COORDINATION AND SUPPORT ACTION
(SUPPORTING)

Call: FP7-NMP-2012-CSA-6
Support for standardisation needs

Project full title:	**New Quality and Design Standards for Aluminium Alloys Cast Products**
Project acronym:	**StaCast**

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StaCast

Project Presentation

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Introduction

The European Aluminium alloys foundry industry (more than 2000 Companies, mostly SMEs) has an enormous potential, associated to the increasing demand of lightweight components in various application fields, from automotive to aerospace.
This potential has still to be fully exploited. European Aluminium foundry industry is now facing the challenge of transforming itself into a quality/efficiency-driven and integration-oriented sector. This target requires the achievement of several intermediate objectives, such as the development of new and advanced Standards and Technical Reports, supporting a systematic improvement in design and production of high quality and highly performing cast components.
This is the scenario in which the EU financed StaCast project (FP7-NMP-2012-CSA-6, Grant n. 319188) has been carried out, with the joint effort of University of Padova (Italy), Aalen Hochschule Technik und Wirtschaft (Germany), Trondheim Norges Universitet (Norway), Associazione Italiana di Metallurgia (Italy), Assomet Servizi (Italy), and Federation of Aluminium Consumers Europe (Belgium).
The acronym StaCast means "New Quality and Design Standards for Aluminium Alloys Cast Products", and the Project has been focussed on

- a public survey of EU Aluminium foundries, to understand their more relevant characteristics, particularly for what concerns quality and standardisation issues,
- the development of a reliable classification of defects and imperfections in Al Alloys cast products, transferred to CEN (European Committee for Stardardisation) as an official Technical Report,
- the development of a procedure for the evaluation of mechanical potential of Aluminium-based foundry alloys, transferred to CEN (European Committee for Stardardisation) as an official Technical Report,
- the elaboration of engineering guidelines for the mechanical design of Al alloys castings.

The strategic role of Aluminium Alloys in EU Foundry Industry

Aluminium alloys have become, in last years, more and more relevant in view of eco-sustainability, because of their low density, coupled with good mechanical and corrosion properties.
The key-application of cast Aluminium alloys is the automotive and transport field, with a growing trend, supported by the reduction achievable in fuel consumption and emission.
Cast Aluminium alloys components for automotive are mostly (60-65%) manufactured by High Pressure Die Casting (HPDC), thanks to the high production rate and to the complexity of shape which can be obtained. EU HPDC production of Aluminium alloys components can be on average estimated at 1.5 millions of tons/year, and is mainly carried out by SMEs: there are about 1500 HPDC foundries in EU (particularly in Italy, Germany and Spain). A complementary important process of production is Permanent Mold gravity casting.
The vast potential of **Aluminium Alloys EU Foundry Industry strongly needs** a coordinated set of **Support Actions**, in which a central activity is the elaboration of **new** and advanced **Standards and Technical Reports**, particularly in the fields of Defects classification and Mechanical Design, which are mutually inter-related.

Defects identification in Aluminium Alloys cast products

The final properties and in-service behaviour of cast products are always related to microstructural features and to defects: both microstructure and defects are the results of process stages, alloys properties, and design of dies and tools. The identification of key-variables, the knowledge of variable-defect relationships and the implementation of real time sensor devices to monitor these variables will allow, in future, control of the process to achieve "zero-defects production".
The achievement of this ambitious target will be made possible by the use of **a new CEN Technical Report** for the **Classification of Casting Defects**, which will help EU Aluminium alloys foundries at promptly performing corrective actions to reduce/eliminate defects. Such a Standard will also be a useful "communication tool" among all the actors in the design and manufacturing chain.

Recently, in year 2010, the Italian Association of Metallurgy, after carrying out a 2-years survey carried out involving about 50 Al alloys foundries, suggested [*E. Gariboldi, F. Bonollo, P. Parona, Handbook of defects in HPDC, AIM, Milano*] a new classification approach, based on a 3-levels defects individuation:

- morphology/location of defects (internal, external, geometrical);
- metallurgical origin of defects (e.g. gaseous porosity, solidification shrinkage, etc.);
- specific type of defects (the same metallurgical phenomenon may generate various defects).

The **path to elaborate** a new **CEN Technical Report on Defects Classification**, as implemented in StaCast Project, has been the development, elaboration and submission of a related CEN Technical Report.

