FP7 Project on Multifunctional Reusable Components for Atmospheric Re-entry "SMARTEES": Project Kick-off

J. Barcena[1], C. Badini[2], S. Gianella[3], V. Liedtke[4], K. Mergia[5], A. Ortona[6] and C. Wilhelmi[7]

[1]Tecnalia (Spain), [2] Politecnico di Torino (Italy), [3] Erbicol (Switzerland), [4] Aerospace & Advanced Composites (Austria), [5] National Center for Scientific Research "Demokritos" (Greece) [6] SUPSI (Switzerland), [7] EADS (Germany)

3rd INTERNATIONAL ARA DAYS CONFERENCE

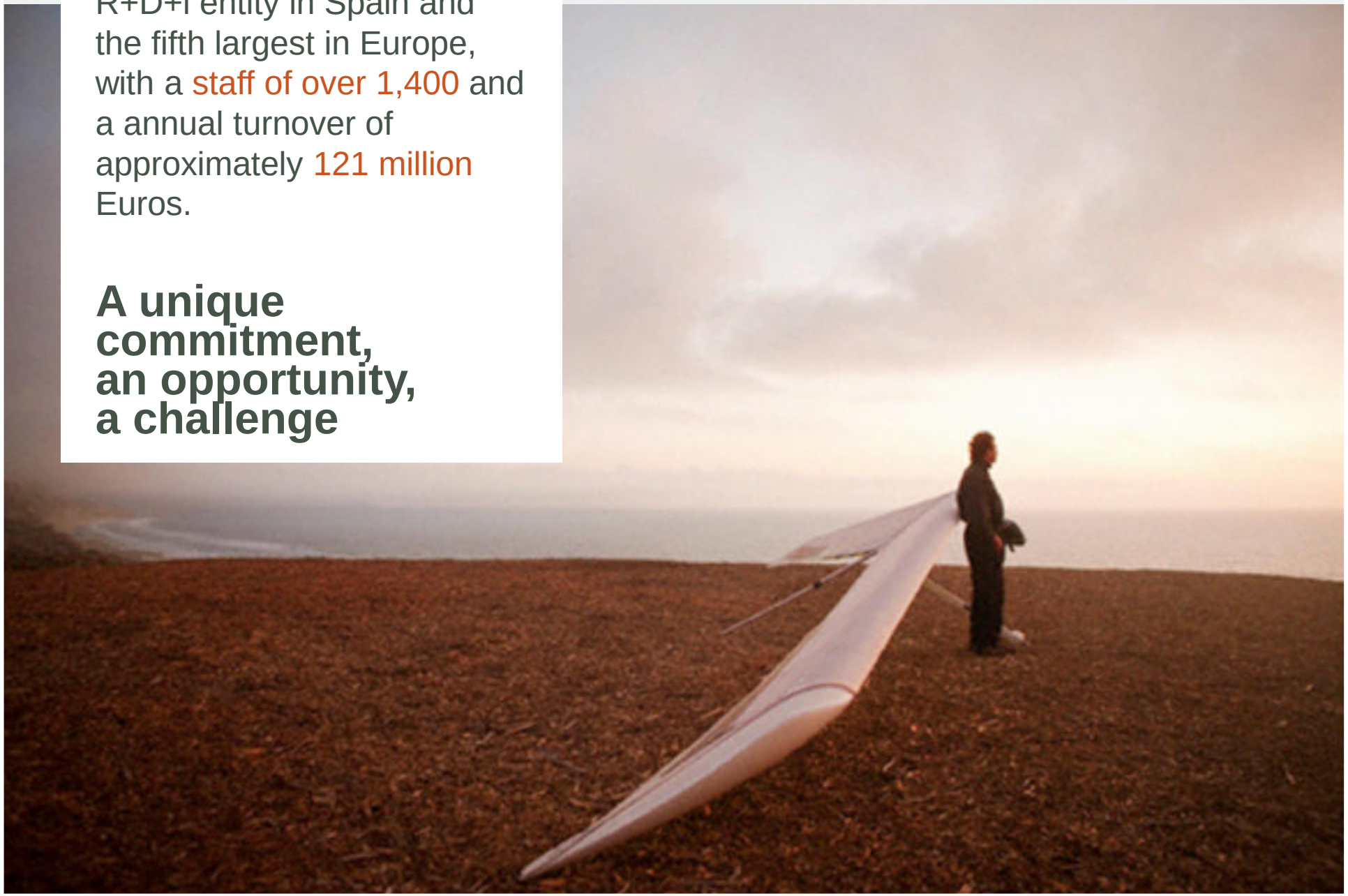
3RD INTERNATIONAL ARA DAYS
2011, May 2-4 – Arcachon – France

OUTLINE

- TECNALIA INTRODUCTION
- MOTIVATION OF THE WORK
- FP7 CALL & PROPOSAL EVALUATION RESULTS
- CONSORTIUM
- CONCEPT OF THE PROJECT
- OBJECTIVES
- WORKPACKAGES
- SCHEDULE

We are the leading private R+D+i entity in Spain and the fifth largest in Europe, with a staff of over 1,400 and a annual turnover of approximately 121 million Euros.

A unique commitment, an opportunity, a challenge



Tecnalia means people

1,437 ..... Staff members

26 ..... Workshops / Laboratories

3.796 ..... Clients

164 ..... PhDs

Creating ideas, creating wealth

53 patents filed

11 granted

3 licenced

1M € income from licences

Share participation in 31 NTBCs.

