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PROJECT FINAL REPORT

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Project acronym: SUPLIGHT

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

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

1 Final publishable summary report

1.1 Executive summary

The majority of lightweight components are currently produced using virgin raw material. By using post-consumer, recycled material, the SuPLight project aims to provide technology to produce lightweight components that will help improve the sustainability of the transport industry. The production of virgin aluminium consumes a lot of energy, but the project is developing new industrial models for sustainable lightweight solutions. One of the project's key goals has been to design new alloys which can use up to 75 per cent or more recycled material. These new alloys have a slightly higher alloy element than virgin wrought alloys.

Many of the components used in the transport industry are currently produced using virgin raw material, or through closed-loop recycling within the production chain. By using post-consumer, recycled material, SuPLight aims to reduce the weight of these components. The mechanical properties of the product have to be on the same level as existing products that are based on virgin material, while the corrosion properties also need to be at the same level. Production efficiency is an issue here. Since more alloying elements is added it's harder to form the material – that reduces productivity, and some of the production processes currently used are not suitable.

SuPLight have developed new forming technologies to compensate for these types of issues, and while this may have an impact on the weight of the component, this is counteracted by its improved sustainability. The project is using a commercially available algorithm to assess the impact of new production methods throughout the full lifecycle of the component. The algorithm itself is based on commercially available tools, but its implementation and the way in which it's being used with the modelling tools has been developed in SuPlight. Researchers can use these tools to identify the specific impact of new production methods throughout the lifecycle of a product. The goal here is to be able to make corrective actions, preferably in the definition of the materials, products and processes to be used.

This reaches right back to the initial production methods. While virgin aluminum can be lightweight, it's also important to consider the energy used in its production. Test cases has been designed, where factors like energy consumption and carbon footprint have been calculated, based on established production processes. These test cases are used as reference points for what it is possible to achieve with new materials and technologies. This is an important element in the project's work in developing tools to calculate and simulate new processing and material routes for components, which may be central elements in transport safety systems.

A multi-disciplinary approach is required to provide this wide variety of information to system manufacturers. Three sets of simulation models are being developed within the project, calculating the impact of new products and technologies. SuPLight have developed a material model, which describes the developmental mechanical properties, given the chemistry and the heat treatment. The project has also developed a tolerance model, which calculates the geometrical tolerances, and how that may vary. The SuPLight product performance model is designed to help optimise the product's geometry, and an atomistic model, which is used to calculate the maximum impurity levels which can be allowed for a specific element. It is also developed lifecycle models, where we look at beginning of life, middle of life, and end of life calculations.

These components of course do not work in isolation, but as part of an overall transport solution. A framework for communication between software tools has been developed within the project, which brings important benefits such as automatised multi-objective simulations and optimisation.

1.2 Description of project context and objectives

The SuPLight consoritum is presented in Table 1.

Table 1 SuPLigth consotrium

Partner name	Type of enterprise
SINTEF Raufoss Manufacturing	Research institute
Gjøvik University College	University college
Raufoss Technology	Industrial partner – large
Misa	SME
University of Stuttgart	University
RD&T Technology	SEM
Ecole Polytechnique Fédérale de Lausanne	University
Université de Technologie Compiègne	University
C3M	SME
Hellenic Aerospace Industry	Industrial partner – large
Norwegian University of Science and Technology	University

Lightweight component and solutions are increasingly important for a more sustainable world, and in this case wrought aluminium alloys have large potentials for dramatic weight reduction of structural parts within transportation. One obvious example is the automotive sector where light weight solutions will be a necessity, regardless of the choice of energy source and energy carriage.

There is, however, a need to increase the post-consumer recycling of wrought alloy aluminium, due to the high energy consumption for manufacturing of virgin aluminium. Accordingly, there is a need for a holistic sustainable Life Cycle Approach for the light weight solutions including materials, products and manufacturing processes. Furthermore, there is a need for dramatically increase post-consumer reuse and recycling, even for high-end light weight components. The project will develop new methods and business solutions to increase and facilitate the reuse and recycling for wrought alloy high-end light weight components. This includes holistic design methods for materials and processes with Performance Indicators and design criteria for sustainability. This includes knowledge databases, toolboxes and organizational models for sustainable manufacturing and material selection. The holistic models will grasp societal, ecological and economic sustainability.