Evaluating mechanical potential of Aluminium Alloys

The achievement of high-quality Aluminium alloys cast products is strongly required by the end-users, being the driving force for the innovation in this field. This target can be reached if defects in castings are minimized and microstructure is optimized, taking into account all the main variables related to the alloys employed and to the process conditions.
The development of a **new Standard** is strongly **needed**, in order to correctly **evaluate** the effective **mechanical potential** of **Al foundry alloys**.
The current Standard employed for defining mechanical properties of Al foundry alloys is EN 1706, which collects UTS, YS, elongation values, reported "only for guidance". According to this Standard, the UTS values are almost constant for all HPDC alloys, and certainly under-estimated and conservative. The recently concluded **NADIA** EU IP-SMEs Project (*New Automotive components Designed for and manufactured by Intelligent processing of light Alloys, 2006-2010, Contract 026563-2*) demonstrated that the real mechanical potential of Al foundry alloys can be accurately defined by means of properly design reference dies. In this way, for instance, the UTS of EN AC 46000 and EN AC 46100 alloys is 308 MPa and 320 MPa, respectively.
The **path to elaborate** a new **Standard on foundry alloys mechanical behaviour**, as implemented in StaCast Project, has been the development, elaboration and submission of a related CEN Technical Report.

Engineering rules for the mechanical design of Al alloys castings

During the design stage of a component it is fundamental to have the "combined" knowledge of:

- the alloys "mechanical potential" achievable in optimized casting conditions;
- the influence of microstructure on mechanical behaviour;
- the negative effects due to the various kinds and amount of defects induced during the casting process.

The design and manufacturing of Al alloys cast components **need** the availability of dedicated **rules and guidelines**, in order to correctly make use of the two **new standards** obtained in issues (2) and (3).

The already mentioned **NADIA** project, together with the **IDEAL** project (*Integrated Development Routes for Optimized Cast Aluminium Components, 2002-2005, Contract GRD2-2001-50042*) demonstrated that the optimization of properties of cast components can be achieved using integrated software tools (for alloy selection, process simulation, mechanical behaviour prediction, cost evaluation, etc.), characterized by multi-scale (nano, micro and macro-scale) models, adequate processing solutions and simultaneous engineering approaches, allowing the so-called "Intelligent Processing" of light alloys.

Such projects demonstrated that:

- microstructural features can be calculated by solidification times predicted using numerical simulation;
- defect content can be evaluated by the use of simulation related quality criteria;
- the effective distribution of mechanical properties can be reasonably achieved by implementing into software tools experimentally derived process-microstructure-properties correlations.

New **Design Guidelines and Rules**, as implemented in StaCast Project, will help mechanical designers at correctly taking into account both the mechanical potential of Al alloys and the limiting role of defects.

StaCast Work Plan and Consortium

The set of activities of the StaCast project has been supported by a consistent work-plan, giving the StaCast Project the intrinsic driving force to achieve expected results. The work-plan is articulated into 6 WPs on a duration of 18 months, logically organized:

- to focus the standardization needs (**WP1**);
- to support the development of new EU Standards (**WP2** and **WP3**);
- to elaborate new guidelines for using such Standards in mechanical design (**WP4**);
- to disseminate the knowledge on and promote the use of new Standards and Guidelines (**WP5**);
- to integrate and manage the overall Project (**WP6**).

The balance amongst partners is optimal, with 3 Universities with specific background on various issues related to Al alloys foundry, 2 Associations representing various subjects (and particularly a high number of SMEs) and one Standardization board, well used at cooperating with CEN (Figure 1).

In detail, the Universities of Padova (DTG), Aalen (GTA) and Trondheim (NTNU) have the role of coordination, data collection and elaboration in view of standards and guidelines. Particularly, **DTG** (Coordinator of the whole Project) is focussed on defects and mechanical properties correlations, **GTA** is focussed on high-pressure die-cast components and related mechanical properties and **NTNU** is focussed on gravity die-cast components and related defects and mechanical properties. The Italian Association of Metallurgy (**AIM**), as Industrial Association, and **FACE**, as Federation

of Aluminium Consumers, support data collection and dissemination of project results. The **UNIMET**, as Italian Standardization board of non-ferrous alloys, has the role of information organization according to standard structure and of interaction with CEN Al alloys Committee.
This is a project in which many partners aim at working together to learn from each other needs and collectively contribute to accelerate the speed at which new standards might be applied in a strategic EU field, such as foundry production of Al alloy components and to help this industrial sector to compete more effectively in international markets.