VII Framework Programme European Projects TECNALIA

150 ..... Projects approved

24 ..... Projects led

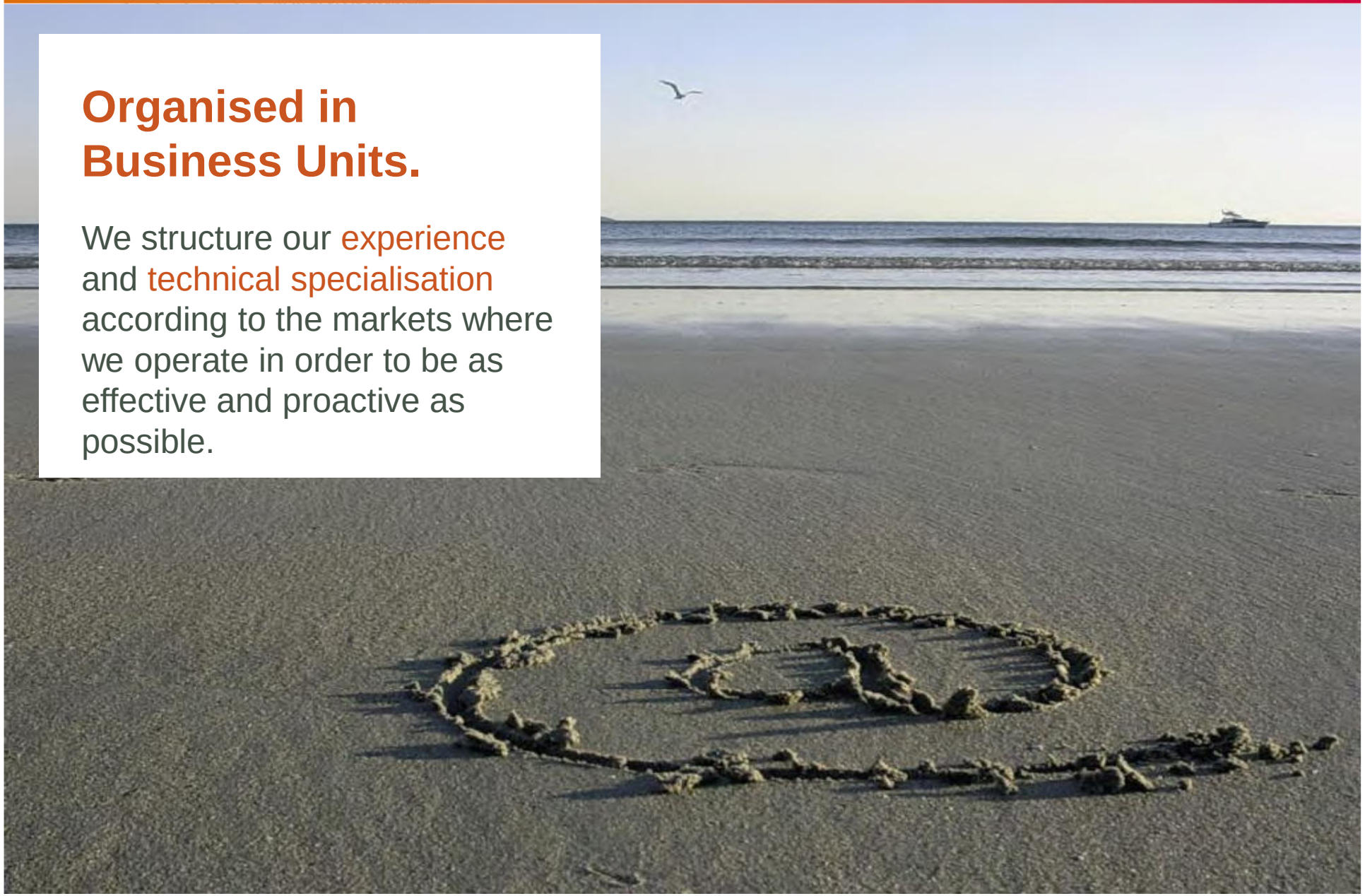
44 ..... million Euros in total income

Tecnalia is Spain's leading private entity in terms of FP7 income.

TECNALIA manages an office to support companies with their European and International projects (OPEI)

Organised in Business Units.

We structure our experience and technical specialisation according to the markets where we operate in order to be as effective and proactive as possible.



SUSTAINABLE DEVELOPMENT

Construction
Energy
Enviroment

INDUSTRY AND TRANSPORT

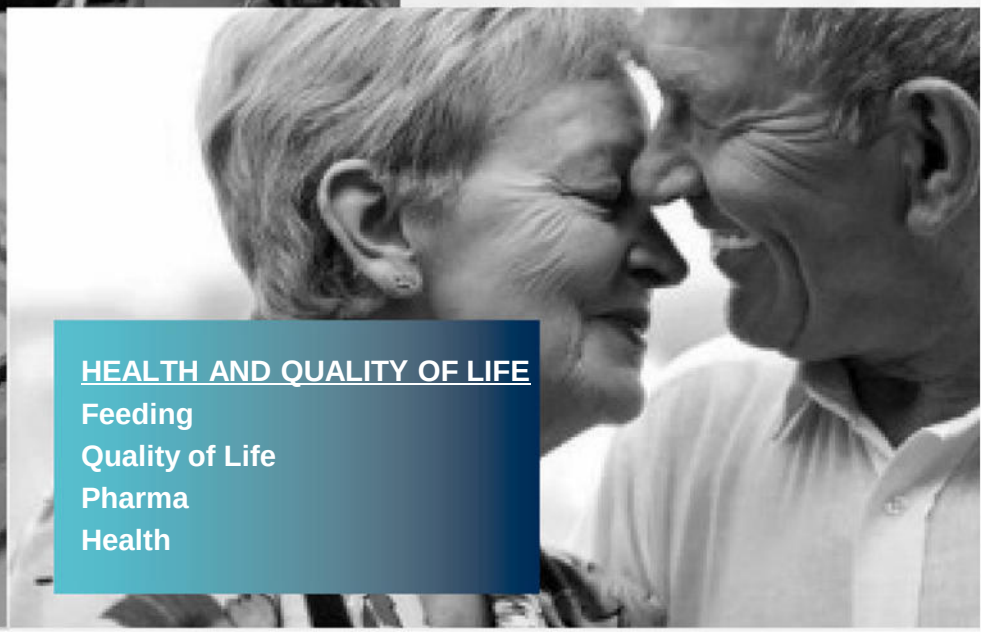
Casting and Iron & Steel
Industrial Systems
Transport

INNOVATION AND SOCIETY

Innovation Systems

ICT / EUROPEAN SOFTWARE INSTITUTE

Media
Information and Interaction Systems
Information Society
Software System Engineering
Telecom



HEALTH AND QUALITY OF LIFE

Feeding
Quality of Life
Pharma
Health

tecnalia Inspiring Business

TRANSPORT UNIT: Facts and Figures

Who we are

Sectorial Business Unit of TECNALIA focusing its Technological Development and Services Offer to Meet the Main Demands of the Transport Sectors.

What we do

Complete Product and Manufacturing Processes Development to meet Customers' Requirements with more Flexible, Robust and Integral Manufacturing Solutions.

