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Eco-Design for Airframe	
Call for Proposal id	**2012-03-ECO-01-061**
Call for Proposal Acronym	**NEMESIS**
Call for Proposal title	**Sustainability assessment for EcoDesign-Guideline technologies**
CFP starting date	**01-01-2013 (T0)**
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EDA task n° :	**TA 33**
Deliverable id :	**1.2 Final activity report and cost statement**
Deliverable due date	**30/07/14 (T0+18)**

Main Author(s)	Partners involved / Persons	Date and Signature
Company	PBLH Cidaut	
Verification and Approval	Topic Manager*: Torsten Müller	Date and Signature
Company	Fraunhofer Gesellschaft	

***The Topic Manager in charge of this call for proposal must approve the deliverable and send it to the Project Officer.**

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ACRONYMS LIST

(Acronyms not used in the document will be deleted from the table. Additional acronyms to be added to the table)

Acronym	Definition
a/c	Aircraft
DoW	Description of Work

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1- EXECUTIVE SUMMARY

The recycling of products and materials within the aircraft construction industry is not yet applied to any real extent, which obviously has a series of negative impacts for the natural environment and the economic sustainability of the industry. Traditionally, the lack of recycling has been explained by the unavailability of suitable technologies, able to meet at once all the relevant technical and economic requirements.

To this regard, the European Commission supported the “Process for Advanced Management of End of-Life-Aircraft (PAMELA)” Project, dating back from 2005 to 2007, and involving major actors in the field of aircraft construction. With extensive physical trials for deconstructing the plane, the project enlightened promising technical possibilities for recycling, as far as major construction materials are concerned.

Nevertheless, it is obvious that, even in spite of the technical possibilities present, there are still a series of barriers hindering the recycling for aircrafts. The NEMESIS project explored and analysed these barriers basically from a two-fold perspective: economical and engineering knowledge.

As an outcome, an integrated methodology for the definition of the optimum dismantling and recycling strategy of aircrafts was developed, taking into account a series of technical and economic constraints.

To achieve this goal, an in-depth analysis of the prospective market for recycling in aircraft was accomplished, which included a survey (questionnaires and interviews) addressed to major actors within the entire value chain of aircraft products.

It is expected that the newly built methodology becomes a valuable tool for these actors towards the creation of an incipient future market of recycling in the sector.

2- SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

During the last decades, recycling has been more and more acknowledged by industry as a key aspect for sustainability. Here, sustainability must be regarded from its broadest scope, involving not only environmental factors, but business factors as well, in a context of fierce commercial competition at a global scale. The automotive sector is possibly a paradigmatic example of the growing importance of recycling, as it is reflected by the End-of-Life (ELV) directive, (released in year 2000), aiming to ensure that the car manufacturers take full responsibility for not only the disposal but also the recovery of their vehicles.

Nevertheless, aircraft production is still an exception to the rule, lagging far behind other industries. In fact, nowadays all the aircrafts are just disposed in the land after the end of their life, without being submitted to any dismantling or re-use operation. The problem is even harsher if we consider that, until 2024, it is estimated that about 6,000 planes will reach their end of life.

As an answer to this scenario, the NEMESIS project was built up over a series of previous R&D works, (most notably the PAMELA project) pursuing a series of well defined objectives, which can be described as follows:

1. Analyze the recycling market, defining the most important materials within the eco-design for airframes.
2. Development of an updated market survey, including the development of a forecast method.

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3. Definition of a recycling methodology for each component of the aircraft, classifying the technologies according to economic and quality variables.
4. Economic feasibility study of the materials and processes in the aircraft recycling.

In order to fulfil these objectives, a careful work plan was established, divided in a series of work packages, WP. The interrelation of these WPs as well as the main partners involved in each of them is shown in Figure 1.