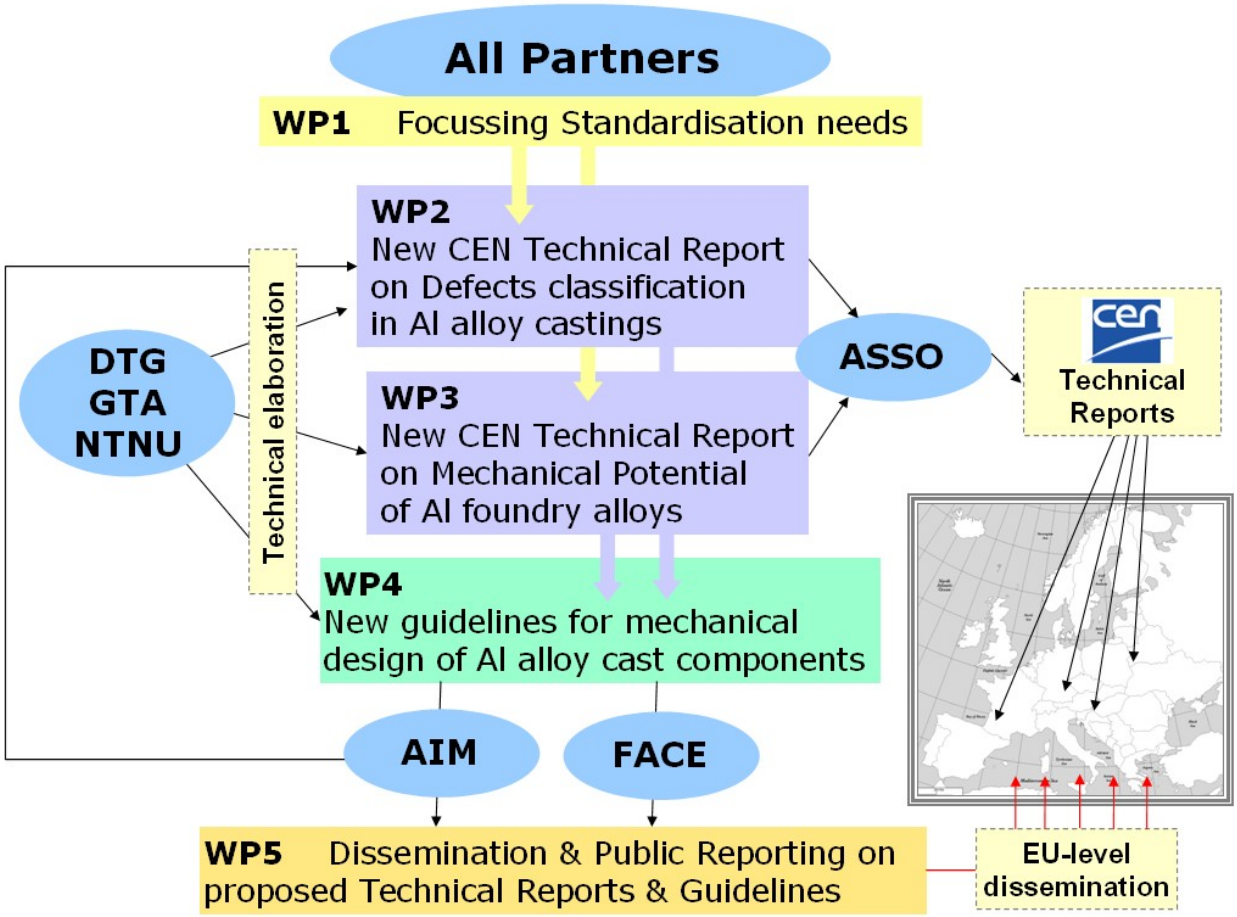

Figure 1. Characteristics and role of Partners in the frame of StaCast Consortium.

Impact of the StaCast project

The current scenario, in which the main players are Foundry, Foundry Supplier, Alloy Producer, Engineering Company, End-User, is shown in Figure 2a. They are used to have a role of "**single players**", without significant interactions among them and using a limited number of standard tools. The new scenario (Figure 2b), expected after the exploitation of StaCast objectives, is characterised by the 2 new Standards, strongly promoting a significant interaction among End-User, Engineering Company and Foundry, and based on the guidelines & rules elaborated by the Project. New standards will support also Alloy Producer and the Quality Evaluation Dept. A group of "single players" is "converted", by the results of StaCast Project, into a balanced **team**, focussed on knowledge based tools to assure products quality and production efficiency.