Targeted Market Segments

- Automotive
- Aerospace
- Railway
- Shipbuilding

TRANSPORT UNIT: Location

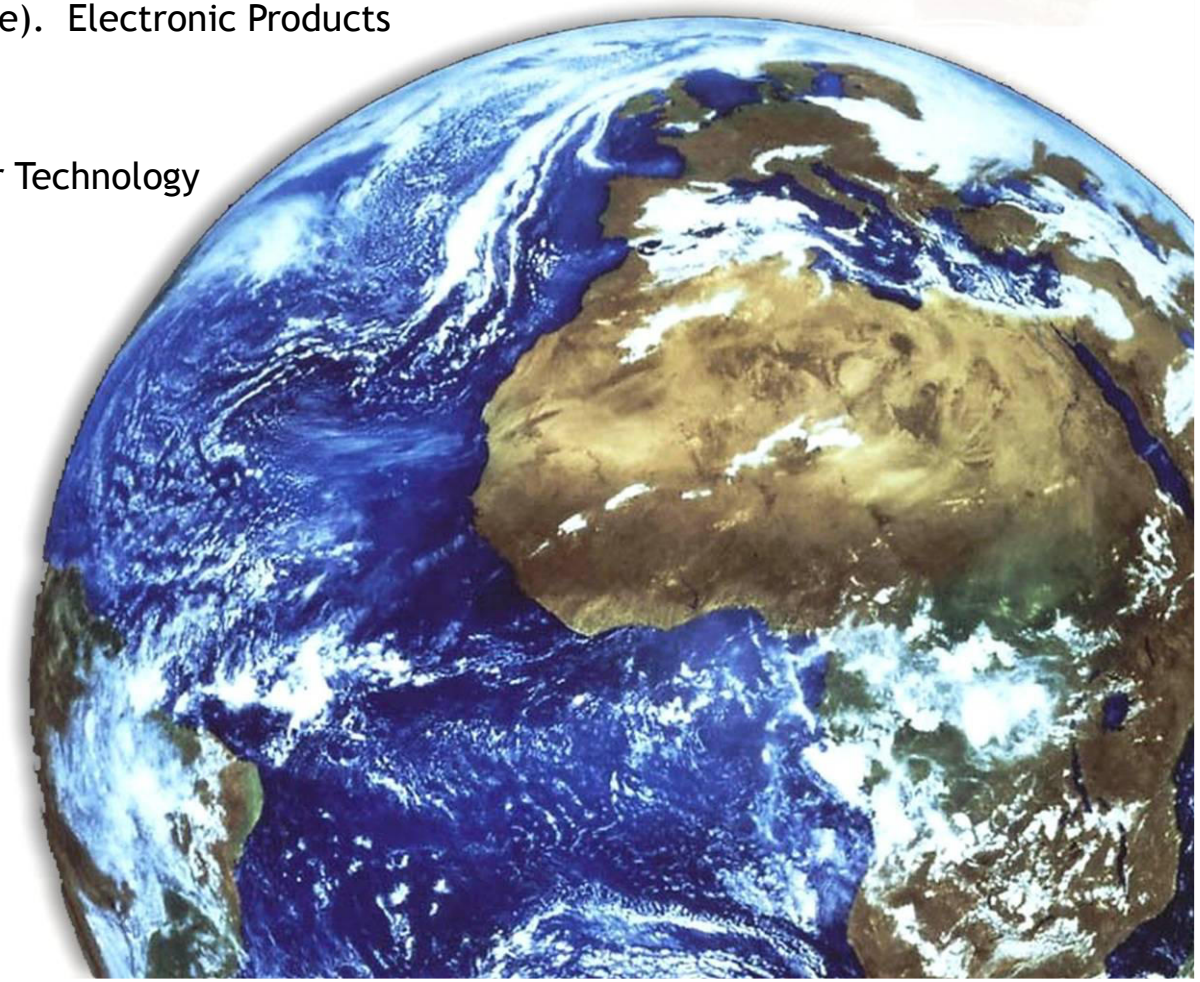
DERIO. Forming
ZAMUDIO. Intelligent Manufacturing Systems
BOROA (Automotive Intelligence Centre). Electronic Products

SAN SEBASTIAN.

- Functional Materials & Powder Technology
- Plastics & Composites
- Product Engineering

IRUN. Pilot Plants

- Surface Engineering
- Casting



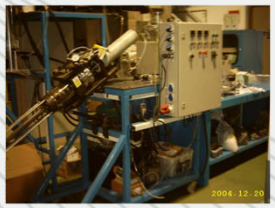
TRANSPORT UNIT: Facilities & Technological Areas. Functional Materials

SAN SEBASTIAN
Miramón Technology Park

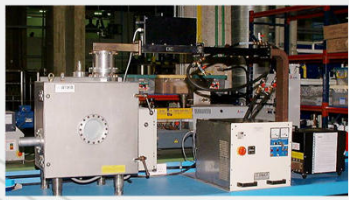
Main Research Areas

- Thermal Management
- Materials for Extreme Environments
- Sensors and Actuators
- Space Electrical Propulsion
- Heating and Dielectric Heating

Hot Press



Powder Extrusion



Microwave Furnace

Sintering Furnaces

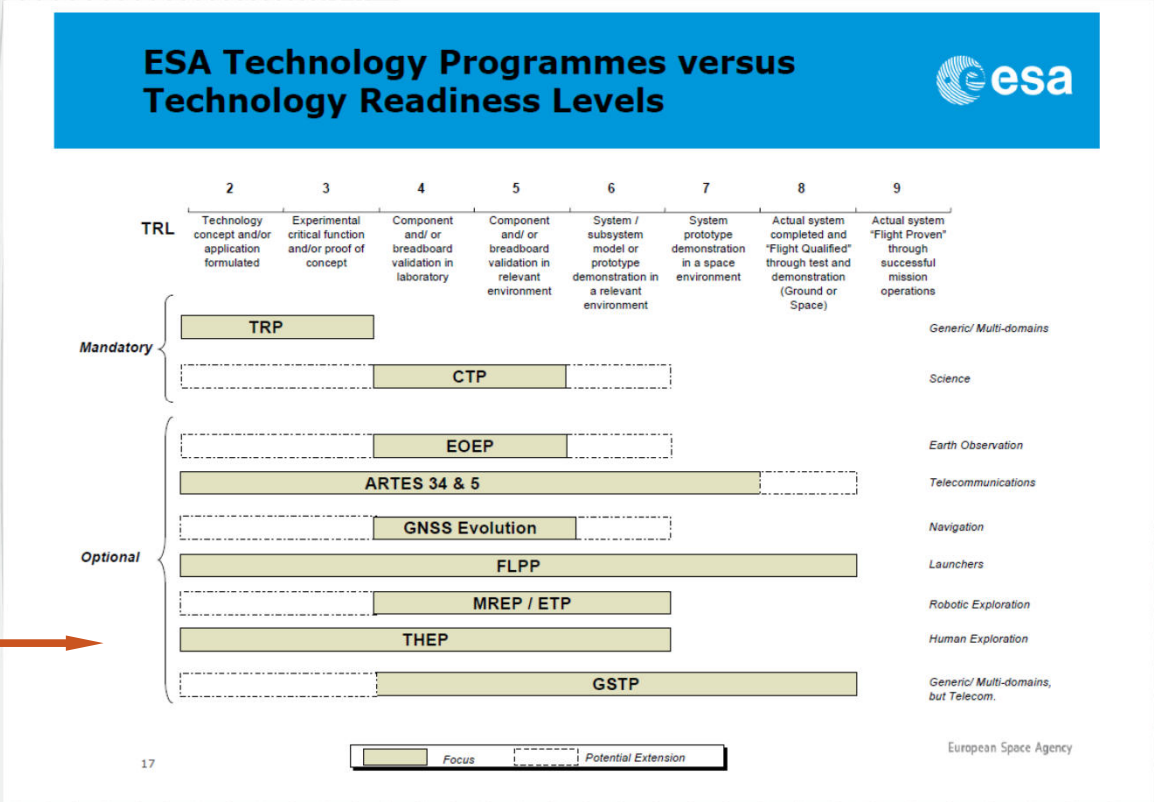
Vacuum Hot Press

Hot Structures_TPS Programs-projects

- IMC Hot Structures- RLV
- GammaTiAl testing FESTIP/X-38
- Smart TPS- EVEREST
- FLPP TPS & System engineering- RLV
- FLPP TPS & Hot Structures-RLV
- SHS Intermetallic Gamma TiAl –complex parts . A5 Vulcain turbine.
- EXPERT- IMC based TPS experiment on Reentry Capsule
- FLPP2-IXV smart tps intermetallic sandwich
- EXTREMAT CSIC-PM1000 integration
- Plansan materials vs PM2000. Development and characterization program. ESA TRP.