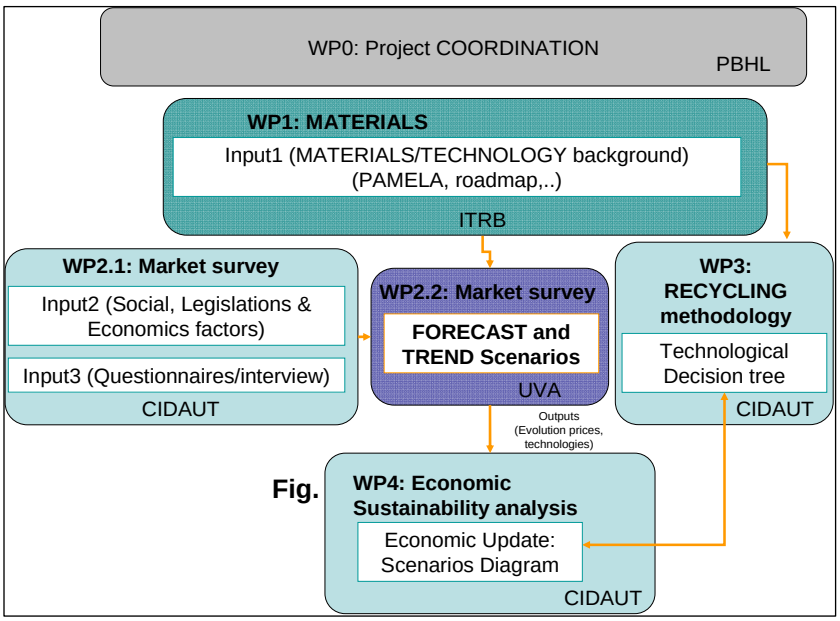

Fig. 2 Scheme of the project

3- PROJECT EXECUTION AND MAIN ACHIEVEMENTS

A fundamental result of the project, achieved in an early stage of its development as part of the WP 2, was the selection of the materials to be used in subsequent WPs. This final list was mainly decided between the partners from ITRB, CIDAUT and FRAUNHOFER.

With this final list of materials, it was performed a database, carried out by ITRB, specifying, for each material: Family (i.e. polymer/metal) - Description- Commercial name – Application and a series of Target companies (raw material buyers) (see Fig. 2).

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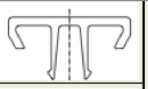
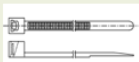
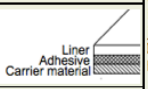
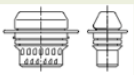
MATERIALS				APPLICATION		TARGET COMPANY
FAMILY	DESCRIPTION	COMMERCIAL NAME		LOCATION	EXAMPLE	RAW MATERIAL BUYER
POLYMERS	Polyamide	PA-XX	PA-12	Seat rail cover		a. Asahi Kasei / AZ b. Asahi Glass c. Dow (inc RHEM) d. Dow Corning e. DuPont HD Micro f. Fuji Film (Ciba Geigy) g. JSR Micro h. Nippon Kayaku i. Shin Etsu j. Sumitomo Bakelite k. TOK l. Toray
			PA-12	Seals		
			PA-66	Bracket for Cable		
			PA-66	Cable Tie		
	Polyphenilene	PP			LIMITED	
	Polyethilene	PE	PE-FL -xxx (PTFE) PE-FX-xxxx PE-FD-xxx	Adhesive tapes for foam single sided adhesive		
				Thermal Insulation	SHEET	
	Polycarbonate	PC	PC-D1-xxx PC-DC-xxx PC-DS-xxx	Flame retardant, low smoke emission	SHEET	
				Connector		
	Polysulphone	PSU			LIMITED	

Fig. 2 Fragment of "Final list of materials"

In a later stage of the project, FRAUNHOFER, ITRB and CIDAUT, created a questionnaire as part of WP 3, focusing the study on the following aspects: Presence now and in the future, Availability on the market, Market price, Forecast price and Qualification of the new materials.

This questionnaire was distributed among a series of companies in the field which was the basis to accomplish a comprehensive market study. The study of responses and their statistical analysis was carried out by UNIVERSIDAD DE VALLADOLID, verifying, whit this first analysis, the coherence in responses.

Based on the prospective methodology, the research team designed the scenarios that included all the representative variables and the values that experts had stated to be more likely to happen in the two periods: 2014 and 2023. The research team built four scenarios on this 2014 and 2023 horizon basis.

The analysis of these scenarios was carried out by UNIVERSIDAD DE VALLADOLID. It appeared clear that, the experts felt the uncertainty on the evolution of the relevant materials in the future.

The next step (WP 4) was basically the analysis of the technologies relevant for the recycling process, identifying, for each of them, some important parameters such as: cost of the process, final product quality, environmental impact and the technology readiness levels (TRL) of the involved technologies. Then it was needed to categorize them in terms of cost and technical quality as far as recycling is concerned; for that porpoise it was used the Concept Scoring Method using a scoring matrix to evaluate concept alternatives.

