test3	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	3	AC156	<u>0.05g</u>	<u>more</u> $E_h EDP_{OOP}$ with more PFA levels
Test4	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	3	<u>AC156 w/ half duration</u>	0.10g	<u>less</u> $E_h EDP_{OOP}$ changing frequency content of PFA input



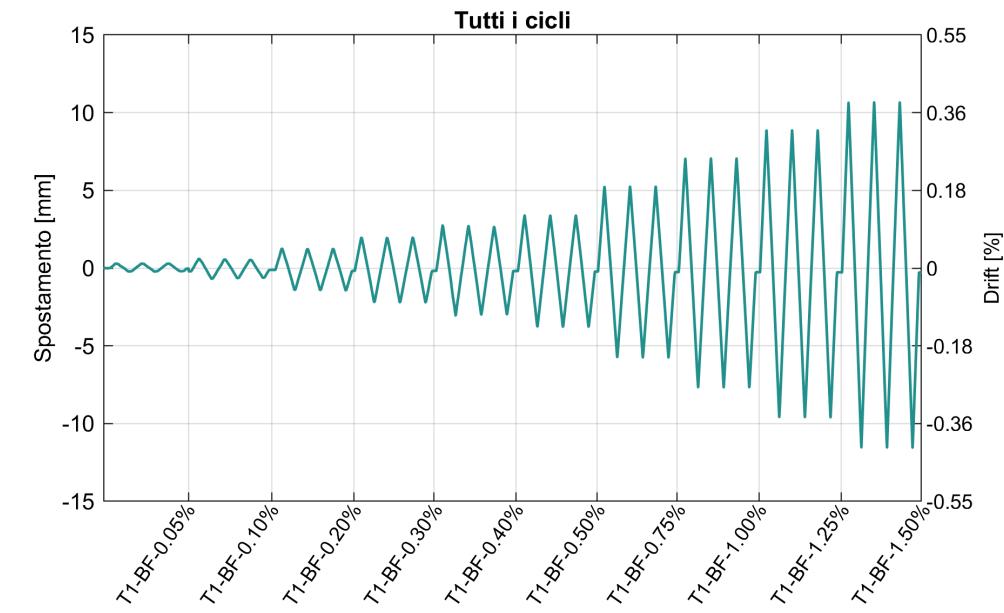


Experimental data elaboration

- Reference tests: Kurukulasuriya et al., 2022
- Specimens - infill panel surrounded by a steel frame (mimicking RC column stiffness)
- Load Protocol - IP quasi-static + OOP sequential IDA



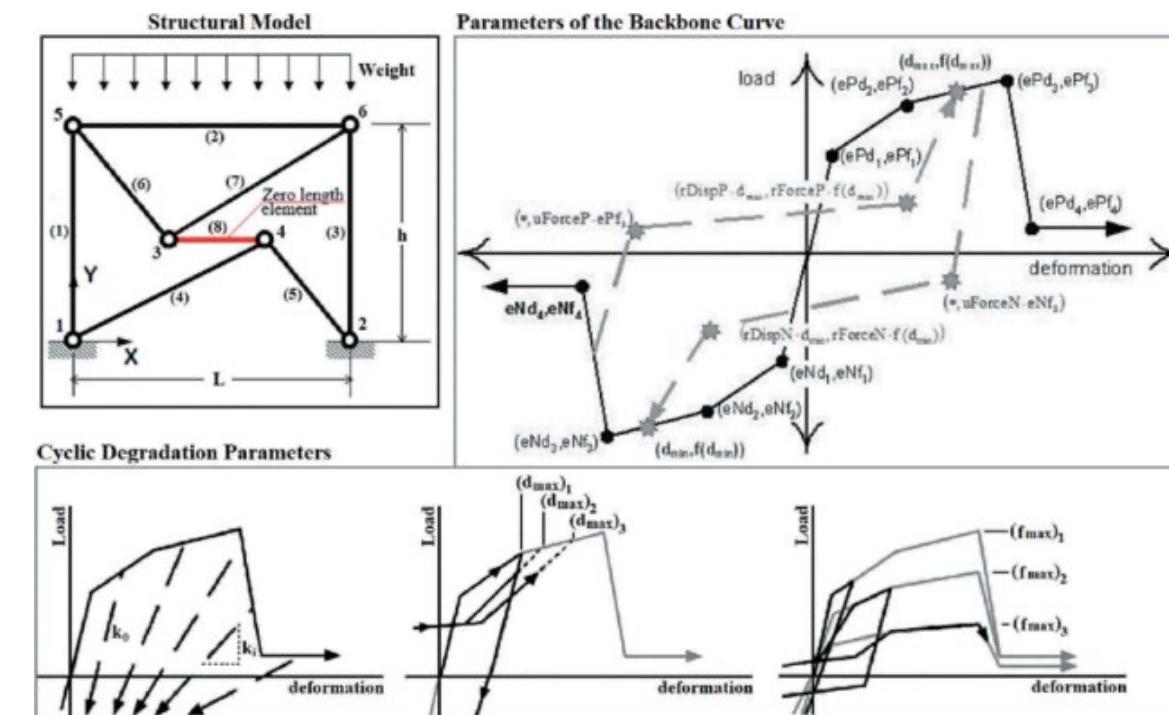
Kurukulasuriya et al., 2022





Potential impacts

- Understanding energy dissipation can be useful for:
 - Experimental test comparison
 - Numerical modelling calibration
- Tests carried out using different loading protocols can be difficult to compare
- With these insights, it can pave the way to compare two different tests via the energy dissipated in both specimens
- Utilising the experimental test data collected for nominally identical specimens, we can calibrate hysteretic parameters for numerical models
- Use OpenSeesPy Hysteretic and Pinging4 models
- Use maximum likelihood method to estimate the most representative set of hysteretic parameters based on energy dissipated during experimental testing