Nowadays, Al alloy foundries are highly limited by "no-quality costs". Considering that scrap rates range from 5 to 15%, it can be estimated that every year in Europe 150.000 to 250.000 tons of aluminium alloys are molten and cast only to produce scrap.

The availability of StaCast results (i.e. the two new CEN Technical Reports) will offer EU foundries a relevant tool to improve quality and reliability of their products and to increase the robustness in their approach to customers. Moreover, each action and result in terms of scrap reduction immediately causes reduction in the energy consumption.

Finally, the StaCast project will have a positive impact on all the members of the supply chain, particularly by:

- positively influencing the robustness in mechanical design of the **engineering companies**;
- increasing the **alloy producers** possibility of supporting foundries in alloys selection;
- increasing the **foundries** possibility of interacting with customers in a concurrent engineering approach;
- offering **end-users** (e.g. automotive companies) the possibility of employing components produced with a more knowledge-based approach, thus improving the technological margin of their products (improved reliability and safety, cost optimization, reduced time-to market).

StaCast will focus on needs of and benefits to SMEs in the **value chain**, performing:

- **vertical integration**, because the entire value-chain, from knowledge (phenomena & structure), control and manufacturing (cast products) and technology (equipment, sensors, processes) will be considered in StaCast standards and guidelines;
- **horizontal integration**, because such standards will be intrinsically of S&T multi-disciplinary nature, thanks to the combination of materials science, manufacturing and mechanical design.

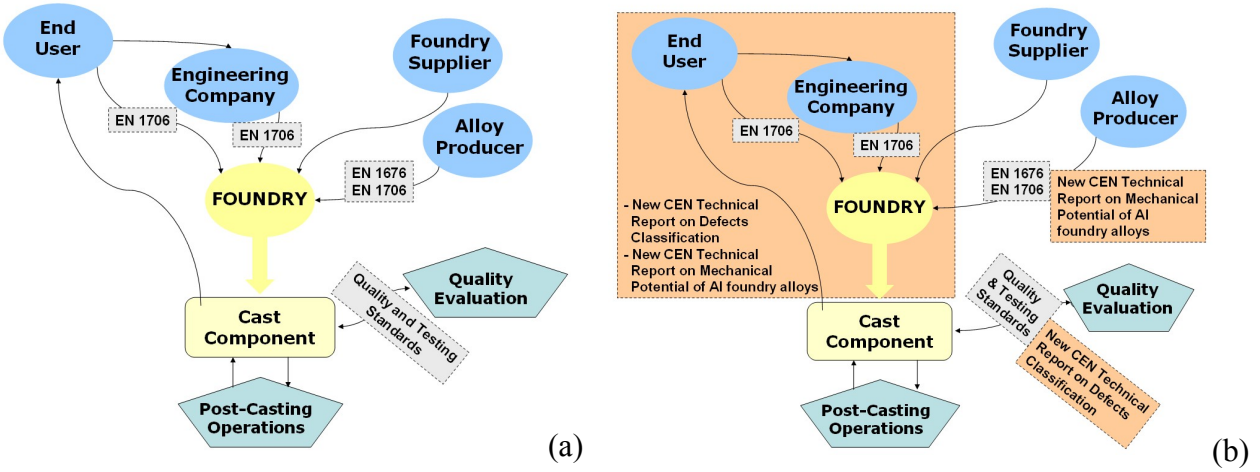

Figure 2. (a) Actual scenario and (b) new scenario in design and manufacturing chain of Al alloys cast components after the exploitation of StaCast objectives.

The StaCast website

A dedicated **Website** (www.stacast-project.org) (Figure 3) has been designed for the StaCast project needs with public and restricted area, including discussion forum for partners, questionnaires, general info, document sharing, administrative & technical databases, events calendar.