MOTIVATION OF THE WORK

- **Future space transportation**, equipped with re-usable components will greatly **reduce the cost of launching a payload into space**. This issue is of great importance, i.e. ESA technology strategy and long term plan 2009, clearly identifies the need of advanced TPS for space transportation and planetary entry, particularly framed on the Transportation and Human Exploration Preparation Programme (THEP).

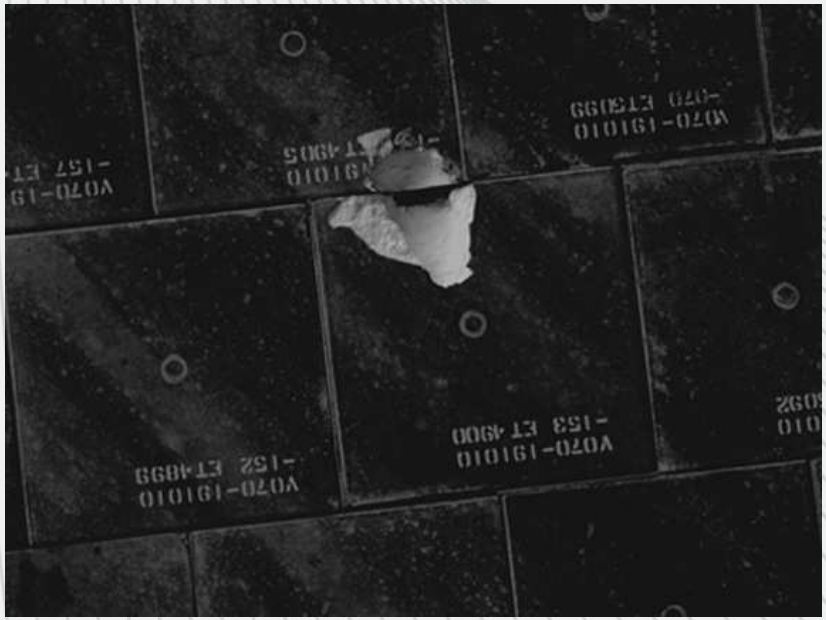


Source: ESA - Ernst Presentation 2009

MOTIVATION OF THE WORK

- From the early 60s, the driving thermal protection systems (TPS) technology for earth re-entry **was dominated by the US Space Shuttle**. Similar dominating situation has been encountered for most of the planetary entry probes, aerocapture, and sample return missions to improve our understanding of the Solar System.

- Another motivation comes from the **safety and reliability** point of view: Columbia Space Shuttle (STS-107 mission) disaster and recent incidents during the STS-122 mission. The fundamental problem of the impact-sensitive heat shield has not been fixed.



Source: NASA, from Endeavour taken Aug. 12, 2007

MOTIVATION OF THE WORK

- Interest to create an **autonomous space thermal protection technology**, by **reducing the dependence** from the leading technologies from other countries. Ref: 2005 Executive summary "The Future of European Space Exploration", regarding Securing European.

- Therefore, there is an **urgent need** to assure the **access to any technology** required to implement Europe's space missions.
  - Other hurdles come from the ITAR restrictions that may create undesirable dependence.
  - The point is to ensure the capabilities to create an **independent supply chain** in the TPS components technology.

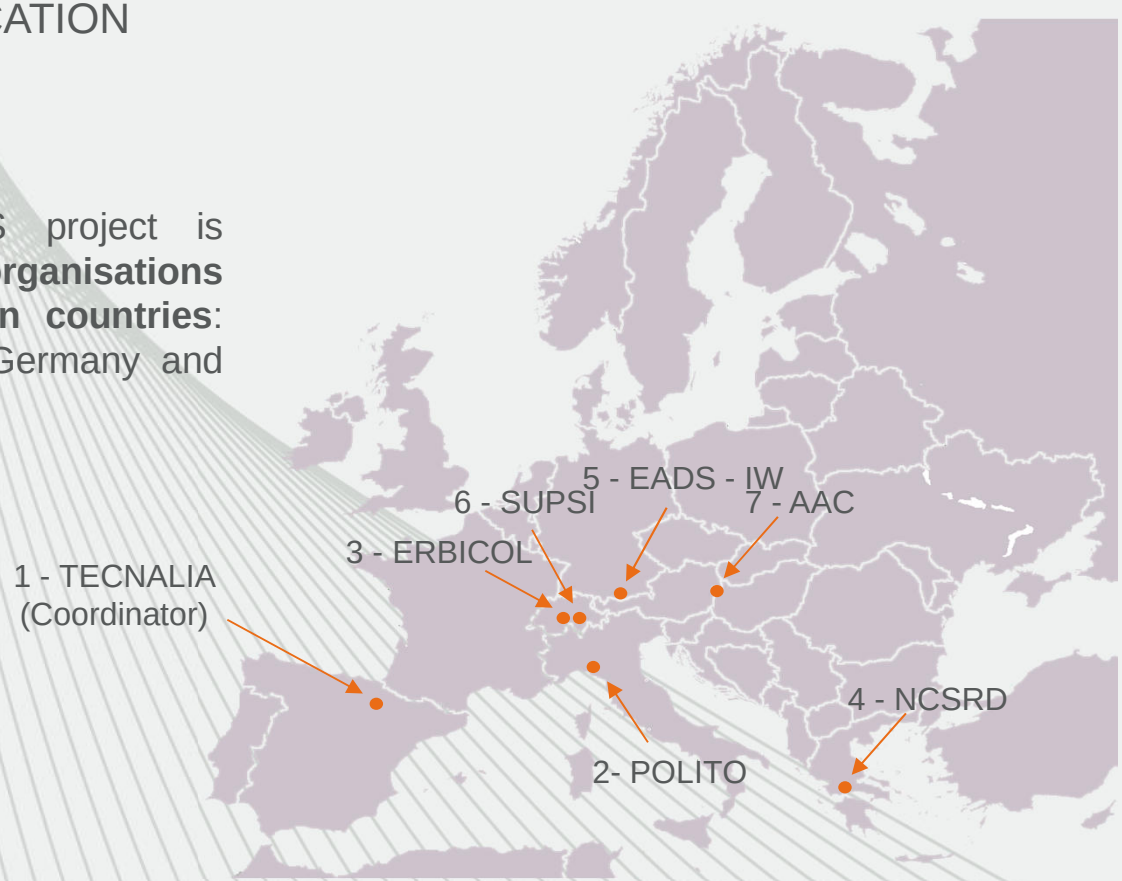
FP7 CALL & PROPOSAL EVALUATION RESULTS

- Proposal framed in the 3rd FP7 space call: SPA.2010.2.2-01 Space technologies – Thermal Components (including Smart TPS technologies for space applications).
- Projects on this call have a funding up to **2M Euro** and have a **3 year** duration.
- Ranking: 6 in its topic
- Final score: 13 points (of 15)
- Key dates:
  - First ideas and consortium completion: Summer 2010
  - Proposal submission: December 2010
  - Proposal evaluation: March 2010
  - Proposal Negotiation: May-July 2010
  - Grant Agreement: signed in December 2010
  - Project Kick-off: January 2011.

