Template

PROJECT FINAL REPORT

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Name of the scientific representative of the project's co-ordinator[1], Title and Organisation:

Ioannis Politopoulos, Commissariat à l'Energie Atomique

Tel: +33169083665

Fax: +33169088331

E-mail: ipolitopoulos@cea.fr

Project website Erreur ! Signet non défini. **address:** http://efast.eknowrisk.eu

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

4.1 Final publishable summary report

4.1.1 Executive summary

High performance experimental facilities are necessary to meet the objectives of earthquake risk mitigation and to make progress in methods for the design and assessment of buildings and infrastructures. Therefore, in order to be positioned within the avant-garde of earthquake research it is important for Europe to build a new high performance experimental facility. For that reason, the EC supported, as a part of the 7th framework project, a design study of a new generation seismic testing facility. This is the EFAST (European Facility for Advanced Seismic Testing) project. Five European partners with a large experience in seismic and dynamic testing were involved in EFAST: Commissariat à l'Energie Atomique (coordinator, France), the Gheorghe Asachi Technical University of Iasi (Romania), Eucentre (Italy), the University of Kassel (Germany) and the Joint Research Centre (European Commission).

The first step was the determination of the performance requirements of the new facility. Then a lay-out of was proposed which goes much further than existing shaking table facilities in Europe. It meets the requirements of modularity, flexibility and operational ease with technological choices that minimize the techno-economic risk. Several aspects have been studied related to the preliminary design. Amongst others the studies during the EFAST project focussed on the following issues:

- Technology: design of the hydraulic power supply system, shake tables, reaction mass, modular reaction structure, telepresence room, evaluation of shake table control methods.
- Advances in experimental techniques: carrying out of real time substructure tests with linear and non-linear physical substructures, evaluation of hardware for fast computer networking, development and utilization of a no-contact vision measurement system.
- Dissemination and access: design of a web portal enabling efficient access and networking, evaluation of the cost of physical access (based on the cost related to the organization of test campaigns)
- Management and operational issues: overall construction cost estimate, study of operational conditions (types of tests, tests' duration, maintenance, necessary staff, safety issues, etc.) and operational cost, consideration of alternative configurations with decreased performances and evaluation of the corresponding cost savings, identification of the potential project risks and evaluation of their impact, proposal of a schedule and road map for the detailed design and construction phase, determination of criteria for the optimum construction site of a future facility.

The medium to long term impact of a new advanced seismic testing facility in Europe will be mainly the reduction of the seismic vulnerability. This will promote sustainable economic development of Europe's seismic regions, but also of the entire Europe, through savings on the total financial loss due to future earthquakes. In fact, the enhanced capabilities of an advanced testing facility will lead to:

- A further insight into the earthquake response behavior of structures, in general.
- The improvement of the numerical simulation tools via their validation with the experimental results.
- The improvement and validation of regulations and recommendations
- Safer design and qualification of industrial structures and equipment, especially those of nuclear and chemical industry.
- The development and validation of new construction methods, materials and devices
- The support of European companies through the aforementioned validation of new technologies and design concepts.

- Demonstration tests for policy makers and public awareness and dissemination purposes.
- A “natural” excellence centre for advanced knowledge in earthquake engineering through training, transnational access and dissemination.

4.1.2 Project context and objectives

Seismic events of the recent past have proved that European and the neighbouring countries, especially those comprised in the Mediterranean area, are exposed to a high seismic risk. Surprisingly the number of victims and the overall economic losses are important compared to industrialized country like Japan and United States often faced with higher levels of shaking. This fact can be explained by considering the higher population density, and that the high number of damaged buildings is due to the large presence of monuments or ancient masonry buildings often vulnerable to earthquake loading.

It is readily apparent that, in developed countries, although the numbers of victims of major earthquakes is tending to drop, the costs of the consequences are constantly rising. The costs of the consequences, resulting in significant damage and widespread disorganization in the area, are constantly rising. Considering damage to plants, loss of data and drops in productivity, are extremely costly. A recent example is the social and economical impact of the L'Aquila (Italy) earthquake in April 2009. It is therefore indispensable for Europe to intensify the research and development in the field of earthquake engineering.

In the last decades considerable advances have been achieved in the Earthquake Engineering (EE) field. The research results have contributed to the preparation of the modern design codes, to the identification of several problems in the existing structures and to innovative solutions for the structural assessment. Despite this huge amount of improvements there are still several open problems. For instance, predictive models have frequently been calibrated on the experimental results obtained from scaled structures, several innovative technologies for building constructions are entering the market and require careful evaluations to verify the level of safety, the experimental validation of the behaviour of large infrastructures (bridges or retaining walls) often requires multi-support excitation, a further insight into soil structure interaction requires testing of heavy models, etc . Available data and future results need to be organized in databases, in order to disseminate them, optimize their use, and provide relevant information for risk oriented approaches. These researches require a large amount of analytical and experimental studies.

Moreover, a look at the international EE landscape reveals that, outside Europe, there are several high performance seismic testing facilities either already operating or under construction. As an example, in 2000-04 Japan, already boasting the most powerful experimental RTD infrastructures in earthquake engineering, spent €350m to build the largest 3D shaking table in the world (20mx15m, 1200t payload). Regarding pseudo-dynamic testing, the ELSA laboratory of the Joint Research Centre of the European Commission in Italy with its reaction wall 16 m high and 20 m long is one of the main seismic testing facilities in the world. However, the situation is different for European shaking tables facilities, having considerably lower performances than that of the major shaking tables laboratories in the world. There is also a trend, mainly in U.S.A. and Asia (China, Japan, Korea) towards facilities with an array of shaking tables which increases operating ease and enable multi-support excitations. The objective is to test structures at the largest possible scale in order to avoid scaling effects.

This means that, unavoidably, if the situation does not change, Europe will cumulate a considerable lag in experimental earthquake EE and in EE in general, with respect to the USA and Asian countries. Europe should not trail these foreign countries, in particular US and Japan, in experimental research in earthquake engineering and rely on their RTD results. It should compete and share results with them as equal, to serve its own needs and promote its own interests. To see the reasons, we should recall first the difference of buildings in Europe from those in Japan or the US. In Europe new residential construction uses mostly concrete framing, often with masonry infills, especially in the seismic southern countries. Europe is also rich in cultural heritage buildings, mainly of masonry construction. By contrast, in US and Japan heritage buildings are not common and new buildings are mostly of timber. Moreover, concrete and masonry construction in US and Japan is very different from Europe. So, the focus of RTD in these countries does not fully serve Europe's needs. In the other major type of Civil Engineering Works, namely Civil Infrastructures, the technology and the materials are fully global. There, Europe is the world leader: in niche technologies (post-tensioning, stay cables, marine or off-shore construction, etc.), in overseas construction (it boasts the world" s top firms: Bouygues, Dragados, Ferrovial, Hochtief, Vinci, etc.) and in overseas consultancy and design, with its huge engineering services sector, etc. As most of the overseas activity is in seismic areas (East, South or Southeast Asia, Central Asia, NorthAfrica, Middle East and Latin America), European construction firms and engineering services cannot retain their competitive edge in seismic markets and their reputation as leaders in technology, unless the EU as a whole establishes itself as equal to the USA and Japan in earthquake engineering RTD.

In addition, it is worth noting that there is an emergence of advanced experimental techniques, such as real-time substructuring and advanced measurement techniques that are being explored in the most innovative laboratories. This is an important point since the new experimental methods, based on the substructuring technique, have the advantage of reducing the specimen size allowing a better use of the hardware resources.

For all the aforementioned reasons a new platform for dynamic seismic testing in Europe is not just useful but necessary. A new high performance testing facility will enable studying a large variety of structures and systems. In fact, such a facility is an indispensable tool to calibrate and validate new conceptual approaches in modelling and simulations developed for performance based analysis and design of new structures or retrofitting interventions of safe structures in Europe and even worldwide. It will also contribute to increase world wide the competitiveness of European science and industry.

Therefore, the European commission granted, as a part of the seventh framework project, the design study project EFAST (design study of a European Facility for Advanced Seismic Testing). The main objectives of EFAST are:

- Define the needs in experimental research in earthquake engineering in Europe.
- Define the features of a new testing facility, complementary to existing research infrastructures in Europe, combining high capacity, flexibility and operational ease
- Make progress in advanced testing methods such as real time sub-structuring techniques and carry out demonstration tests.
- Study the technical feasibility of this facility.
- Study financial issues related to the construction cost, operating and maintenance cost and access cost.

4.1.3 Description of the main results

4.1.3.1 Required general performances of a new European seismic testing facility

The 1st international EFAST workshop pointed out some of the fields that need further experimental research. In particular, more experimental evidence is needed in the following topics:

- In plan irregular buildings exhibiting torsion response,
- Precast and prestressed concrete elements and systems,
- Masonry buildings and infills. In particular more experimental data of buildings with more than one storey are needed,
- Infrastructures (e.g. bridges implying multi-support excitation capability),
- Retrofitting,
- Aseismic devices (e.g. isolation bearings, dampers etc.),
- Equipment and components. In particular the motion of the floor the equipment/component is mounted on should be reproduced implying high acceleration and displacement capacity,
- Soil-structure interaction Due to the considerable weight of such models only elementary configuration could be tested. In any case a high payload table is required.

One common point to all classes of problems is that, in order to conduct a meaningful risk assessment, the actual available margins of structures have to be estimated. This holds for all structures but it is even more critical for structures of major importance (e.g. power generation facilities, hospitals etc.). To this end, tests with excitation level up to failure should be possible in future. Depending on the tested structure of interest (building, equipment or secondary structure), failure can be defined as loss of operational function, collapse or relevant significant damage or collapse. This implies that the new facility should have the capability to apply high intensity excitations (high acceleration, velocity and displacement) to models which will be representative of the prototype structures. Since the pseudo-dynamic testing facility at the ELSA laboratory of the Joint Research Centre of the European Commission in Italy, with its reaction wall 16 m high and 20 m long, is considered as one of the main seismic testing facilities in the world, it is proposed that the new facility should be, mainly, a new generation shaking table facility with the possibility to apply advanced experimental techniques like real time hybrid testing also. In addition, the new facility should comply as far as possible with the requirements of flexibility, adaptability and operational ease.