SupLigth address new industrial models for sustainable lightweight solutions – with 75% recycling in high-end structural components for transportation. Advanced optimisation algorithms are used for optimisation of product performance/weight ratio, tolerances and material-properties. The project has a holistic view with a life cycle approach. These underlying ideas, which also are represented as RTD activities in the SuPLight, are summarized in Figure 1 below.

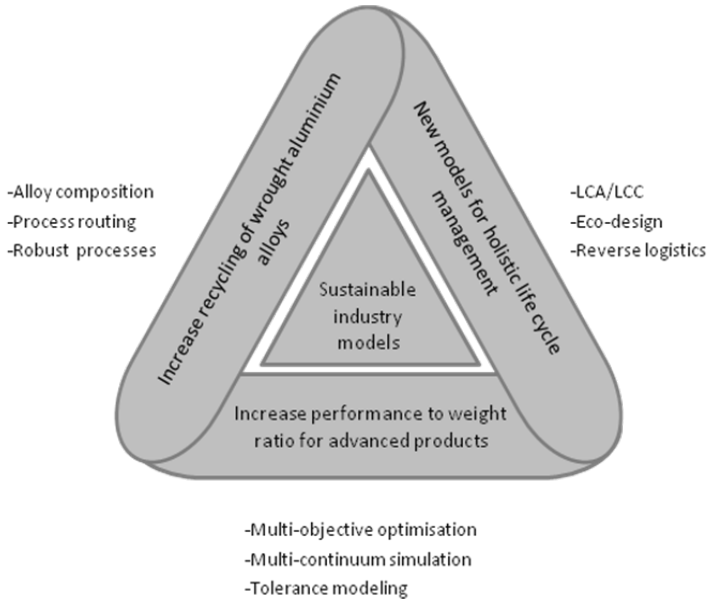


Figure 1 Overview of RTD in SuPLight.

Main objective of SupLigth*: Sustainable lightweight industry solutions based on wrought alloy aluminium*

Sub goals*:*

- *Advanced lightweight products from low grade input re-used materials*
- *Optimization of product weigh/performance ratio trough advanced optimisation algorithms*
- *More than75 % post consumer recycled wrought aluminium alloys*
- *New methodologies and tools for holistic eco-design of products, processes and manufacturing*
- *New industry models for sustainable manufacturing of lightweight solutions*
- *Lightweight solutions in a closed-loop life cycle perspective*

Reuse and recycling is a key issue for increasing the sustainability of light weight components, and there is a large potential for dramatically increase in material recycling. SuPLight aimed to demonstrate 75% or more post-consumer recycled materials for high-end aluminium products. This required new material and process knowledge on how to increase the usage of low grade input re-used materials in advanced light weight components. Better solutions and business networks for the recycling material flow where disassembly and sustainable inverse logistics had to be found. The ability to produce high performance products based on lower grade recycled input materials is an important contribution for sustainability with positive effects both on economy and ecology. Lower grade materials demands more robust processes, enabling larger tolerances on parameters such as alloy chemical composition. To achieve this, quantitative models for the correlations between material quality, manufacturing processes and product performance was established. Those models are based on both new knowledge created in the project and adaptation of knowledge from other areas of research and other industries.

Knowledge based and product and process development for sustainable solutions

Knowledge based development of sustainable manufacturing processes and high performance products are another key element in SuPLight. The project has implemented usage of simulation and analysis of existing tools for holistic product-process weight/performance optimization through multiple FEM simulations with parameter optimisation algorithms. By running multiple FEM simulations on a large number of possible product designs, the optimisation algorithms will find a close to optimum weight/performance ratio to de given constrains. Moreover, SuPLight has developed design methods for effective concurrent eco-design of products and manufacturing process with a holistic view to the total lifecycle. Zero energy, zero waste, nonpollution manufacturing, transportation and use, should always be the ultimate goal and there are huge potentials within an optimized combination of technologies and knowledge throughout the life cycle. Optimal tolerance distribution is one of the keys for process path decisions, as well as minimisation of losses during use phase (such as gaps in a combustion engine).