CONSORTIUM

- CONSORTIUM MEMBERS LOCATION

The core group of SMARTEES project is composed of **7 public and private organisations** coming from **6 different European countries**: Spain, Italy, Greece, Switzerland, Germany and Austria.



CONSORTIUM

#	Participant	Short Name	Country	Contact point	E-mail	Profile
1	Tecnalia Research & Innovation	TECNALIA	Spain	J. Barcena	jorgebarcena@tecnalia.es	Materials research centre
2	Politecnico di Torino	POLITO	Italy	C. Badini	claudio.badini@polito.it	University
3	Erbicol SA	ERBICOL	Switzerland	S. Gianella	sandro.gianella@erbicol.ch	SME, ceramic component supplier
4	National Center for Scientific Research "Demokritos"	NCSRD	Greece	K. Mergia	kmergia@ipta.demokritos.gr	National Research Centre (largest in Greece)
5	EADS Deutschland GmbH	EADS	Germany	C. Wilhelmi	christian.wilhelmi@eads.net	Industrial partner, space systems manufacturer, end user
6	Scuola Universitaria Professionale della Svizzera Italiana	SUPSI	Switzerland	A. Ortona	alberto.ortona@supsi.ch	University
7	Aerospace & Advanced Composites GmbH	AAC	Austria	V. Liedtke	volker.liedtke@aac-research.at	SME, material tester & qualifier

CONCEPT OF THE PROJECT

- SMARTEES address the development of advanced ceramic composites structures for reusable thermal protection systems. The solution will be based on a novel reusable TPS architecture which can withstand the extreme environment conditions during earth atmospheric re-entry.

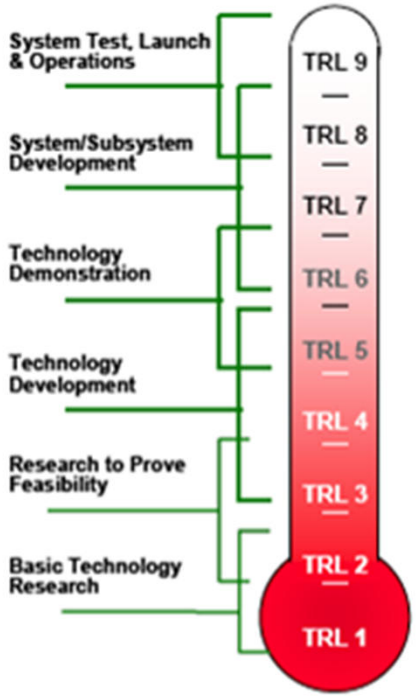
- The concept of the project is based on the **integration of conventional and non conventional parts** to create a **sound TPS protection component** with **multifunctional properties** (oxidation protection, emissivity, insulation,..). The design will incorporate the integration of materials at different levels:
  - Advanced protection layers to withstand high oxidative re-entry conditions
  - Ceramic composites and porous structures with high insulation capabilities (aided by material modelling)
  - Joining technologies to provide a full TPS solution (not only at hot-structure level.

- The space sector may take advantage of the novel reusable TPS technologies, since there is a high potential for its use in cargo and crew space return vehicles. I.e. for a cost effective, safe and reliable return from the international space station (ISS).

OBJECTIVES

The main objective is to develop a new reusable solution based on multifunctional concept with very high insulation and environmental protection capability during re-entry and the ability to reach a TRL level between 4 and 5 at the end of the project.

- From this pr
  - Develo
  - Suitab solutio
  - Proof-
  - Validat the sp
  - Obtain
  - Reduc and bo
  - Achiev techno



ESA & NASA Technology Readiness Levels(*)	
9	Actual system "flight proven" through successful mission operations
8	Actual system completed and "flight qualified" through test and demonstration (Ground or Flight)
7	System prototype demonstration in a space environment
6	System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)
5	Component and/or breadboard validation in relevant environment
4	Component and/or breadboard validation in laboratory environment
3	Analytical and experimental critical function and/or characteristic proof-of-concept
2	Technology concept and/or application formulated
1	Basic principles observed and reported