Table 1 shows some indicative performance parameters for different classes of tests. The given numbers are reasonable rough estimates as a trade-off between needed performance and cost. Obviously it is not feasible, either for technological or financial reasons, to build a facility so big that everything could be tested therein. The objective is to propose a design that will enable to carry out meaningful tests using conventional and/or more recent techniques and technologies which have already demonstrated their efficacy and reliability.

The acceleration values in Table 1 may seem to be unrealistically high. However, it is worth noting that a) several records of real earthquakes revealed very high acceleration values (e.g. 0.98 g Northridge earthquake, 1994, 0.85g Kobe, 1995) b) in the case of scale models, if a velocity similitude is considered, the table acceleration should be multiplied by the inverse of the scale ratio i.e. table acceleration will be higher than ground acceleration of the prototype and c) the values in Table 1 are conventional acceleration values corresponding to a rigid specimen. Consideration of the dynamic amplification of the specimen results in a higher demand of force capacity which is equivalent to a higher demand of conventional acceleration capacity. In the case of soil-structure interaction tests, the major part of the mass on the table is due to the weight of the soil itself and its container which will have, in general, a weak dynamic amplification. Therefore, in that case the required shaking table acceleration could be smaller. Regarding secondary structures and equipment, because of the amplification of the shaking motion at the floor level, floor accelerations to reproduce on the table may be much higher than ground accelerations.

Table 1 : Performance demand for possible classes of tests

	Soil-structure Interaction	Tests on civil engineering	Secondary structures or equipment
Height of specimen	6 m	15 m	10 m
Mass of specimen	500 tons	200 tons	1 - 100 tons
Number of directions	1	1 - 3	1 – 6
Displacement	± 1 m	± 1 m	± 1 m
Velocity	± 2 m/s	± 2 m/s	± 2 m/s
Acceleration	± 1 g	± 2 g	± 2 g (100 tons) ± 6-7 g (10 tons)
Frequency range	0.2 – 50 Hz	0 – 50 Hz	0 – 100 Hz

Velocity values are also in agreement with actual recorded velocities (e.g. 1.4 m/s North\-ridge earthquake, 1994, 1.5 m/s Kobe, 1995). High displacement values are also necessary for the shaking table motion to be representative of strong, low frequency ground motions or of floor motions of low frequency buildings (in the case of secondary structures or equipment tests).

4.1.3.2 General layout

A lay-out of the facility is proposed which meets the above performance requirements. The underlying philosophy is resumed to the following points:

- The new facility should be a significant step ahead and go much further than existing shaking table facilities in Europe
- It should be a combination of components and technology that have already been validated by their operational use in other existing facilities. In fact EFAST is a design study not a pure R&D project therefore there was no room in EFAST for innovation and adoption of “revolutionary” technology and techniques. Moreover, the choice of well validated technological solution is imposed because of:
    - Technical reasons. In fact the new facility should be able to carry out accurately big scale, high capacity demanding tests from the 1st day of its operation. A less or more long period of adaptation and/or changes to achieve this goal (accurate big scale seismic testing) is not acceptable.
    - Safety reasons
    - The requirement to minimize the techno-economic risk for potential investors. Actually potential investors desire to minimize divergence from the foreseen date of operating start and from the foreseen budget at the moment of their commitment.

- The design is based on the feedback from

    - those of the EFAST partners running big shake tables
    - some of the most experienced manufactures of shake tables in the world

- The proposed solution is a trade-off between dreams and real world (performance vs. cost). In fact, too high cost (construction, maintenance, handling, specimen transport etc) would kill any chance for the facility to be constructed. In addition, given that the proposed configuration is composed of up-to-date elements and technology but already existing and operating allows us to make a construction and operational cost estimate with a good accuracy.

The general lay-out of the facility is shown in **Erreur ! Source du renvoi introuvable.** to **Erreur ! Source du renvoi introuvable.**. The facility consists mainly of:

1. Two 6 DOF 6 m x 6 m shaking tables. The payload of each table is of about 100 tons. The tables can be positioned in any place within the trench. The gap between them can vary from 0 to 20 m. They will be able to operate independently or be linked and operate as a single table with a payload of 200 tons. They will be able to have a synchronous or asynchronous motion.

The two shaking tables allow the following configurations:

- two separate tables operating independently (adjustable distance between the 2 tables from 0 m to 20 m),
- two separate tables but working together, linked by means of a special truss or plateau and supporting a large specimen (distance between 2 tables adjustable from 0 m to 20 m),
- two separate tables, operating simultaneously but with different motions to test multi-supported structures (distance between 2 tables adjustable from 0m to 20m),
- Two tables linked together to realize a large table of 6 m x 12 m.
- One or two tables (in this case fixed rigidly to each other) can be mounted on bearings fixed at the bottom of the pit to operate as a single axial table (1 DOF along the length of the pit). This would enable to test even higher models since the height of the specimen could be equal to the height of the hall (distance between the ground level and the bottom of the crane) plus the depth of the pit.

Obviously a higher number of tables, possibly in different trenches, would enable testing more complex configurations. However as already mentioned, the proposed facility is a trade-off between performance-capacity and cost, that is why only two tables are proposed. Their performances are summarized below:

- maximum horizontal displacement ± 1 m in OX and OY,
- maximum vertical displacement ± 0,75 m in OZ,
- Maximum horizontal velocity 2 m/s in OX and OY,
- Maximum vertical velocity 1,5m/s in OZ,
- Maximum acceleration 2 g in OX and OY,
- Maximum acceleration 1,5 g in OZ,
- Maximum duration of excitation at full power 30 seconds.

If necessary, the maximum payload of the two 6 DOF tables could be increased with minor modifications of the actuators (slight increase of their length providing higher shock absorption capacity). However, unless the actuators' capacity increases, this will be done at the price of a smaller maximum acceleration at full payload.

During periods of maintenance or repair, the tables can be uncoupled from the horizontal and vertical cylinders and stored temporarily on the strong-floor or on the outdoor area (cf. item 6). Dedicated trusses/frames will maintain in a vertical or horizontal position the cylinders during maintenance (those frames can be the same which will be used for the initial placement of the cylinders in the pit).

2. one 1 DOF (horizontal) shaking table 11m x 11m with high payload of about 500 tons. It will be mounted on hydrostatic bearings fixed at the upper part of the pit walls. This shaking table will be intended for heavy specimen and in particular for soil-structure interaction tests. The maximum acceleration at full payload will be of about 0.6g – 1g. Actually in a first step for economic reasons we consider that this table will be actuated by the actuators of the two moveable tables. Therefore the achieved acceleration will depend on the number of the actuators which will be utilized. This big shaking table will not be in the pit permanently but it will be mounted on when a mono-axial test of a heavy specimen must be carried out. Obviously, in the case of configurations where the gap between the two 6m x 6m shaking tables is 20 m, the 11m x 11m table should be taken out of the pit. To this end the crane was designed to have the capacity to lift up such a heavy structure;

3. a reaction mass which consists, mainly, of a pit that hosts the aforementioned shaking tables, a room (of about 30m x 20m x 4.5m) hosting pumps and accumulators and a big strong floor area . This thick (2 m) strong floor slab gives enhanced adaptability to the facility. In fact several experimental set-ups (small to medium shake tables, dedicated testing machines, reaction structures etc) can be mounted on it. The necessary power will be supplied to the actuators at any position by means of hoses. The reaction mass weighs about 25000 tons. Vibration nuisance analyses showed that vibration isolation of the reaction mass by means of specific devices (e.g. springs and dampers) is not necessary. Therefore and to avoid the considerable cost increase associated with isolation devices the reaction mass is put directly on the ground.

4. A modular reaction structure, which can be placed anywhere around the pit, allowing for real-time hybrid testing possibly combining shaking tables and actuators attached on the wall.

5. A hydraulic system composed of piping, actuators, pumps and accumulators with a capacity consistent to the performance criteria given in table 1.

6. An outdoor area devoted to the construction of specimens, especially reinforced concrete or masonry models;

7. A high capacity crane bridge with 4 hooks each one having a capacity of 50 t (total capacity 200 t). It spans the whole width of the working area and it can move along the whole length of the hall and the outdoor area. The crane will be able to lift and transport heavy models from the construction area and install them on the tables and vice versa. Its capacity allows also handling of the shake tables, even of the big mono-axial table. The crane bridge includes also a cantilever crane of a capacity of 20 t which will be used for handling low to medium weight items (pipes, actuators, light specimens etc.). The foundations of the crane frame rails are designed to be independent of the foundations of the hall and the offices building.

8. In addition to the experimental hall (overall dimensions LxWxH=47m x 42m x 19m) a 2-storys building (offices, control room, meeting room, teleconference room etc.) for about 40 persons of about 1000 m² per story is foreseen.

It is worth noting, that though not investigated here because it was beyond the scope of this design study, a strong interaction between the aforementioned "purely experimental" facility and a numerical high computational capability facility, on site or remote, is necessary. Actually, high performance and accuracy numerical simulation is necessary not only for advanced experimental methods, like real-time sub structuring involving complex numerical substructures, but also for conventional tests. Being able to quickly obtain accurate results of predictive analyses before testing and interpretation analyses after testing is of a paramount importance for successful experiments of models with complex behaviour. Predictive analyses are necessary to define the whole testing configuration (model geometry, boundary conditions, properties, input characteristics, measurement technology, sensor locations and calibration etc.). From the experimental point of view, interpretation analyses may be useful for the detection of problems or unexpected response that occurred during the test (e.g. unsatisfactory behaviour of sensors, actual boundary conditions different from that considered etc.). This aspect is of particular importance in the case of series of tests where fast numerical interpretation analysis can be used as a tool of quality control between two successive tests.