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In a next stage, also within WP 4, it was prepared an automatic decision tree (Fig. 3) enabling the user to select the most suitable technology route for recycling (not only a stand alone technology but a sequence of them) under two conditions: lowest cost or highest quality. This decision tree was developed for aluminium and carbon fibre, with the aim of extending the study to other materials in the future.

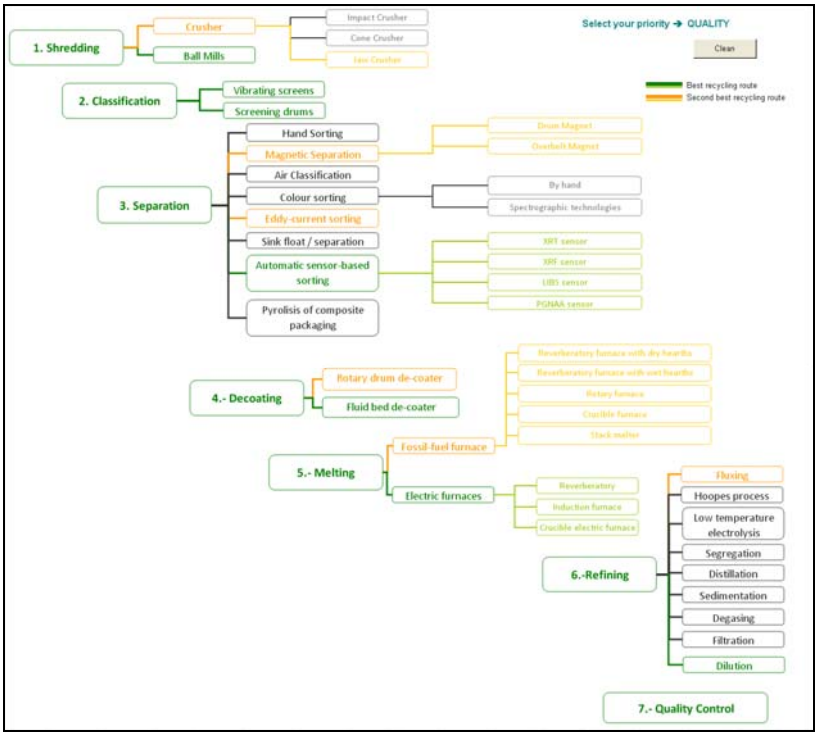

Fig. 3 Decision tree for Aluminum

Finally, it was carried out an application example in which the results obtained in previous tasks were integrated. To perform this example the Belly Fairing was chosen as the target component of the aircraft and the computer application was developed in Microsoft Office Excel. Therefore this application can easily be used for any other component of the aircraft. This study was developed by CIDAUT.

Late work in the project (WP 5) was mainly devoted to the collection by UNIVERSIDAD DE VALLADOLID of economic and historical data of the main variables analyzed (price and demand). The study vas focused in the most abundant materials of the airplane (aluminium and carbon fibre). With this historical data and by means of a statistical analysis it has been carried out a forecast calculation, including two different estimation models for the price and demand.

CIDAUT then compared these statistical results with those obtained in the Market Survey in WP 3. In the analysis of the comparison, it has been observed a wide range of opinions among the experts surveyed and important differences in comparison to the statistic study results.

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Finally, it was conducted an analysis of the feasibility of different methodologies studied in WP 4. For each of the methodologies it was analyzed different economical parameters and potential industrial applications were defined. It can be concluded that, as far as CFRP is concerned, the ratio properties/cost is still a big barrier for the recycling processes, whereas aluminium, appears to give much more promising options, although efforts towards cost reduction should be sustained to allow recycling a mass penetration in the industry.

4- POTENTIAL IMPACT

• Impact

With an in-depth technical, economic and even social analysis, the new NEMESIS methodology will enable all stakeholders to pull down the barrier of uncertainty at the time of launching a business in aircraft recycling. The key point yields in the usage of reliable data and models, which are structured in an easy-to-use, comprehensive tool, and even allows users to assess different market scenarios and associated risks.