sample

igh accuracy

f stand-offs

the

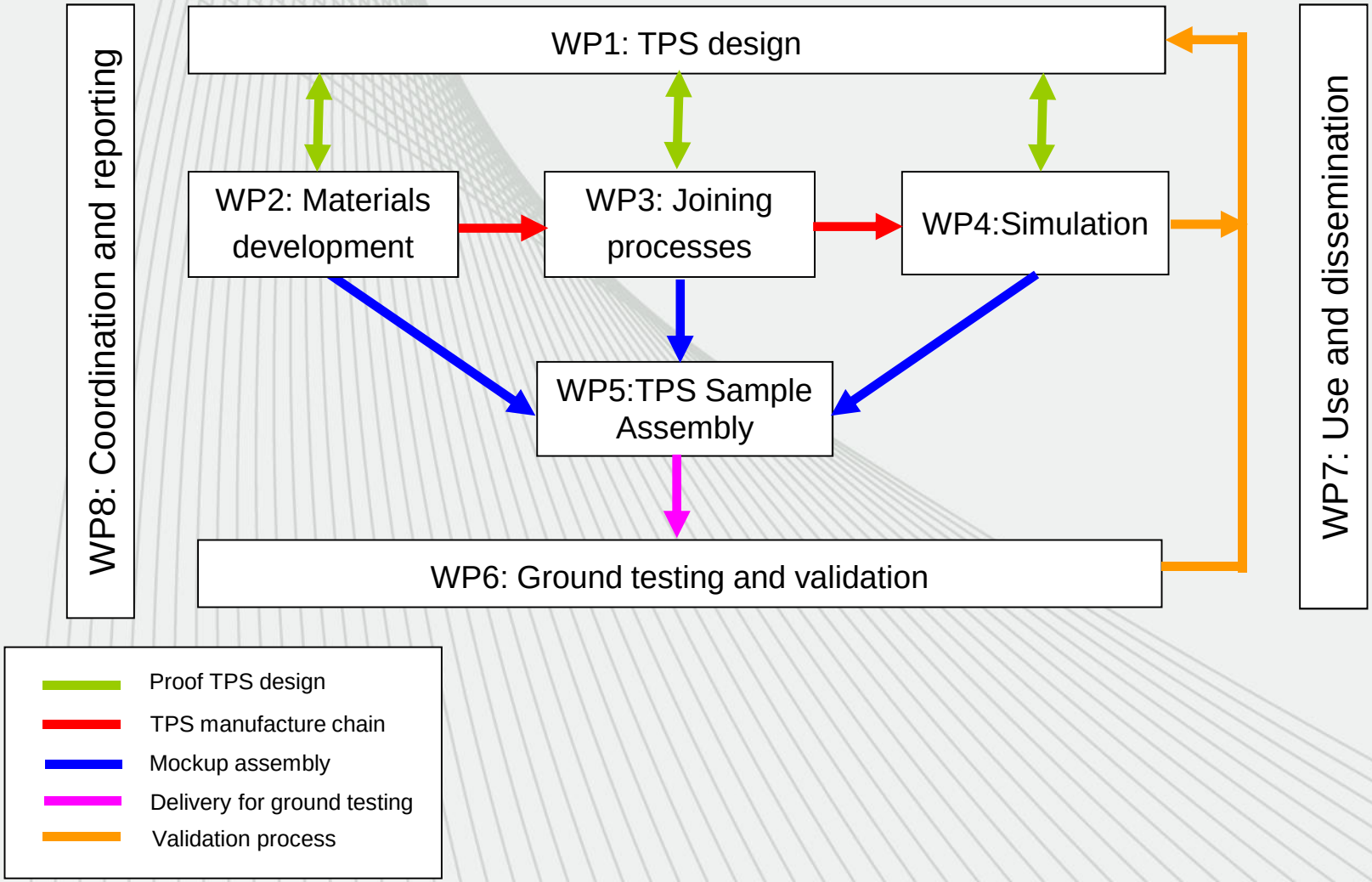
WORKPACKAGES: LIST

The work plan is distributed among a total of 6 technical workpackages and 2 non-technical workpackages:

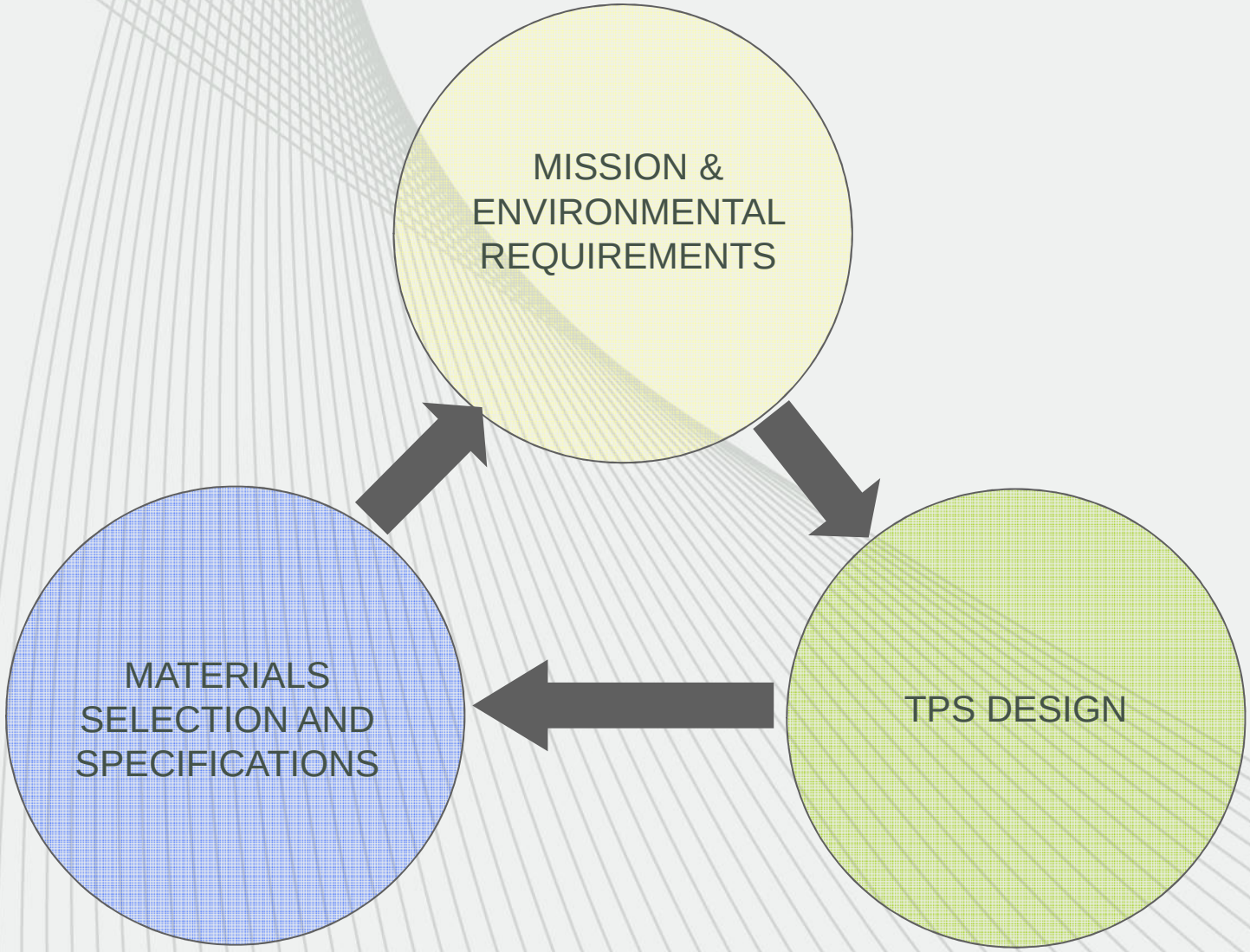
- WP1: Requirements and design.
- WP2: Materials development
- WP3: Joining processes.
- WP4: Simulation.
- WP5: TPS technology sample assembly.
- WP6: Ground testing and validation.

- WP7: Use and dissemination.
- WP8: Coordination and reporting.

WORKPACKAGES: STUDY LOGIC



WP1: TPS DESIGN



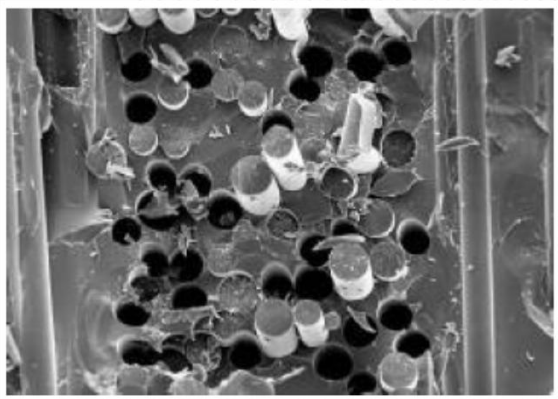
WP1: TPS DESIGN

- Mission definition is on-going and several alternatives have been assessed.
- Once the mission is selected the following specifications will be collected:
  - Heatfluxes
  - Time (during peak & total)
  - Pressure profile
  - Mechanical load
- The next step is the definition of a preliminary TPS design:
  - Materials & structure levels
  - Shape and thicknesses
  - Joining definition
  - Stand-off attachments

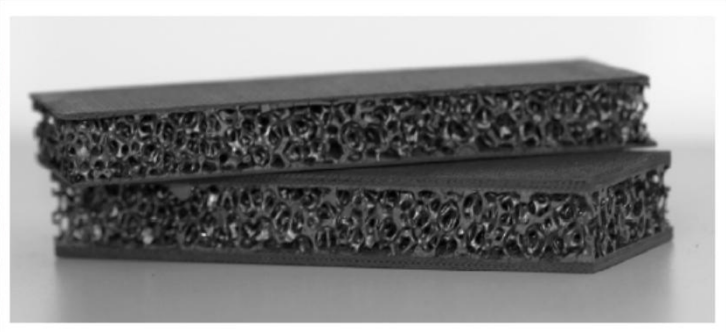
WP2: MATERIALS DEVELOPMENT

- External protective layers based on UHTCs hot structures
  - Suitable for environments leading to a external surface temperature > 1700 ºC.