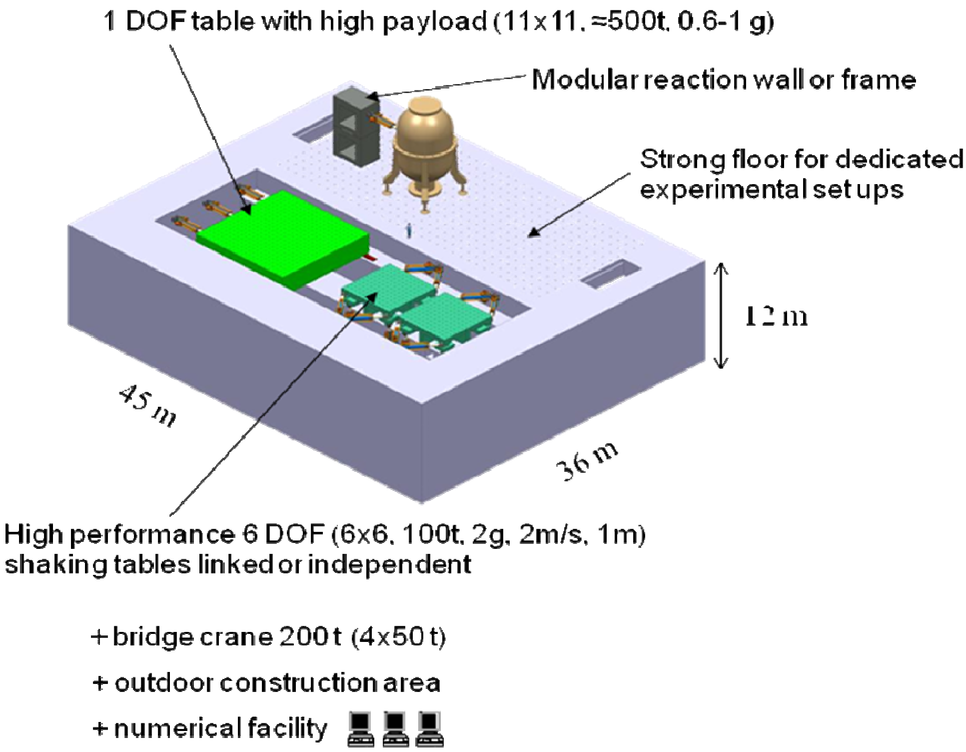


Figure 1. General lay-out

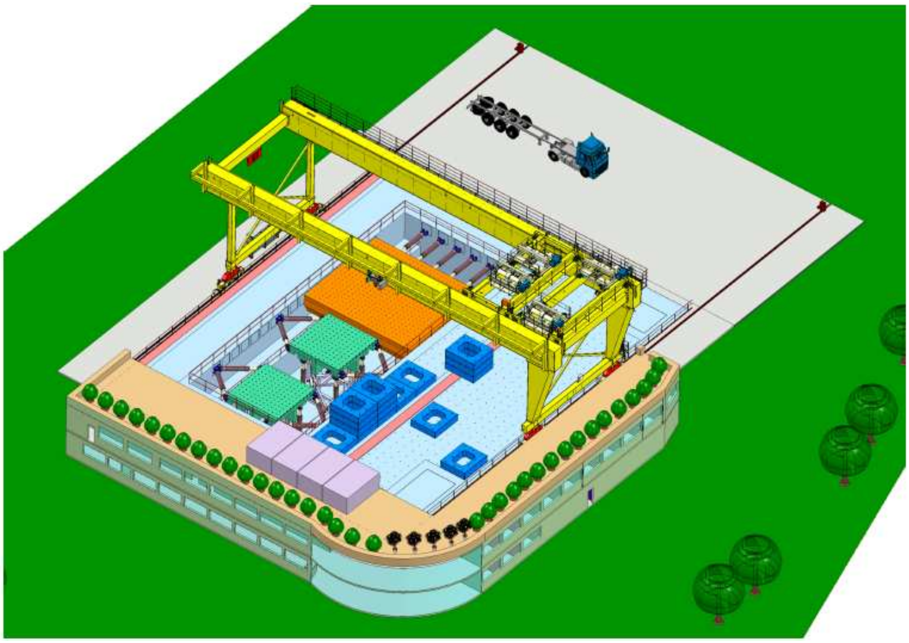


Figure 2. Overall view

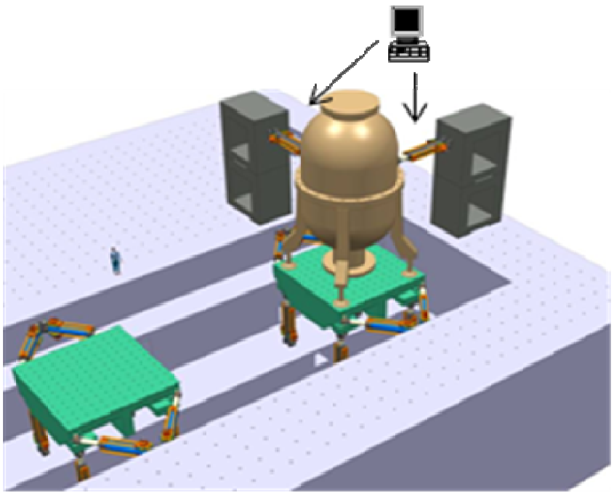


Figure 3. Real-time Hybrid testing

4.1.3.3 Studied aspects

After having determined the general characteristics of the future experimental facility, several aspects have been studied related to its preliminary design. Amongst others the studies during the EFAST project focussed on the following issues.

Technology

- The preliminary design of the hydraulic system has been accomplished. In particular the number and type of pumps, actuators and accumulators was determined. The cooling and piping systems were also determined.

- Several table geometries were studied which resulted in optimum weight/stiffness ratio. The interaction between table and specimen due to the table deformability was also investigated.
- For the reaction structure two alternative modular adaptive reaction systems are proposed. A modular steel reaction system and a modular reaction wall composed of reinforced concrete blocks assembled by means of pre-stressed rods.
- Taking into account the results of the design of the hydraulic system, the shaking tables and the reaction system, the geometry and dimensions of the reaction mass were determined. Soil-structure interaction analyses were carried out to estimate vibration nuisance in potential neighbouring buildings or facilities.
- Shaking table control methods were studied and comparison between some commercially available controllers was carried out.
- An overview and critical analysis of the most common approaches for telepresence rooms was carried out and a design proposal is made (Annex II, section 4.1.3.5).

Advances in experimental techniques

- A considerable effort was devoted to real time substructure testing. Real time hybrid testing with linear or non-linear substructures were designed and carried out at the University of Kassel, EUCENTRE and CEA. A summary of the outcome of these tests are presented in Annex I (section 4.1.3.4)
- Hardware for fast computer networking was tested.
- A no contact vision measurement system was developed. The accuracy of measurement sensors (e.g. load cells) necessary for real time substructure testing was also investigated and specific, high accuracy, load cells were designed when needed.

Dissemination and access

- Based on a comprehensive study, the design of a web portal enabling efficient access and networking was proposed taking into account both hardware and software aspects.
- Regarding physical access, based on the experience of the EFAST partners, procedures related to the organization of the test campaigns are proposed and the corresponding cost is estimated.

Management and operational issues

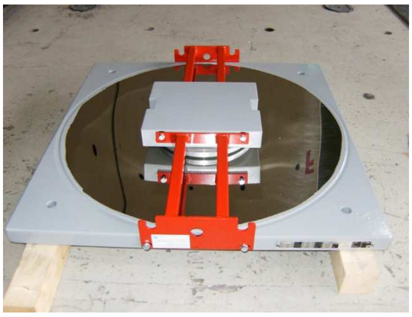
- On the basis of information given by manufacturers and experts in projects costs, the construction cost of the facility was estimated.
- The operation conditions (types of tests, tests' duration, maintenance, necessary staff, safety issues, etc.) were investigated and the operational cost was estimated.
- Alternative configurations with decreased performances (e.g. only one 6 DOF table instead of two etc.) were considered and the corresponding cost savings were estimated.
- The criteria for the optimum construction site of a future facility were determined.
- The potential risks were identified and their economic and time impact on the project was estimated.
- A schedule and road map for the detailed design and construction phase is proposed.

4.1.3.4 Annex I: Real time hybrid tests

a)Tests carried out at EUCENTRE

EUCENTRE/Italy conducted a real-time substructure test campaign. The reference system is an existing base isolated structure (Figure 5a); such a structure is one of the new buildings, built immediately after the 2009, April 6th L'Aquila earthquake, to host the earthquake victims who were living close to the epicentre.