Sustainable manufacturing with Holistic Life cycle Approach

There exists a plenty fold of tools, methods and methodologies for sustainable product development and manufacturing. Today, the main barriers to sustainable industrial development are not the lack of strategies, models and tools, but how to implement them and how to introduce them into existing practices whilst ideally improving competitiveness. The project has focused its work specifically on sustainability in manufacturing and development of light weight solutions. The project intended to find new use for existing of eco-design methods and sustainable product development methodologies, by focusing on the customization and implementation phase. The goal was to design of new eco-friendly materials, manufacturing activities and processes, as well as the related light weight products. Both new applications of existing advanced materials and the development of new materials are covered. Cleaner and greener activities involving trade-off conflicting objectives, namely costs, technical feasibility and environmental impacts are addressed by the proposed new methods.

SuPLight industry models

The emphasis is put on a novel transferable modelling canvas for sectorial industrial model generation in material-information intensive sectors. The project findings are in the fields of material science, material data and methods resp. criteria for e.g. eco-design and will form the capabilities “material”, “data” and “methods, criteria” of the SuPLight industry model. The modelling canvas extends these building blocks with generic process models (building block “processes”) that are capable to layout lean and low environmental impact structures. To validate developed principles and to demonstrate the sectorial impact to the European competitiveness an information platform has be setup. By means of this platform the market perspective for supply and sales market as well as the enabling network are integrated to the model to help the operating organisations in the chosen industrial sector to align their capacities and business solutions. Companies, especially SMEs are addressed to find their position in the value adding architecture of light weight recycled aluminium products and to demonstrate which changes will have to apply in the related sector. The platform provide the following elements:

(a) Description of new materials, design restrictions with new materials and requirements towards manufacturing processes (eco impact from new material use)

(b) *Substance flow data,* life cycle data, FEM models/guidelines

(c) Eco design criteria /toolkit

(d) Generic support to eco-efficient development and manufacturing processes

(e) Supporting external stakeholders to set-up individual supply chain related network (expert-, supplier-, consultancies-, partner- identification) and to identify market opportunities.

1.3 Main S&T results/foreground

The summary of the main results of SuPLight are in the following divided into 4 main areas: New wrought aluminium alloys and processes based on post-consumer scarp, Simulation based optimisation of light weight solutions, Holistic life cycle approach, Sustainable industry models and SuPLight demonstrator.

1.3.1 New wrought aluminium alloys and processes based on post-consumer scarp

The activity within development of new aluminum wrought alloys and processes was aimed at providing the material data in order to support establishment of an aluminium technology based on scrap resources. The main focus was to find the solution for an increase in usage of low grade input re-used materials in advanced lightweight components. The starting point was a scenario, which assumed a wider tolerance in alloy chemical composition. This scenario requires a detailed study of consequences of variation in alloy chemical composition (both the alloying and the trace elements) on productivity and final product properties.

To reach the goal mentioned above, two sets of experimental trials were performed in parallel. The first one was focused on the alloy's recycling chemistry (Table 1) and its impact on productivity when the conventional production processing route i.e. forging value chain is in question. The second one was focused on simplifying of the conventional forging value chain in order to avoid potential challenges related to extrusion of the alloys of recycling chemistry. The emphasis was on concept development of fusion between casting and forging technologies. (Figure 2) Assessment of impact of the alloy's recycling chemistry on product properties is based on testing of the generic components produced through both processing routes.

The experimental data were applied in the following evaluation of the energy efficiency of production processes based on higher degree of re-used material and simplified production process. In addition, the technology feasibility regarding the environmental and economic impacts and availability of scrap was assessed.

Table 2 Model alloys

Model Alloy		Si	Fe	Cu	Mn	Mg	Cr	Ti	Zn	Ca	Li
Alloying elements beyond the standard	AA6082 – Refer.	1.05	0.25	0.00	0.54	0.81	0.13	0.02	0.02	0.00	0.00
	AA 6082+Si	3.73	0.23	0.00	0.58	0.84	0.13	0.02	0.02	0.00	0.00
	AA 6082+Fe	1.03	0.66	0.00	0.51	0.82	0.13	0.01	0.02	0.00	0.00
	AA 6082+Cu	1.02	0.25	0.91	0.51	0.75	0.12	0.02	0.02	0.00	0.00
	AA 6082+Fe+Cu	1.02	0.65	0.88	0.51	0.79	0.13	0.02	0.02	0.00	0.00
Trace elements beyond the standard	AA6082 – Refer.	0.98	0.15	0.00	0.43	0.69	0.13	0.02	0.02	0.00	0.00
	AA6082 + Zn	0.92	0.16	0.00	0.40	0.75	0.13	0.02	1.1	0.00	0.00
	AA6082 + Ca	1.06	0.16	0.00	0.49	0.64	0.13	0.02	0.02	0.08	0.00
	AA6082 + Li	1.03	0.16	0.00	0.51	0.77	0.13	0.02	0.02	0.00	0.83