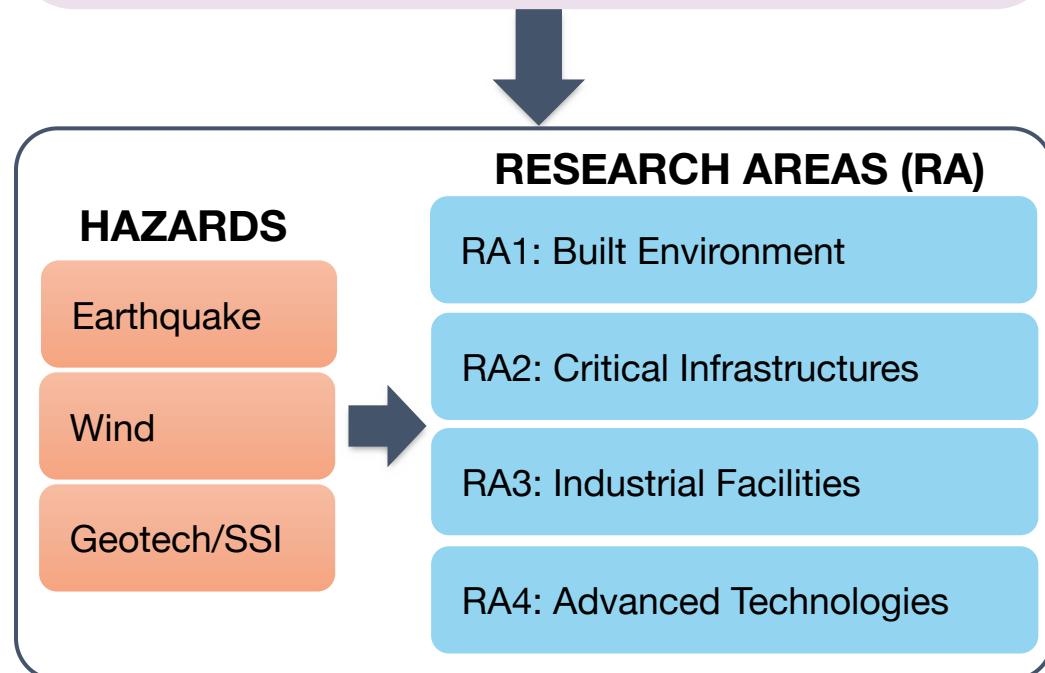
Conclusions

- This presentation gave an overview of the research possibilities with the ERIES research project
- It showed how frontier research is targeted through experimental testing facilities around Europe and Canada
- Case study example project ENFRAG described the investigation of the impact of energy dissipation in damage estimation
- It is envisaged that similar research projects can have a lasting impact on earthquake engineering through the problems tackled and the experimental data produced

RESEARCH GOALS

Advancing frontier knowledge on individual issues that contribute to the broader research theme of:

- Loss-driven design and mitigation approaches
- Risk quantification and prioritisation
- Green and sustainable development



The objective of ERIES is to provide transnational access (TA) to research infrastructures to advance frontier knowledge related to seismic, wind and geotechnical hazards

Project Coordinator



IUSS

Scuola Universitaria Superiore Pavia

Research Infrastructures



EUCENTRE
FOR YOUR SAFETY.



ARISTOTLE
UNIVERSITY OF
THESSALONIKI



ΠΑΝΕΠΙΣΤΗΜΙΟ
ΠΑΤΡΩΝ



LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL



UNIVERSITÀ
DI GENOVA



TU/e
EINDHOVEN
UNIVERSITY OF
TECHNOLOGY



le futur en construction



TA User Groups



Total Budget:
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Duration: 4 years
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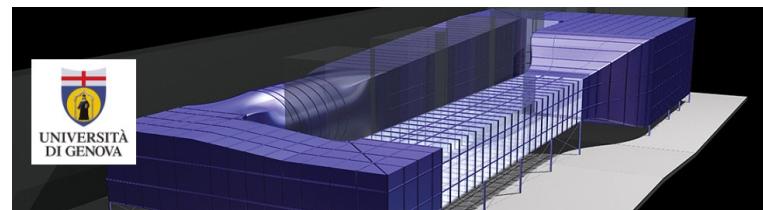
Funded by
the European Union

TA User Groups



World-class experimental research infrastructures include:

- Shaking Tables
- Reaction Walls
- Soil Pits
- Wind Tunnels
- Doppler Lidar Systems
- Hybrid-Simulation Capabilities (Multi-lab)

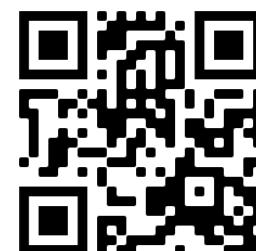


Funded by
the European Union

ERIES: Engineering Research Infrastructures for European Synergies (2022-2026)
Funded under the Horizon Europe Framework Programme
Ref: 101058684-HORIZON-INFRA-2021-SERV-01-07

- External user groups prepare project proposals in line with the goals of ERIES
- They collaborate with ERIES research infrastructures via transnational access
- This means European* users travel to another country and use the research infrastructures made available as part of ERIES
- Cost of experimental testing in addition to travel and accommodation of user groups are covered

More
information



www.ries.eu



Applications collected and evaluated at cut-off dates:

- 30th Sep 2022
- 8th Jan 2023
- 7th Jun 2023
- 3rd Nov 2023