a



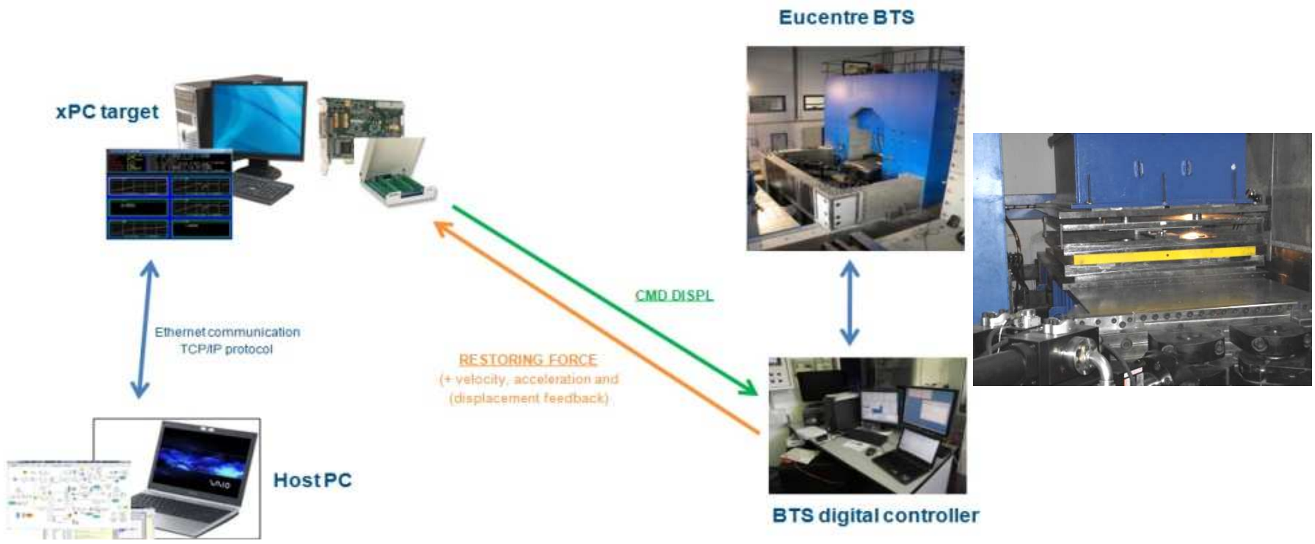
B

Figure 4 (a) Reference system; (b) FPS isolation device

The structural system is made of a rectangular matrix of supporting columns directly seated on a concrete slab foundation; on the top of them, a Friction Pendulum System (FPS) isolation device (Figure 4b) supports a thick concrete slab which serves as basement of the building. Such structure is particularly suitable to be investigated by means of a Real-Time Dynamic Hybrid Testing Technique with Sub-structuring (RTDHTwS), because the expected non-linearities are likely concentrated in a well identified portion (the base isolation system), which constitutes the physical sub-structure to tested experimentally. The rest of the structure is simulated numerically. Even if a numerical model of the experimental substructure is not strictly required, a fully simulated reference solution is useful to optimize the test setup and estimate the response of the system before doing the test.

Hardware and software setup

Compared to more conventional experimental tests, RTDHTwS, in general, require a more complex hardware and software architecture. In Figure 5, the main components of the implemented system are sketched.



(a) (b)

Figure 5 (a) RTDHTwS implemented setup; (b) isolation device tested on the EUCENTRE's BTS

The xPC Target can be a standard PC or Workstation, running the real-time operative system generated by xPC target toolbox from Mathworks. On xPC Target the main system, the RT algorithm and the interface for the external communication as well, run in real-time. Everything is previously implemented on a non-RT windows-based PC (Host PC), with Matlab and Simulink software, then downloaded through TCP/IP connection to the xPC. The Host PC works also as a Graphical User Interface (GUI) for the xPC during the RT simulation.

The BTS (Bearing Testing System) of the Eucentre TREES Lab is an experimental facility made of a 5-DOF shake table, situated beneath a vertical reaction structure which, combined with 5 vertical actuators, allows the application of the vertical load to the specimen. The experimental facility is controlled by a specifically designed MTS advanced PID digital controller.

The communication loop of the whole system is made of numerical parts and a real time algorithm which send a command displacement, after a D/A conversion, to the BTS controller, which apply the command displacement and send back the feedback of displacement, acceleration, restoring force, etc. to the real time machine.

Results

Since it is not possible to test physically the whole reference structure (superstructure + bearings) the experimental substructure tests are compared to the analytical results for the whole structure. Figure 6 shows that the substructure technique reproduces successfully the dynamic response of the system.

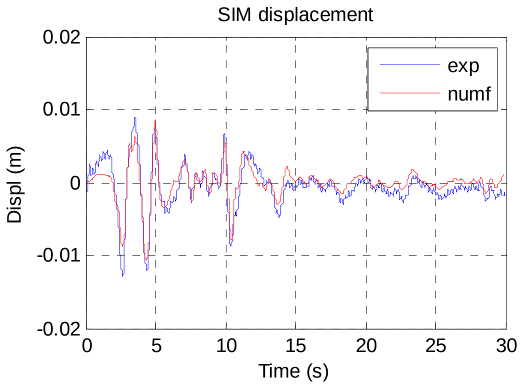


Figure 6. Experimental and numerical displacement of the friction pendulum

b)Tests carried out at UNIKA

UNIKA/Germany developed a test setup for real-time substructure testing using a hydraulic shaking table and a non-linear Tuned Mass Damper (TMD). Series of identification tests, reference tests and substructure tests have been performed. The feasibility of using the method of real-time substructure testing using shaking tables was assessed for E-FAST.

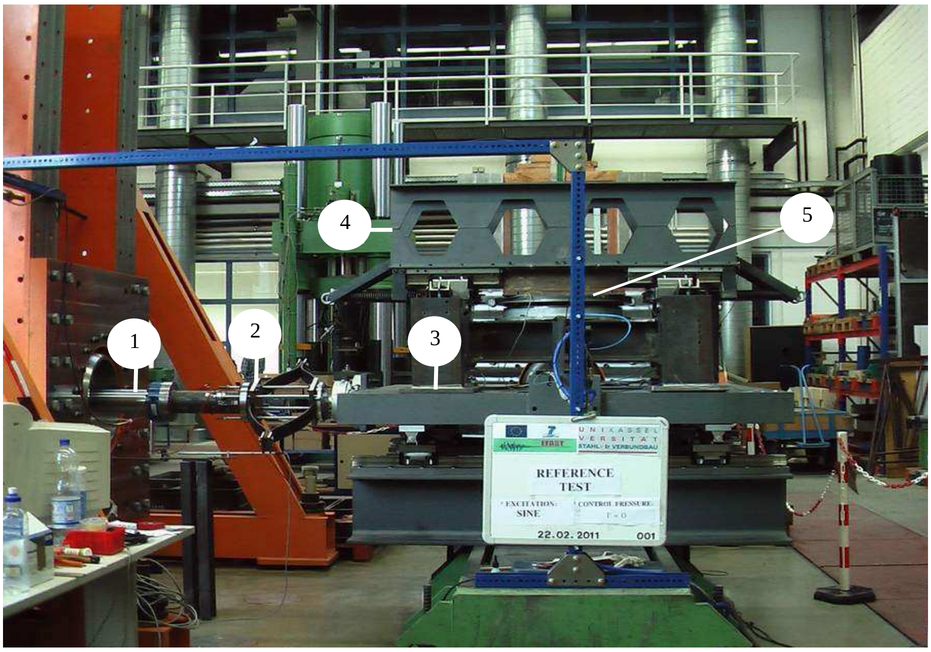


Figure 7. The test setup for reference tests in one direction includes: the hydraulic cylinder (1); the SDOF main structure consisting of the shaking table (3) and leaf spring (2) a TMD (4) and a nonlinear controllable friction device UHYDE-*fbr* **(5).**

UNIKA modified its existing shaking table and TMD. The test system comprising a bi-directional shaking table and a non-linear TMD has been modified for two degrees of freedom (2-DOF) substructure tests. The shaking table has been supplied with a leaf spring in order to use the shaking table as one DOF while the TMD serves as the second DOF (figures 7-8). New multi-directional load cells were designed and used in this test setup. With the new load cells, the interface between shaking table and specimen is represented in high resolution and the coupling force between experimental and numerical parts was reproduced and measured correctly. The constitutive law of the TMD may be adapted by means of a controllable friction device UHYDE-*fbr* (US Patent number 5456047).

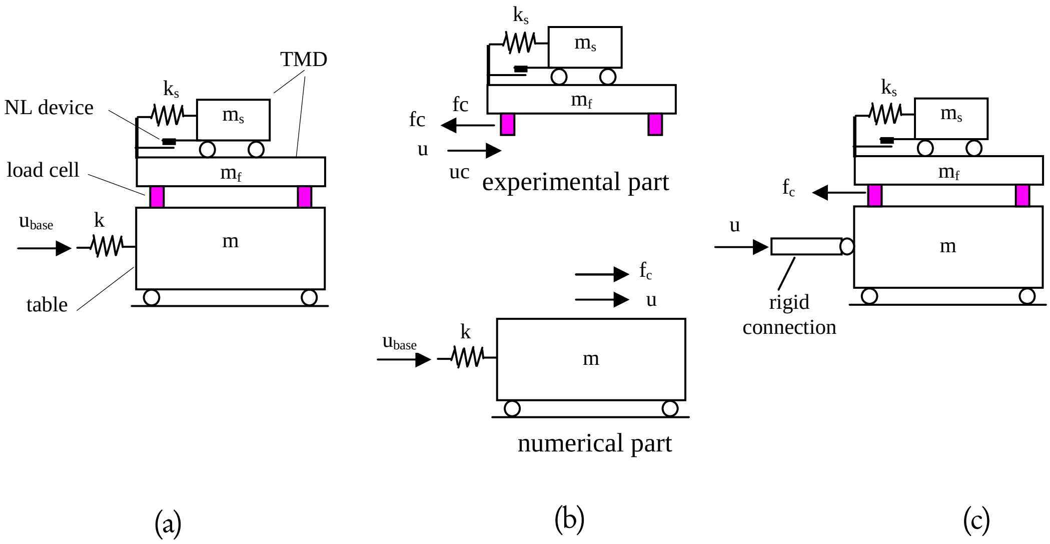


Figure 8. (a) Two-DOF system for reference tests (b) definition of numerical and experimental parts (c) model for substructure tests.

Before carrying out substructure tests of the non-linear TMD using the shaking table, UNIKA performed identification tests to identify the test setup and carried out a series of reference tests for comparison between the response of the substructure tests and their respective references. UNIKA carried out more than 100 substructure tests to investigate the feasibility of the substructure algorithms and error compensation methods developed by UNIKA and the implications of these algorithms in the case of shaking table force real-time substructure testing. The substructure algorithm developed by Dorka was used successfully. The feasibility of the adaptive error force and adaptive phase lag compensations developed by Nguyen and Dorka was tested in real-time substructure testing using the controllable friction device UHYDE-*fbr* to produce different non-linear coupling effects depending on the applied pressure:

- No pressure: linear substructure
- Constant pressure: elastic-plastic coupling
- Pressure increasing or decreasing with displacement: bi-linear plastic coupling
- Sudden drop of pressure: simulated sudden partial failure of coupling
- Pressure depends on velocity: simulated viscous damping in coupling.