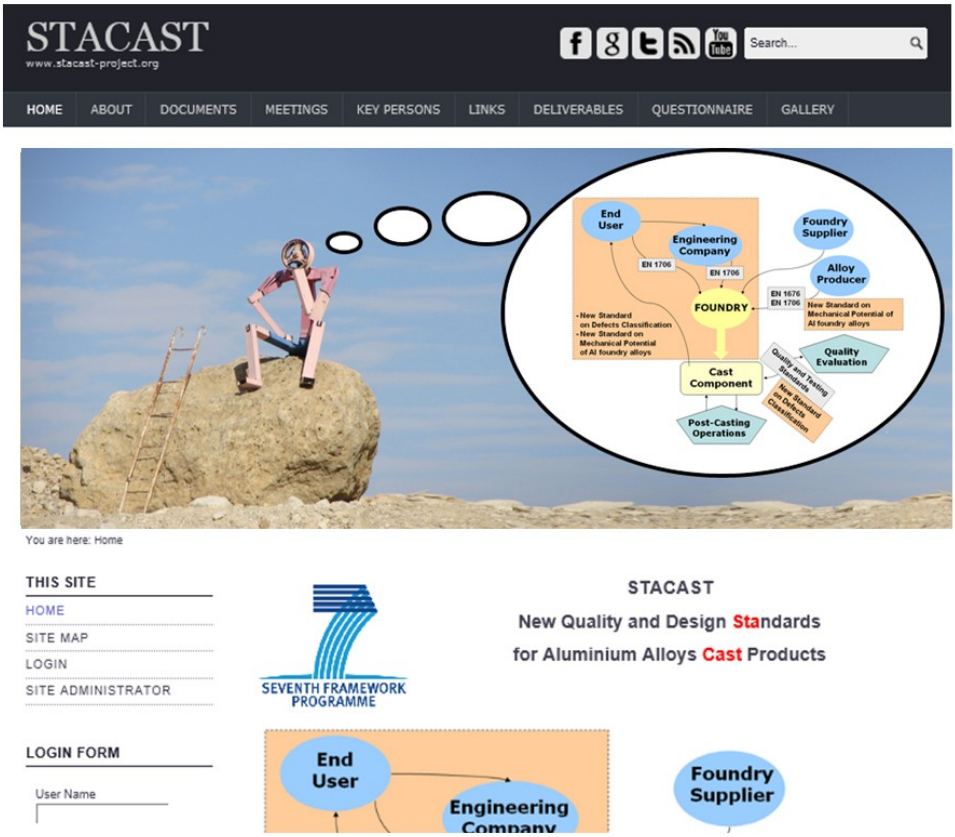

Figure 3. StaCast website (www.stacast-project.org)

The StaCast Contacts

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The **University of Padova** was founded in 1222 and currently has 12.000 students in Engineering School. The *Engineering and Management* Department (DTG), established in Vicenza in 1998, has the specific mission of linking technological and management issues. The department currently has 48 professors, 15 PhD students and 20 technicians. One of the strongest research areas refers to **light alloys and foundry processes**.

PARTNER N. 2

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The Aalen University of Applied Sciences is located in the eastern part of Baden-Württemberg and has the only foundry laboratory in southern Germany. The foundry laboratory belongs to the faculty of mechanical engineering and material science which is the largest faculty in Aalen. It is specialised in development activities in high pressure die casting with all alloys starting from Zinc to Magnesium, Copper and Aluminium using 4 die casting machines.

PARTNER N. 3

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The **Norwegian University of Science and Technology** (NTNU) is a fully integrated University with focus on Science and Technology. The Department of Materials Science and Engineering (about 20 professors, 60 PhD students and 20 post docs) is the main institution for teaching and research in materials engineering in Norway, with light metals technology (and particularly **Solidification and Casting of Light metals**) being one of its strategic areas.

PARTNER N. 4

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AIM is an Italian non-profit & cultural organization, devoted to gathering and dissemination of scientific knowledge in the field of metals, through publications, conferences, meetings. AIM publication programme covers a wide range of subjects, from physical metallurgy to production processes of metals and their applications. AIM successfully managed, in 2005-2006 the EU Leonardo Pilot Project METRO (Metallurgical Training On-line).

PARTNER N. 5

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Assomet Servizi was founded in 1989. It supplies services to promote knowledge and use of non-ferrous metals; it manages specific activities for industrial companies (statistical elaborations, feasibility & economic studies) and publishes reports on technical, economic and standardisation issues. It is highly involved in the Italian Standardisation Body for non-ferrous alloys (UNIMET), actively cooperating with EU Technical, Economic & Standardisation Bodies.

PARTNER N. 6

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FACE serves the needs of aluminium users and consumers in the EU. It was established in 1999 to represent the interests of thousands of EU downstream aluminium businesses. FACE is aimed at promoting the use of aluminium and its economic, social and environmental advantages, assessing the impact of new technologies on the production, semi-fabrication, trade and use of aluminium, reducing the costs of primary aluminium products thus stimulating demand.