1. Publishable summary

1.1. Summary description of the project objectives

The main objective of the LOWFLIP project is to develop a low cost flexible and integrated preforming/moulding/curing composite parts manufacturing process for the needs of different transport sectors, such us the aerospace and the automotive-surface transport sector, which will require minimum investments in comparison with current SoA processes. The specific scientific and technical objectives of the project to reach the main goal set by LOWFLIP are the following:

- To develop, assess and analyze new composite raw materials (dry semipregs/B staged systems and fast curing/highly reactive resin systems under vacuum) for easy and low cost automated manipulation & fast curing / processing and process steps integration.
- To develop low cost and flexible multifunctional handling / placement / draping solutions for both small complex parts (pick & place solutions) and big structures (automatic fabric placement solutions).
- To reduce composite manufacturing process steps, meaning integrating preforming, resin integration and curing steps, and reduce process cycle by the implementation of:
    - Selective, fast and energy efficient heating technologies for binder or resin activation, such us ultrasonic activation and direct resistance.
    - A multifunctional tool with preforming, injection and curing functionalities and fast and energy efficient novel heating technologies based on low cost and low pressure compaction membranes that include heating, resin infiltration, compactation and curing functionalities
- To develop and validate supporting simulations tools in critical aspects for the automation of the process such us drapability and curing optimization and in critical composite components performance aspects in transport applications such as impact / crash behavior suitable also for the new materials developed.
- To implement and validate at laboratory scale the above described multifunctional handling/placement/draping and integrated preforming/injection/curing solutions.
- To design and produce prototype cells that integrate the technologies validated at laboratory and to create a new process concept for the composites manufacturing sector.
- To demonstrate the relevance of the prototype cells with the realization of 3 composite structural parts demonstrators in order to satisfy the needs of SME/ end users of the automotive, truck and aeronautic transports sectors
- To ensure a successful exploitation and to establish the basis for the market uptake of LOWFLIP through a strategic and business-oriented commercialization plan including dedicated business models and the appropriated IPR management for the knowledge generated during the project.

The quantified targets of the project are:

- A reduction of the investment costs compared to SoA processes of 50%
- A reduction of the energy consumption compared to SoA processes of 50%
- Equal productivity compared to SoA
- Equal technical performance compared to SoA

	Current Start of Art			
	Large parts		Small/ medium Parts	
			RTM	
	ATL	AFP	Preforming	Moulding
Productivity (cycle time)	45 kg/hour	30 kg/hour	<6mins - 3hrs per part	<10mins - 4hrs per part
Investment costs	2,5-3,0 M€	1-5 M€	40,000 - 540,000 €	136,000 - >1,000,000 €
Energy consumption (kWh)	60-80 kW (installation	60kW (installation)	1kWh - 5kWh	7kWh - 24kWh

LOWFLIP project targets	Large parts	Small/medium parts
Productivity	Equal	Equal
Technical performace	Equal	Equal
Investments costs	50% reduction	50% reduction
Energy consumption	50% reduction	50% reduction

1.2. Brief description of the work performed since the beginning of the project and results achieved

The major tasks addressed during the first 18 months of the project were the **definition of demonstrator parts**, the **development of a new material suitable for LOWFLIP process, the definition and development of new processes for large and small parts,** as well as **innovative tooling solutions for fast and energy efficient heating.** Also, **new simulation models** were developed to predict the material behaviour . All of these tasks are closely linked to each other, requiring a collaborative exchange between the partners. A fast progress towards the final definition has been made and 3 demonstrator parts were identified at the beginning of the project for all different transport sectors by Carbures (automotive), AESI (aviation) and Kögel (truck). The latter is a front wall that is currently manufactured out of aluminium, which means that a first CFRP prototype will be developed within LOWFLIP.

In parallel, a new **material has been developed by SGL** (WP2). A new resin system is used to impregnate dry fibers and produce semipreg and prepreg material. The material has been tested with regards to its handling and processing properties, as well as its mechanical properties. The material meets the requirements defined by the partners and will be used further in the project. More work will be done regarding the mechanical characterization of different materials, since first tests have shown a strong correlation with the curing and processing parameters.

In the WP3, corresponding to development of multifunctional handling/placement/draping systems, **new processes were designed** for large and small part manufacturing.

Therefore, **process requirements** have been collected by the partners, which serve as an important basis for the development of the laying head system and the pick & place application. Advanced concepts for both small and complex 3D parts, as well as the automated manufacturing of large parts were developed. For both, the automotive (Carbures) and the truck (Kögel) part, tools were designed in detail together with Tecnalia, ALPEX and USTUTT. A lab scale cell of a new tapelaying system developed by USTUTT and FILL has been installed which will be used for the validation of a new innovative process concept. A large scale version of the production cell is planned later in WP7 to manufacture all demonstrator parts.

New tool concepts for fast & energy efficient heating and curing were developed in WP4 for the different demonstrator parts. A metallic mould with interchangeable fluid systems for energy-efficient curing will be used for the Carbures part. A composite tool with integrated resistive heating circuits will be built for the manufacturing of Kögel's front wall – a part with a dimension of about 3,5 m x 3 m. Finally, a state-of-the-art metallic mould is used for the aircraft demonstrator with integrated stringer elements.

To start the activities within the **simulation group** (WP5), a kick-off meeting has been organized at the AESI facilities in Madrid on April 1, 2014 among all WP5 partners (MECAS, Aernova, Tecnalia, USTUTT). Afterwards, the general meeting has been held at the Carbures facilities in Jerez de la Frontera, Spain, on April 2 and 3, 2014.

To simulate the behaviour of the new material, **draping simulations with new material models** were performed in WP5. Moreover, a test campaign for experimental draping has been established and input parameters were defined by the partners.

Due to the fact that a new prepreg material has been used, the test facilities were upgraded with different thermal heating systems in order to be able to influence the viscous behaviour of the material. In this way, LOWFLIP will enable the partners to perform more research on the processing of new, innovative materials, such as the developed out-of-autoclave prepreg.

1.3. Expected final results and their potential impact and use

By developing a new manufacturing process including the material system, many innovative solutions are addressed to meet the requirements on automated manufacturing of the transport sector. Mainly the expected final results are:

- A new material system that is suitable for automated, fast and energy-efficient CFRP parts manufacturing
- A process with a low level of investment vs HP-RTM/ C-RTM and ATL/AFP, accessible for SMEs.
- A fully automated solution: high production capacity, low cost equipment and high quality level for structural application
- The reduction of process steps and energy consumption by investigating merging possibilities throughout the process
- A new process for small to medium sized 3D application (automotive)
- A new process for medium to large panel application (aerospace, cargo transportation)
- New numerical models for composite materials and processes and further development of integrated product / process analysis tools to reduce the number of experimental tests required during the development of composite parts.

The process can be used in general for many different applications, where a high degree of automation for large volume CFRP part production is required. The developed material specifically addresses the automotive, aeronautic and truck sector, but more applications are possible.

1.4. Address of public website

www.LOWFLIP.eu

Figure 1: LOWFLIP website