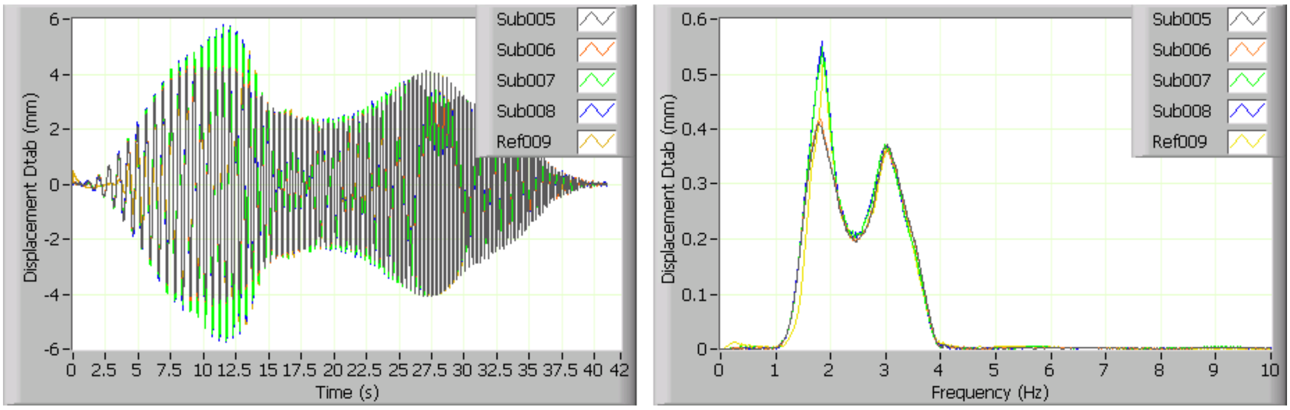


Figure 9. Table displacement in substructure tests compared with reference test (Ref009), linear TMD (pressure p = 0). Substructure tests with k = 4 sub steps and: no error compensation (Sub005), only PID force compensation P = 0.95 (Sub006), only phase lag compensation (n_u = 5, λ = 0.99) (Sub007), both PID force compensation P = 0.95 and phase lag compensation (n_u = 5, λ = 0.99) (Sub008).

For example, figure 9 shows the comparison between substructure test variations and their reference test for the linear TMD (pressure in friction device p = 0). It demonstrates the effectiveness of the various compensation strategies but also highlights the need for phase lag compensation for a hydraulic system with low dynamic capacity.

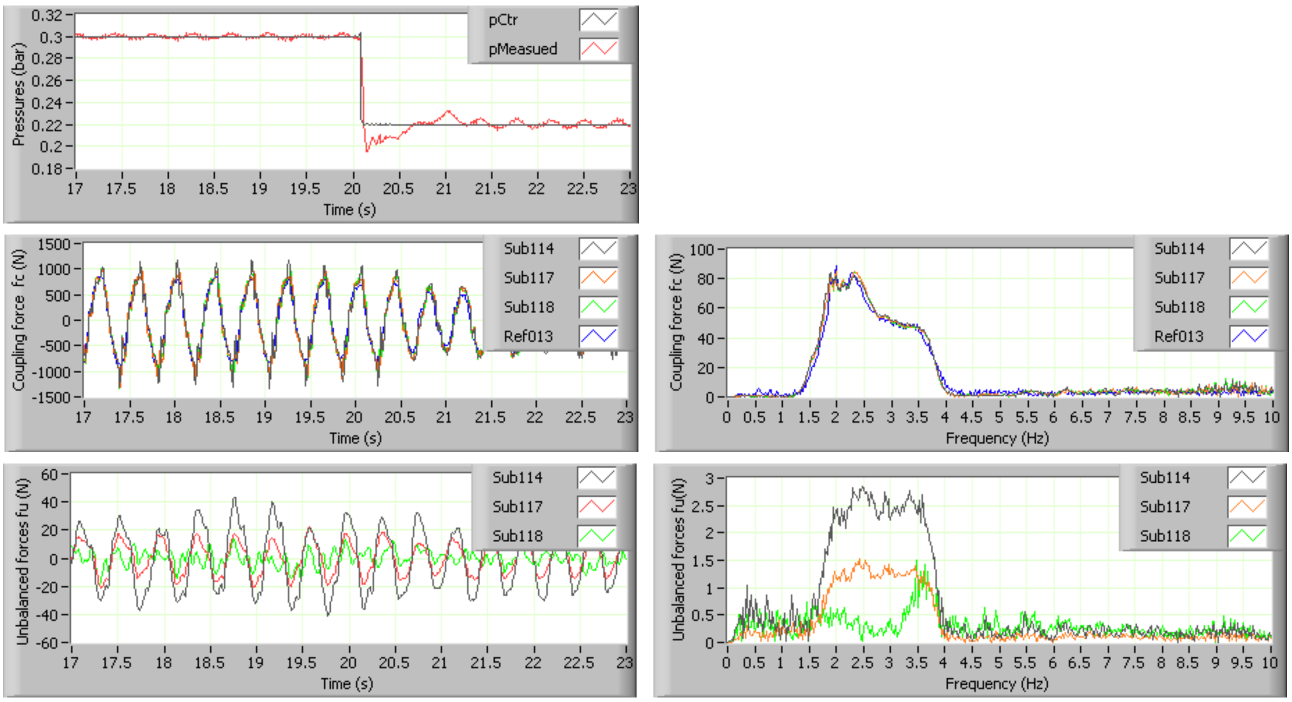


Figure 10. Comparison between substructure tests with k = 4 sub steps for different error force compensations: without compensation (Sub114), with P=0.95 (Sub117) and with adaptive compensation (Sub108, n_u=7, λ=0.99) to their reference test (Ref013) including a drop in pressure from 0.3 bar to 0.22 bar in the Uhyde-fbr friction device at t = 20.08 sec.

In another test with sudden drop pressure, figure 10 shows that force compensation with P = 0.95 (sub117) can slightly reduce error and the adaptive force compensation (Sub118) does reduce significantly the error in the vicinity of the eigenfrequencies of the system (at 1.9 Hz and 3.1 Hz).

Conclusions

1. The substructure algorithm with sub-step control has been tested and the substructure solutions have shown that the algorithm provided very good accuracy and it is stable even in the particular test system with strong coupling and high nonlinearity.

2. Equilibrium errors may occur at the end of the time step, which can destabilize the test. They can be compensated by PID force compensation with a simple proportional gain or an adaptive compensator. The PID force compensation worked effectively and reduced the unbalanced force and thus improved the accuracy of the substructure response.

3. The adaptive force compensation was tested and it can reduce most error force in substructure tests, especially forces in the frequency range of the system (from 2 to 3 Hz). In some tests, although the error in frequency range of the system was well compensated by the adaptive force compensation, certain errors were in the higher frequency range (about 6 to 10 Hz, higher than the frequency range of the system) were large. However, this did not affect the response of the system very much.

4. Phase lag in hydraulic systems, in particular in typical shaking tables used for tests on civil engineering structures, is considerable and it causes large errors in the substructure tests. It may cause instability in other types of substructure tests where small damping is present in the numerical structure.

5. Adaptive phase lag compensation was used to compensate this error and the results show that the phase lag can be compensated efficiently by the newly developed adaptive phase lag compensation which does not work well for linear specimens only, but as these tests have shown, even in the presence of strong and sudden non-linearity. This is important for large hydraulic shaking tables, which all have large phase lag.

6. In light of these results, the new large tables envisioned for E-FAST may well be capable of real-time substructure testing.

c)Tests carried out at CEA

Model of hydraulic actuator

The first task associated to the experiments carried out at CEA/France was to improve the control of actuators through the development and validation of an accurate hydraulic actuator's model. A non-linear model of hydraulic actuators has been developed. The goal is a) the numerical simulation of physical tests and b) a more control of real-time substructure tests by taking into account in the control loop the dynamics of the actuator. The model was validated through its comparison with experimental results for a large range of frequency and various excitation signals. The agreement between the model and the test is very satisfactory in the frequency range 0-30 Hz. Figure 11 shows an example of a time history sample demonstrating the accuracy of the model.

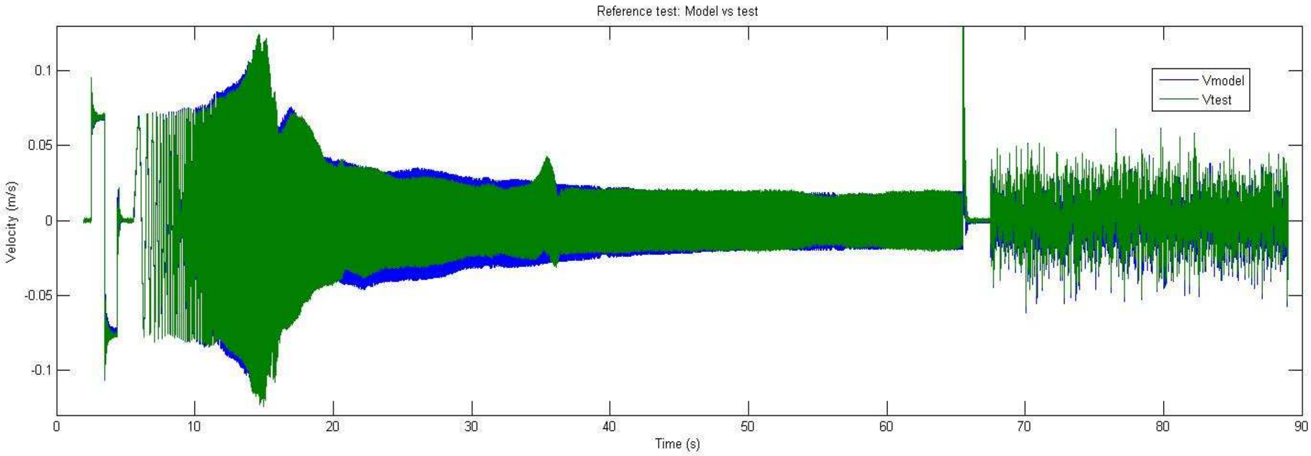


Figure 11. Comparison of the analytical (blue) and experimental (green) response of the actuator.