The new tool is thus regarded as door-opening for recycling of aircraft, and as such it is expected to have a deep impact in the society, by several means:

In the first hand, it is necessary to consider that the range of enterprises potentially involved in recycling greatly spans from micro-companies of about 10 workers to largest multinational. Furthermore, the smallest companies are found in nearly every town or city of the EU. This pyramidal structure, with small and big companies cooperating together has in many chances proved to be optimum for economic development, particularly as far as jobs creation is concerned. Moreover, the high technologies inherently linked to aircraft recycling (beyond the undoubted benefits of cost reduction) can definitely contribute to maintain and reassure the privileged position of Europe within the global aircraft construction market.

Obviously, the impact in terms of environmental benefits can neither be dismissed. Nowadays it is estimated that about 15,000 tons are disposed. As a key tool for recycling, NEMESIS will allow to drastically cut that figure up to a reasonable limit of about 70% in the medium term.

Finally, we should cite as well the benefits in terms of energy consumption, which are inherently linked to recycling. This is particularly visible as far as one of the major construction material of aircrafts is concerned, the carbon fiber (more and more required by several sectors), since it is estimated that, in comparison with the use of virgin fibres, recycling is able to reduce energy consumption from the very high figures of about 200-300 MJ/Kg by nearly an order of magnitude.

In all, the new recycling methodology delivered by NEMESIS, will open the door to direct business opportunity for scrap recovery companies, and also indirect business with the use of secondary materials (as for instance recovery carbon fibres (rCF)) in new markets, notwithstanding, of course, a huge benefit for environment in terms of a drastic, but yet achievable reduction of land material disposal.

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• Dissemination

During the project, a Dissemination Plan was prepared by the NEMESIS consortium partners. In what follows, a description of the dissemination activities developed so far and those to be developed in the future is presented, including conferences and seminars.

At the beginning of the project, a visual identity including a logo for NEMESIS Project was developed:

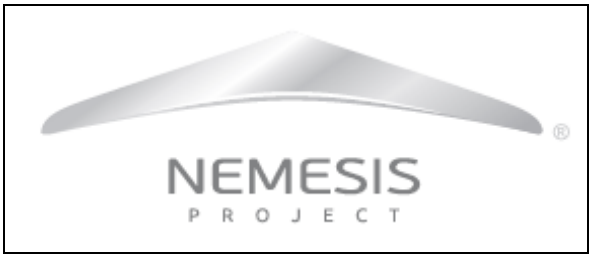

Fig. 4 NEMESIS project logo

This has been used to identify the project in the web page and other external communications.

Furthermore, the project website (www.nemesisproject.org) was designed by PBLH, to achieve the objective of promoting the dissemination of the project activities and the widespread of the non-confidential results.

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Fig. 5 Screenshot of the homepage of the website

Additionally, the activities and first developments of the project were disseminated through CIDAUT Newsletter, an online publication reaching over 1,000 recipients from fields ranging from the corporate, research and public sectors with whom CIDAUT has previously collaborated.

Furthermore, NEMESIS project activities and outcomes were disseminated in two events:

AIMERE Project Workshop: AiMeRe CleanSky is a project that studies how to improve the aircraft metal recycling of ageing aircraft at the end of their life cycle.

NEMESIS project was presented in the framework of this event by a member of NEMESIS project, Mr Rocco Lagioia, who gave an overview of the activities foreseen in the project and the future challenges that the consortium would have to address.

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Paris Air Show 2013: The consortium was present at this event, where awareness raising actions were developed among existing contacts, and the last version of the questionnaire was presented and distributed in order to gather the opinion of key stakeholders of the sector.

• Exploitation

First steps for the exploitation of the outcomes of the project (most particularly the newly created methodology) have been accomplished within the Clean-sky framework, to which the consortium has granted full access rights. Beyond that, the project has reinforced and consolidated the previously identified synergies between aeronautics and automotive sector in terms of recycling, as originally identified by CIDAUT, and published by the European Parliament[1].

Thus, NEMESIS constitutes a huge step forward towards the generation and implementation of trans-sectorial recycling concepts beyond the aerospace scope. It is the intention of the project partners to physically materialize these concepts in future R&D projects, within the Cleansky, H2020 Programmes or others.

5- PUBLIC WEBSITE ADDRESS

www.nemesisproject.org

[1] Technological Synergies between the Automotive and the Aeronautics Sector and their Supply Chains, Maria Teresa Fernandez, Ana Sofia Caires, CIDAUT Foundation, published by European Parliament 2009

(http://www.europarl.europa.eu/document/activities/cont/201109/20110906ATT25983/20110906ATT25983EN.pdf)