- Integration of advanced CMC structures and ceramic foams.



Qualified CMC structure from EADS



CMC-SiC sandwiches, (SUPSI, A. Ortona) made with ERBISIC ceramic foams (Erbicol S. Gianella)

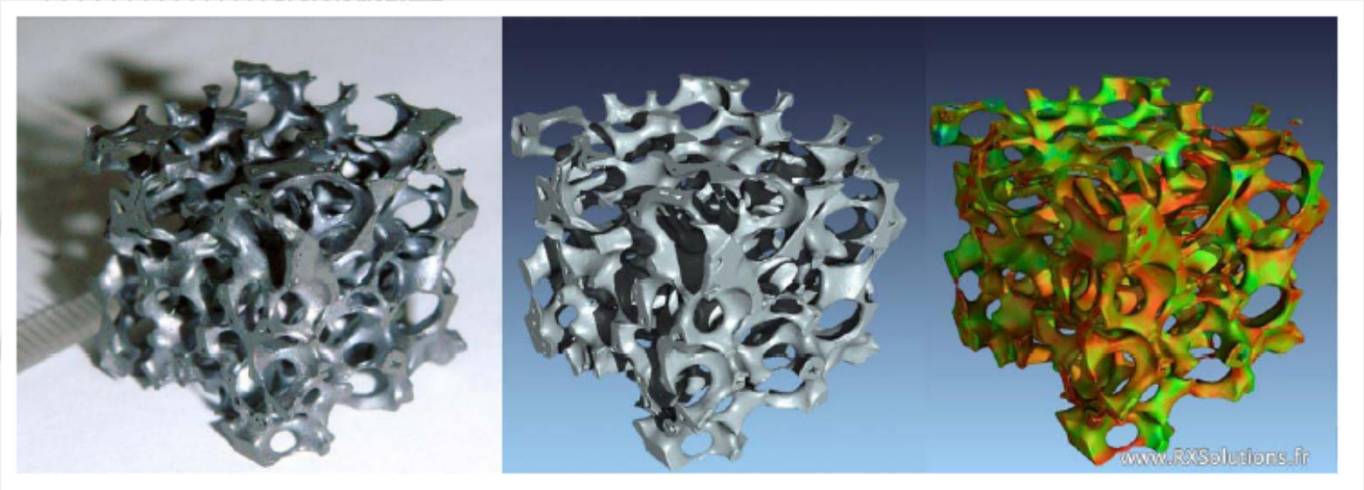
- Definition of metallic materials: stand-offs and vehicle sub-structure

WP3: JOINING PROCESSES

- Definition & selection of the bonding processes
- Execution of the bonding process
  - External hot-structure to CMC assembly
  - Assembly of stand-offs to the structure
- Thermo-mechanical characterization and high temperature oxidation testing
  - Thermal conductivity
  - Emissivity
  - Mechanical loads
  - Coefficient of thermal expansion
  - Cataliticity

WP4: MODELLING & SIMULATION

- Modeling of the different parts of the TPS (aided by computed tomography)



Credit: SUPSI (A. Ortona) made with ERBISIC ceramic foams (Erbicol S. Gianella)

- Themo-mechanical analysis
  - Inputs for W1 (specifications), WP2 (materials) and WP3 (processes)
  - Definition of temperature distribution
  - The output of this work will help to calculate critical design parameters (WP1)

WP6: MODELING & SIMULATION

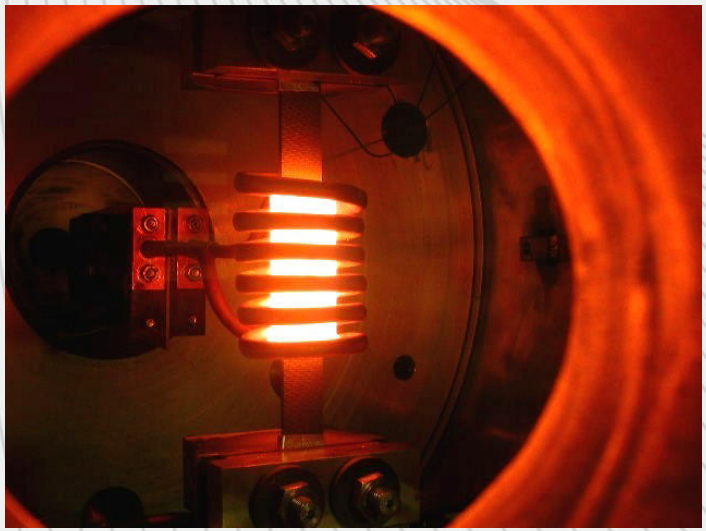
Ground testing for re-entry applications can be performed in different ways:

- **Plasma Windtunnels**
  - *Close to reality*
  - *Costly; screening tests hardly justifiable*
- **Standard Test Rigs (e.g. furnaces; mechanical test machines)**
  - *Cheap, fast and easy; good for screening tests*
  - *Hardly relevant for re-entry applications*
- **Specific thermo-mechanical test facilities**
  - *Significant cost advantage to plasma windtunnels*
  - *More versatile, e.g. combination of T, F, p*
  - *Plasma-related thermochemical processes cannot be reproduced*
  - *Modern materials‘ durability may exceed the durabilty of test rig components*

WP6: MODELING & SIMULATION

- In a final stage the technology sample will be tested in a relevant ground facility simulating the re-entry conditions.
- The testing will determine the fundamental performance and the degradation mechanisms.
- This final step will give insight into the overall performance of the TPS, identify possible modes of failure, and assess the efficiency of the thermal insulation and the heat fluxes into the sub-structure of a spacecraft.
- The ground testing outputs will be reviewed in comparison with the outputs of TPS requirements and environment specifications.

Standard Test Rig (at AAC)



Credit:V. Liedtke (AAC)