Real time hybrid tests

The second task was to perform two hybrid tests on a three degree of freedom linear structure (a 2 storey steel fram and an oscillator (tuned mass damper, TMD) with the following substructure configurations:

- TMD as physical part and the 2 storey frame as numerical part.
- The 2 storey frame as physical part and the TMD as numerical part.

Figures 12-13 show the three experimental setups corresponding to the above tests

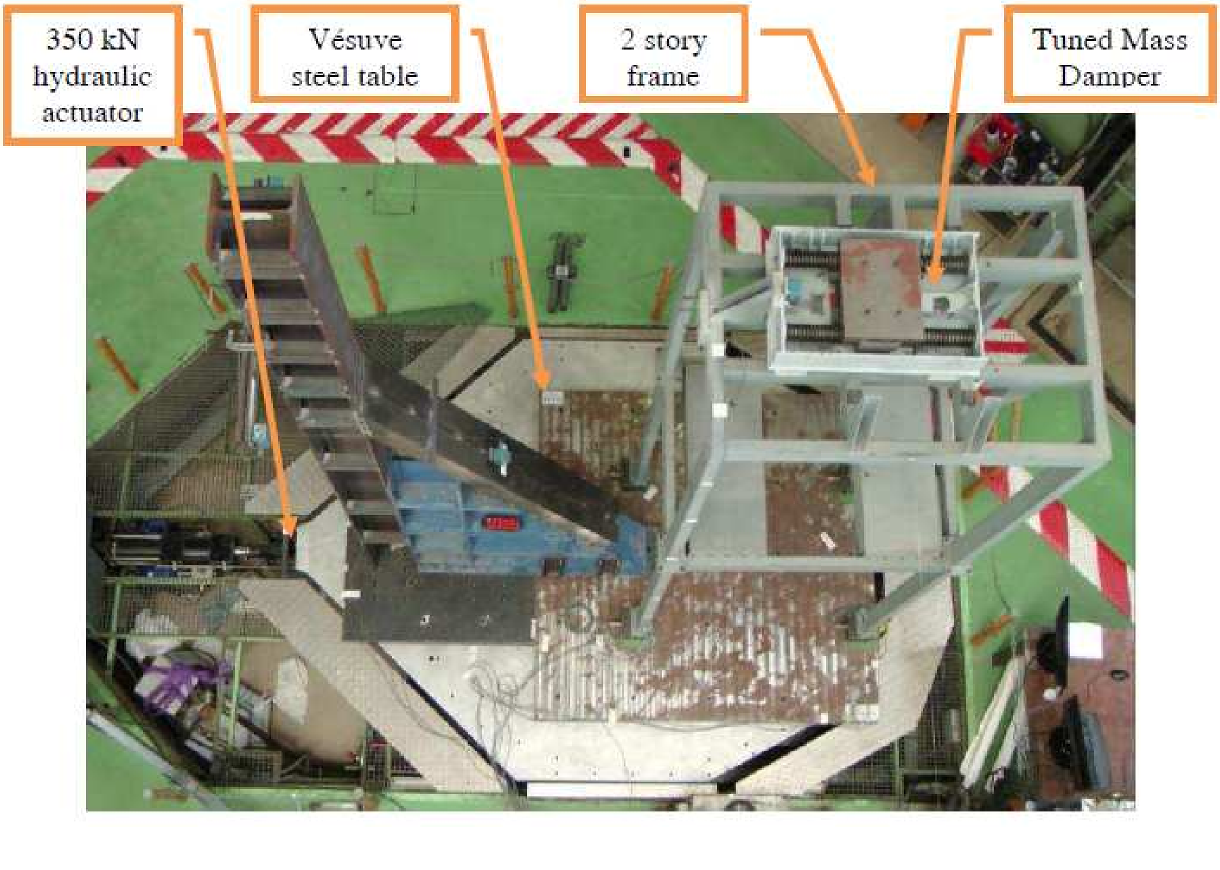


Figure 12. Reference test of the whole system (2storey frame + TMD)

a b

Figure 13. Real time hybrid tests : a) physical substructure TMD (2storey frame simulated) and b) physical substructure 2storey frame (TMD simulated)

For the test shown in Figure 13a (TMD as a phyciscal substructure) a PID displacement control was used. It was observed that stability of the hybrid test was only possible for a narrow range of dynamic control gains. Therefore, Off line tuning should be an important step of a hybrid test procedure. Figure 14 shows that the results of the hybrid tests do not fit very well the results of the reference test. Further work is needed to improove the hybrid test.

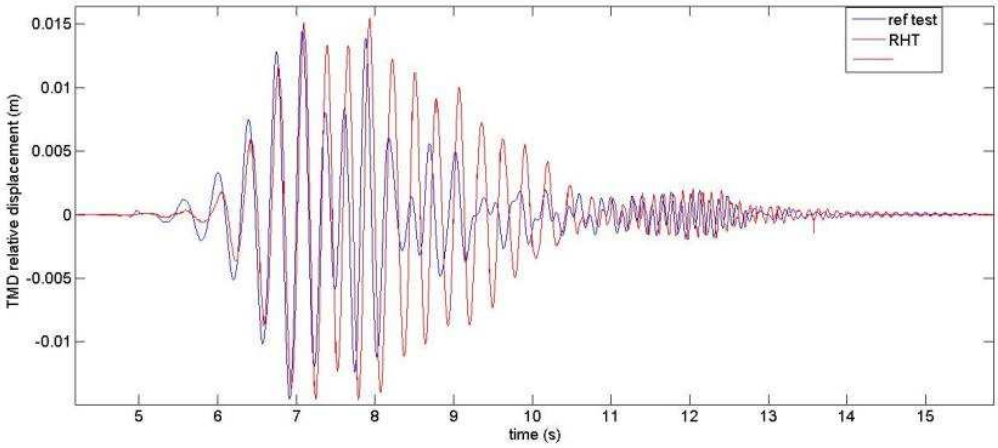


Figure 14. TMD displacement of the reference test and of the substructure test (TMD as a physical substructure)

For the test shown in Figure 13b (2storey frame as a phyciscal substructure) a PID force control was used. It was observed that the tuning of the gains was much easier than in the previous case. The results in Figure 15 demonstrate an excellent agreement between the reference test of the whole system and the hybrid test.

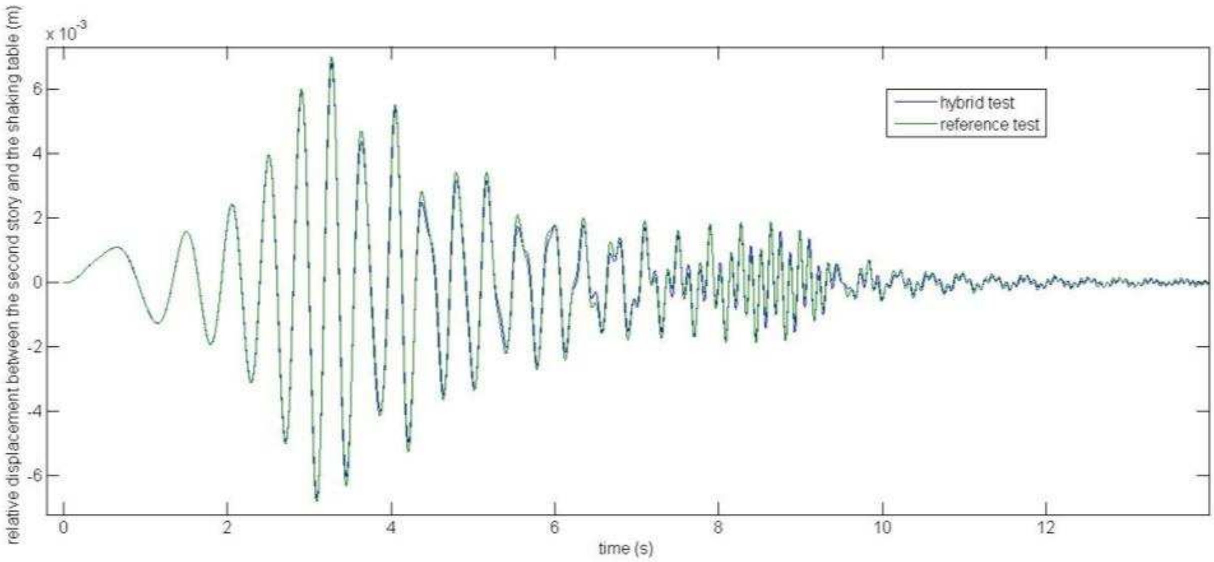


Figure 15. 2nd storey displacement of the reference test and of the substructure test (2storey steel frame as a physical substructure)

4.1.3.5 Annex II: Telepresence room

One of the important issues which ensure the virtual dissemination of any advanced laboratory specialized in research and studies in earthquakes engineering is the issue of Telepresence, nowadays developed in some advanced laboratories, especially, in USA and Japan.

We have proposed in our research studies a "display wall" where each display or group of displays will have a dedicated purpose. Due to the importance of the experiment itself the idea will be to place the displays related to it in the center and the displays for the Telepresence at margin. Table 2 is shows the basic concept we used in our studies for designing Telepresence in EFAST project.

Table 2. The display wall

Classic HD Telepresence	Local Sensor data	Local Simulation result	Classic HD Telepresence
Classic HD Telepresence	Local Input data	Local experiment Video streams	Classic HD Telepresence
Low quality Telepresence	Platform control set	Platform data	Low quality Telepresence
Multiple Remote Sensor data	Remote experiment video streams	Remote desktop	Active Collaboration tool

Figure 16 presents a configuration with keyboards on the table. There are 1U rack specific keyboard and monitor units that are hidden in table and that can be opened as required. All supplementary devices like KVM switches, keyboard cable length extenders or echo cancelation units are placed under the table.

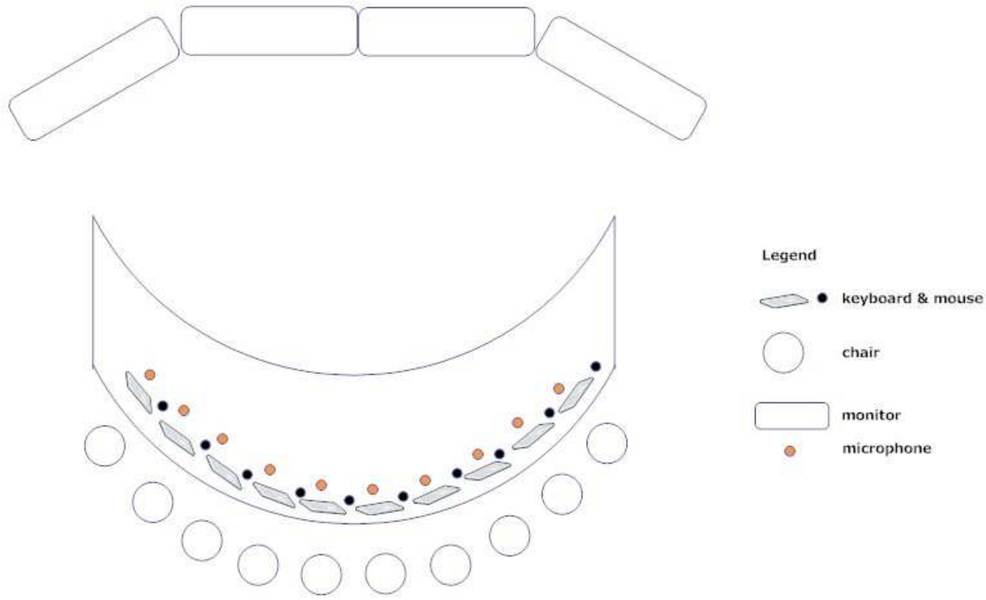


Figure 16. Telepresence room - upper view

After market analysis and considering the proposed technical solutions by other EE laboratories, the following technical data resulted for Telepresence system within the structure presented in Figure 17.

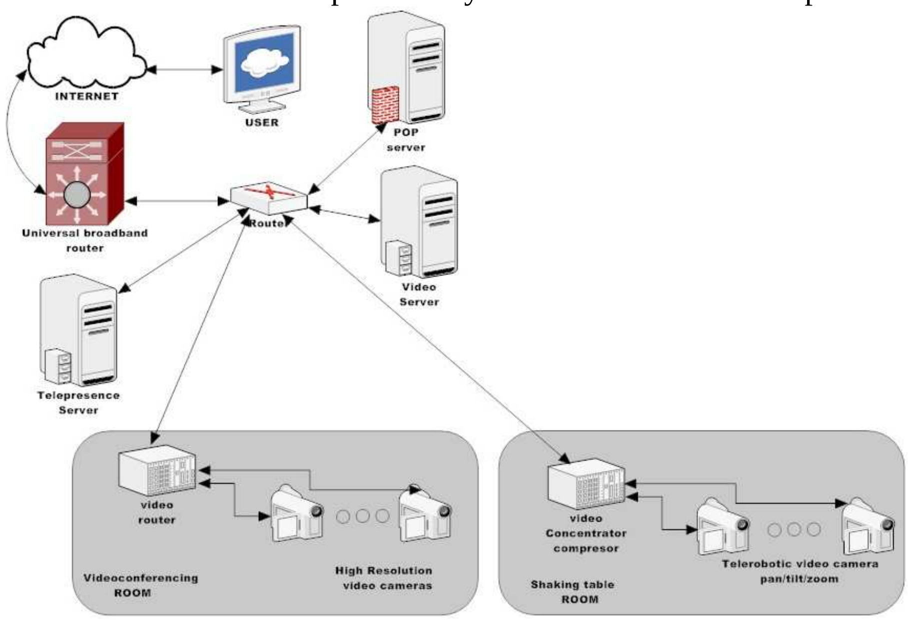


Figure 17. EFAST Telepresence system structure

For EFAST the following minimal video structure is required due to the large dimensions of the laboratory itself:
4 – high quality high speed cameras for the specimen;
8 – high quality PTZ cameras for the specimen;
4 – high quality PTZ cameras for videoconference component;
Other type of advanced video related specimen analysis (e.g. using laser based measurement systems or techniques based on pattern recognition).

For the Telepresence room a HD quality solution must be elected. Due to the complexity of input design requirements the solution must be custom. In any combination this approach will further increase the basic costs. Nowadays, even 3D holography systems are available in the market the simulation software used by the earthquake engineering community is not yet prepared to interface it. The cost of HD Telepresence system is high if we take into account the network hardware. If a medium quality Telepresence solution is selected, the costs will dramatically decrease.

4.1.4 Impact

The medium to long term impact of a new advanced seismic testing facility in Europe will be mainly the reduction of the seismic vulnerability. This will promote sustainable economic development of Europe's seismic regions, but also of the entire Europe, through savings on the total financial loss due to future earthquakes, to be shared by all EU member states, rich or poor, seismic or not.

Actually, Europe as a whole, including Turkey, has about the same overall seismicity as the USA or Japan. Among the about 490 million of European inhabitants, more than 20 million (4% of the total) live in high seismicity areas and another 44 million (9% of the total) in moderate seismicity ones. If Turkey and the Western Balkans are included, 41 million (7% of the total population of about 580 million) live in high seismicity and 64 million (11% of the total) in moderate seismicity areas. In the last two decades of the 20th century earthquakes caused about 5000 casualties in the EU (4500 of them in Italy) and about 19000 in Turkey alone. The total 20-year toll should be contrasted to that of about 5600 in Japan and just 130 in the US. During the 20th century earthquakes inflicted a total monetary loss estimated to $58 billion in Europe, $200 billion in the whole of Asia (most of it in Japan) and $46 billion in the Americas.
Regarding Europe and the neighboring countries, the earthquake disasters of 1980 in Irpinia (Italy), 1999 in Izmit (Turkey), 1999 in Athens (Greece) and 1989 in Spitak (Armenia) are among the most costly ones in history. As an example, only the 17 August 1999 Izmit, Turkey, earthquake caused over 18,373 deaths with injuries to another 48,901 people and destruction of immense proportions. There were reported 93,000 housing units destroyed and another 15,000 small business unites badly damaged. More recently the L'Aquila (Italy) 2009 earthquake had a considerable social and economical impact. The earthquake's life toll climbed up to 305 fatalities and thousands of injuries. There were displaced up to 25000 people and the number of damaged buildings in the region of L'Aquila raised up to 10000 buildings. The overall total costs of the L'Aquila earthquake, including financial losses and reconstruction costs could rise up to € 16 billion.
As urbanization increases fast in the very seismic areas of Northwestern Turkey and Southeastern Romania, the seismic risk in Europe will increase unless corrective and/or predictive measures are implemented. Keeping in mind that the most seismic parts of Europe (from West to East: Portugal, Southern Italy, the Balkans, Greece and Turkey) are also those having the longest road to convergence with the rest of Europe, an earthquake disaster in any of these economically more fragile areas will be a major setback in their course to convergence and may require the EU as a whole to foot part of the bill.

In general, the impact of severe earthquake events is related to:

a)Direct Economic Losses

In most cases, the direct economic losses are the most significant in terms of total loss from an earthquake disaster, mainly due to the damage of buildings and infrastructure. This may also be the type of earthquake economic impact easiest to measure due to the nature of the losses and to the fact that most of the buildings implicated have some sort of measurement method for the losses incurred

(e.g. government statistics, private companies specialized in damages evaluation, insurance companies). These parties may also be combined for most cases.
This type of economic losses includes:

- Structural damage;
- Non-structural damage;
- Damages to building contents and inventory;
- Costs due to the shutting down of the building due to maintenance (e.g. relocation costs, lost rental income, lost wages, lost income).

The types of infrastructure involved in this section of economic losses are:

- Transportation infrastructure (highways, roadways, airports, ports, light and heavy rail, buses, ferries;
- Utilities damage (electric power, water, wastewater, communications, oil, natural gas).

The previously mentioned costs may also be increased due to revenue losses associated with outages, costs associated with providing backup services and possible fines for unavailability towards users.

b)Human Impact

Perhaps the most important from a society point of view, the human impact may be major in the event of a catastrophic earthquake, both in terms of direct losses and injuries (or *casualties*) and in terms of the long-term social and economic impact. The following situations may imply:

- Loss of human lifes
- Shelter (long-term and short-term);
- Quality of life issues;
- Healthcare and long-term mental impact;
- Unemployment.

This range of economic issues may also be increased by the loss of the *social capital*. This term has been used when referring to the ties that an individual or community has with that certain place which was affected by the earthquake. These ties may be:

- Friendships;
- Professional relationships;
- An internal sense of stability.

c)Emergency Response and Recovery Costs

In a normal earthquake scenario, these costs may include:

- First-responder costs (personnel costs, including overtime) encompassing search and rescue, fire fighting, emergency medical services; police security at damage sites;
- Service costs related to building damage, including post-earthquake building safety inspections (e.g., safety-tagging), emergency shoring and demolition, and debris removal.

In addition, measures including loans from the government, private insurance policies, grants etc. must be activated to contain the disaster.

d) Business Interruption and Other Economic Losses

The economic impact for businesses may become the most important part of recovering from an earthquake. The property damages, human casualties and the interruption of business activities may damage the economic environment consistently. For example, direct business interruption can result from building or equipment damage, utility outage, lack of employees (due to injury, displacement, or transportation interruption), or supplier interruption. These problems also lead to more cascading problems, due to the interruption of services, cancellation of previous orders from clients affected by the earthquake and the fact that employees affected by this may work less or less productively. Indirect or secondary losses are those incurred in the days, weeks, or months following a disaster and include losses due to business interruption caused by infrastructure disruption (e.g., electric power, gas, water), reduction of critical services to residents in hazard-prone areas, and psychological trauma. As an example, after the Niigata Cheuetsu-Oki earthquake (Japan, 2007) ,the Riken manufacturing company, one of the largest parts suppliers to major Japanese automaker, including Toyota and Honda, was shut down for two weeks because of non-structural damage to equipment. Toyota alone lost production of more than 120,000 cars in the first weeks after the earthquake. In addition, the Kashiwazaki-Kariwa nuclear power plant, which is the largest in the world, stopped completely its production for two years.