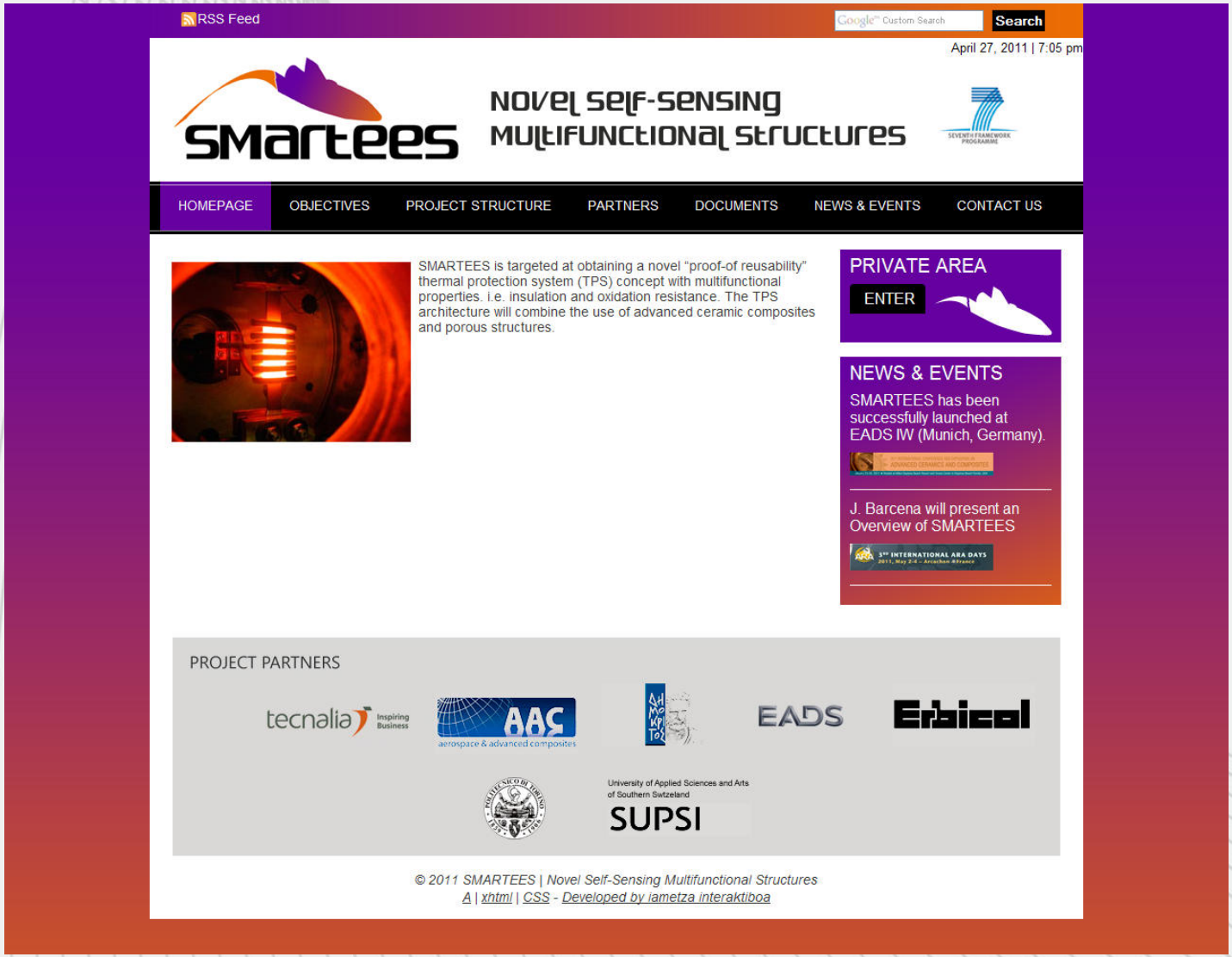
WP7: DISSEMINATION ACTIVITIES

- Definition of exploitation plan
- Assessment of IP
- Dissemination plan: lectures in relevant conferences & peer review journals
- Use of social networks such as Linked-in.

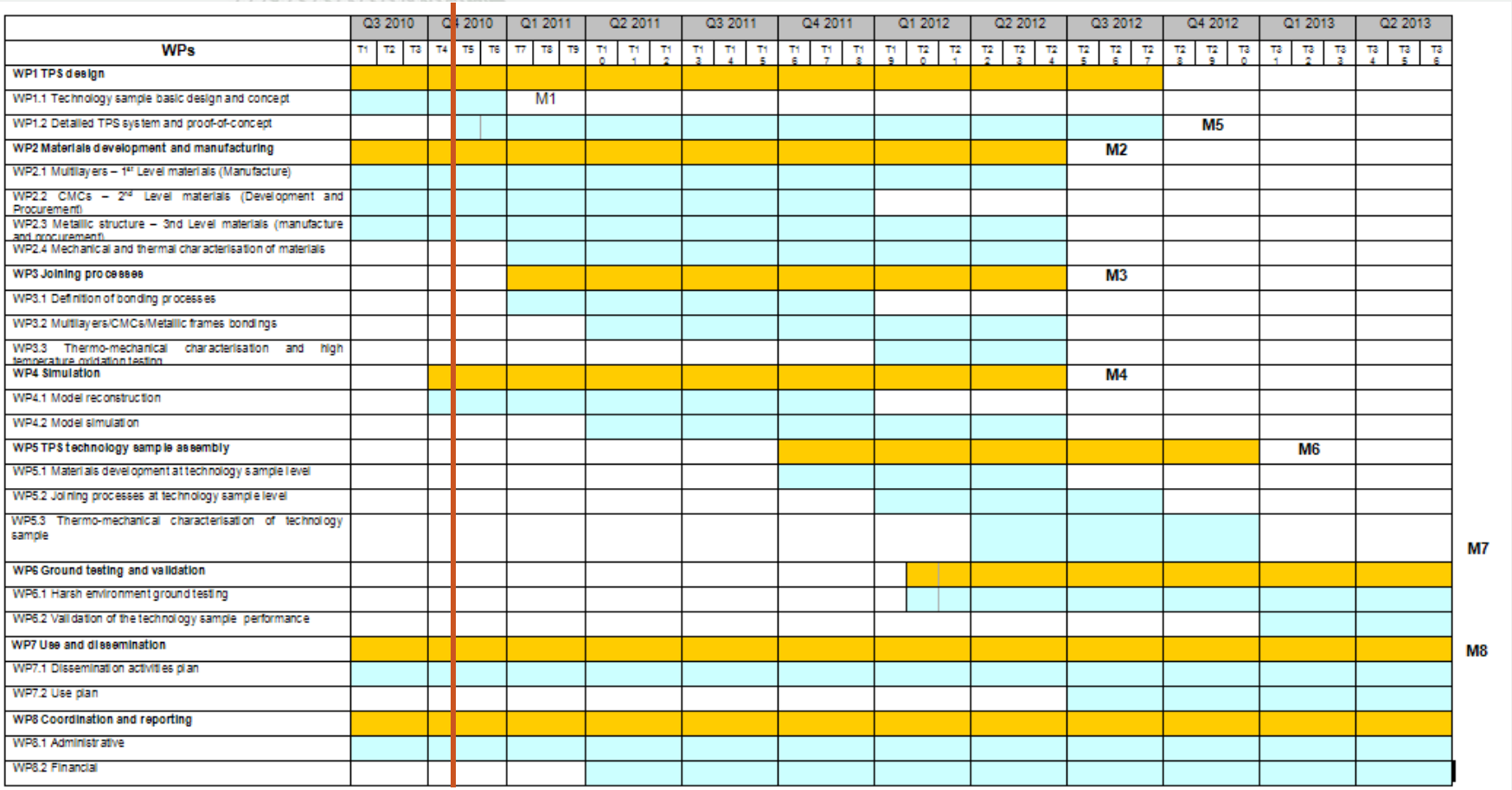
Project webpage available soon

www.smartees-project.com

WP7: DISSEMINATION ACTIVITIES



SCHEDULE



4 Months

END OF PRESENTATION

Many thanks for your attention