EFAST will contribute to reduce all the above losses. Earthquake risk mitigation will be achieved through improvements of knowledge in earthquake engineering. In fact, progress in earthquake engineering cannot be made without experimental research on large scale models whose behavior is similar to that of real structures. This new, advanced, versatile, high capacity experimental facility, which will be unique in Europe and one of the most important seismic testing facilities worldwide, will allow the European earthquake engineering community to make significant progress in R&D and will have considerable impact on the state of the art and the practice of aseismic design and construction methods and technology. In fact, the advanced experimental capacities of EFAST will result in:

- A further insight into the earthquake response behavior of structures, in general;

- The improvement of the numerical simulation tools via their validation with the experimental results. Although there is a tremendous evolution of the analysis tools, there is still a lot of work to be done regarding their capacity to reproduce the behavior of complex structures at a realistic scale and under realistic dynamic loading;

- The improvement and validation of regulations and recommendations. Actually it is widely admitted and confirmed by the feedback from past earthquakes that the role of design and construction codes is of paramount importance for the aseismic protection of human life and structures. Eurocodes are an important step towards this direction but, as recognized at the 1st international EFAST workshop, there are still several aspects which need to be completed and/or validated;

- Safer design and qualification of industrial structures and equipment, especially those of nuclear and chemical industry. To this aspect, it is worth noting that the involvement of Europe in nuclear industry is twofold. Actually, some European countries run a large number of nuclear power plants and at the same time European companies are word leaders in the design and construction of nuclear power plants. The EFAST facility will be able to carry out tests of structures and equipment for R&D and qualification purposes. In fact, special attention was given in the design so that the new facility will be able to test not only “classical” civil engineering structures but other kinds of structures and equipment also. This will be possible thanks to the high acceleration capacities of the tables (which enables to take into account floor response amplification), the 3-dimensionnal excitation capability, the multi-support excitation capabilities (e.g. tests of equipment such as pipes, crane bridges etc.), the large displacement capability (which avoids filtering of low frequencies) and the large operational frequency bandwidth;

- The development and validation of new construction methods, materials and devices which will improve the protection level of structures against earthquakes and lead to a better performance/cost ratio of aseismic structures;

- The support of European companies through the aforementioned validation of new technologies and design concepts. The R&D and qualification tests related to the activities of European companies will gain them with international prestige thus contributing to their export policy. EFAST will secure and enhance the competitive edge that European construction firms and engineering services currently hold in overseas seismic markets, by establishing Europe as a world leader in earthquake engineering research;

- Demonstration tests for policy makers and dissemination purposes. The benefit from such demonstration tests is well understood in the US and especially in Japan. The high capacities of EFAST will enable carrying out tests of realistic models which have considerable effects on public awareness;

- A “natural” excellence centre for advanced knowledge in earthquake engineering through training, transnational access and dissemination. Within the framework of national and international collaborations EFAST will be a crossroads for exchanging ideas and training on experimental earthquake engineering and in earthquake engineering in general. It will also promote, through networking and distributed databases, a wider sharing of data and knowledge across the field of earthquake engineering and between academia, research and industry.

4.2 Use and dissemination of foreground

- **Section A**

During the project period several dissemination activities were undertaken. An inquiry was sent to three target groups of current or potential users of earthquake experimental facilities. The target groups include research laboratories, industry (mainly nuclear industry companies and institutions) and construction companies. Two international workshops (March 2-3, Ispra, Italy and June 29-30, 2011, Ispra, Italy) and one international conference on experimental techniques (4th conference on Advanced Structural Experimental Engineering, June 29-30, 2011, Ispra, Italy) were organized. These events were addressed not only to academia but also to industry and companies involved in the design and construction of aseismic structures.

The public project website area is updated and information on events such as the workshops organized within the project is available. Videos of real time hybrid tests carried out during the project are also available in the website. The reports which are not confidential are also available. An open forum area where visitors may make suggestions on seismic tests and exchange between them and the partners of the project has been added. An on line demonstration tool of shaking table tests has been developed and is accessible to the web site visitors.

The project partners participated in several conferences where they presented the design characteristics of the new facility and their results on advanced experimental techniques. The list of these dissemination activities was submitted on line via the reporting web tool of the European Commission.

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Section A (public)

This section includes two templates

- Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[2] (if available)	Is/Will open access[3] provided to this publication?
1	*Economic transformation in Hungary and Poland'*		*European Economy*	*No 43, March 1990*	*Office for Official Publications of the European Communities*	*Luxembourg*	*1990*	*pp. 151 - 167*		yes/no
2										
3										

[2] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[3] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[4]	Main leader	Title	Date	Place	Type of audience[5]	Size of audience	Countries addressed
1	*Conference*		*European Conference on Nanotechnologies*	*26 February 2010*				
2								
3								

[4] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[5] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

- **Section B**

The EFAST project is a design study project and not a pure R&D project. Therefore, except making progress in real time hybrid testing, innovation and/or adoption of "revolutionary" technology and techniques was not an objective for EFAST. In fact, as already mentioned, the choice of well validated (by their operational use in existing advanced facilities) technological solutions is imposed because of safety reasons and also to minimize the techno-economic risk. This will make the project of a new seismic testing facility more attractive for potential investors and users. Therefore there has not been new knowledge production (e.g. prototypes, patents etc.) within EFAST.

The main foreground is the preliminary design study of a new European world class facility for seismic testing. In particular, amongst others, the outcome of this design study includes:

- performance criteria for the new facility
- a proposal of the laboratory lay-out
- functional specifications
- the preliminary design of the main components of this facility (reaction mass, hydraulic system, shake tables, reaction system, telepresence, web portal, etc.)
- drawings of the proposed configuration
- safety analysis
- preliminary risk analysis
- cost estimate (construction, operational, access costs)
- detailed design and construction schedule
- criteria for the host site

The outcome of the preliminary design study contains the necessary information which may allow policy makers to make a decision regarding the next phase which would be the detailed study and the construction of the facility. To this end and to influence positively the policy makers and potential investors it would be better if the project is included in the ESFRI roadmap of research infrastructures. In fact this would give more visibility to the project and would be an acknowledgement of the quality of the project and of its positive economic and social impact. However, during the duration the project, there has not been any planned update of the ESFRI roadmap, and nothing was known about the procedure to be followed and the documents to be provided in the case of a new update, if any. Nevertheless, a draft report dealing with the scientific case (i.e current needs and expected scientific benefice) as well as with the expected socio-economic impact was prepared. It may be used at any future time if there is a call for an update of the ESFRI and/or national roadmaps.

The important steps towards the construction of the new experimental facility are:

- To obtain the maximum benefit from such an advanced experimental laboratory, the facility should be integrated in a research centre/institute which will study all aspects (theoretical, numerical, experimental) related to earthquake engineering. It is desirable that several partners, not only from academia but from industry also, participate in this research centre. The complementarity between partners will result in a) the determination of a consistent mid-term and long-term common research strategy for earthquake risk mitigation b) significant scientific and technical progress thanks to the joint efforts and c) a higher prestige and higher degree of confidence of private and/or public investors (during the process of financial negotiations) as well as of external users and customers. This research centre could be an existing research centre or a new joint research unit. In the case a new research centre is created, a phase of contacts, exchanges and negotiations will take place between possible partners. In particular the role of each partner, his technical, scientific and financial contribution and the governance rules must be determined.

- Before launching the detailed study and the construction of the facility a decision has to be made by the policy makers; Of course, this decision depends on the possibility to collect the necessary funds to finance the project. Therefore a round of presentations of the project to potential investors and policy makers public or private must be undertaken to explore their interest to participate in the financing of the new facility. The targets of this communication are institutions and companies either involved in the aforementioned research centre of external to it.
- Once a group of potential investors/shareholders willing to collect the necessary funds, corresponding to the cost estimated during the preliminary design study, is identified, a phase of negotiations will follow with iterations between their financial contribution and the governance rules of the new facility. If the new facility is fully integrated in the above research centre provision about the governance of the experimental facility will be made in the governance rules of the whole research centre.
- Once the consortium synthesis and rules are determined and the financing of the project is warranted, the decision can be made to launch the detailed design and construction phases

4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	212109
Title of Project:	Design Study of a European Facility for Advanced Seismic Testing
Name and Title of Coordinator:	Ioannis Politopoulos

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***no***
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	

• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE	
• Research having direct military use	
• Research having the potential for terrorist abuse	

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		1
Work package leaders	1	4
Experienced researchers (i.e. PhD holders)	1	11
PhD Students		7
Other	2	2

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**2**
Of which, indicate the number of men:	2

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	○ x	Yes No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○
○ Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

x No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

x No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

x No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[6]: 2

○ Associated discipline[6]:2.1 | ○ Associated discipline[6]:2.2

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ x	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

○ Yes- in determining what research should be performed

○ Yes - in implementing the research

○ Yes, in communicating /disseminating / using the results of the project

[6] Insert number from list below (Frascati Manual).

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

x No

○ Yes- in framing the research agenda

○ Yes - in implementing the research agenda

○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)

x Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)

○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid	 x	Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	 x

13c If Yes, at which level? ○ Local / regional levels x National level x European level x International level	

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**4**
To how many of these is open access[7] provided?	**0**
How many of these are published in open access journals?	
How many of these are published in open repositories?	
To how many of these is open access not provided?	**4**
Please check all applicable reasons for not providing open access:	
x publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[8]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	

17. How many spin-off companies were created / are planned as a direct result of the project?	
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	x	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:* *8.7*

[7] Open Access is defined as free of charge access for anyone via Internet.
[8] For instance: classification for security project.

Difficult to estimate / not possible to quantify	❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes x No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes x No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

❑	Press Release	x	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	x	Website for the general public / internet
❑	DVD /Film /Multimedia	❑	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	x	English
❑	Other language(s)		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]