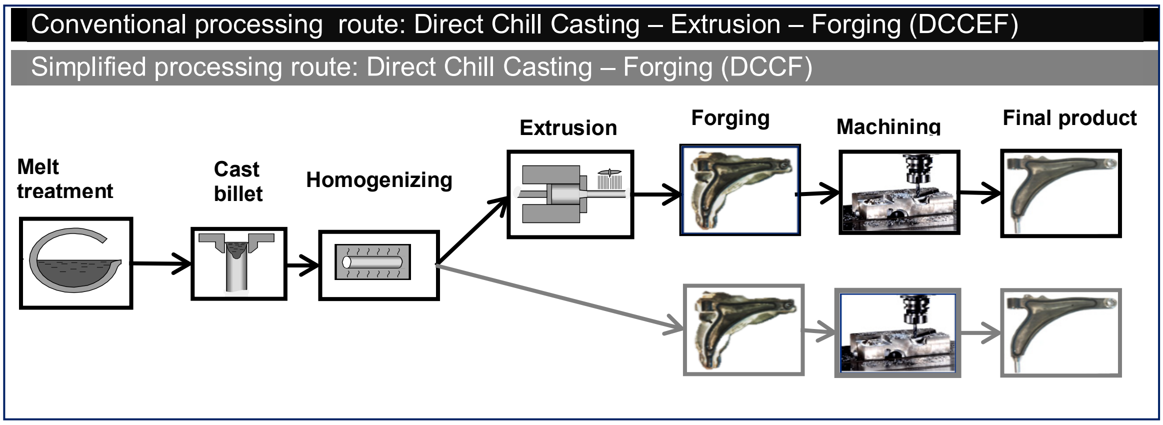


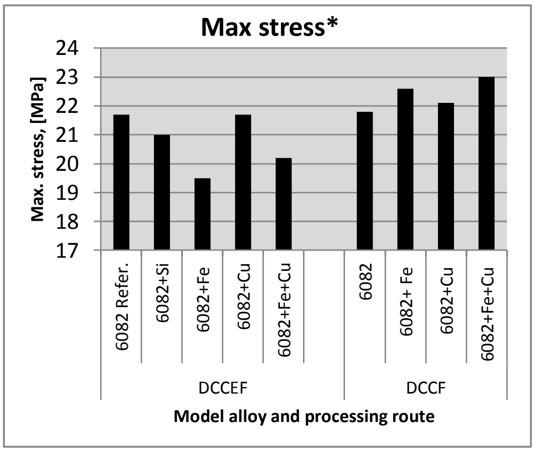
Figure 2 Conventional and simplified forging value chain

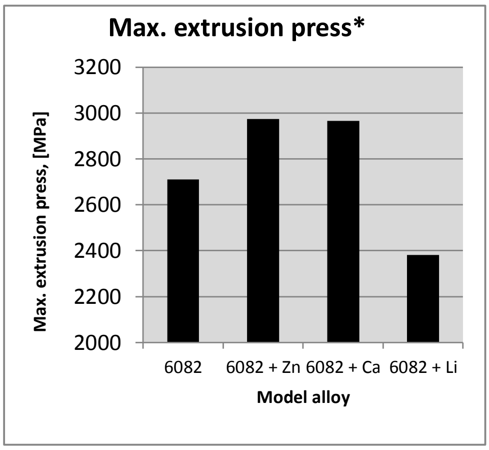
Th

- **Relative quantification of impact of the alloy's recycling chemistry on productivity**

    - **Formability**

      Productivity in the forging value chain depends on the alloy formability. Maximum press force required for forming of an alloy, at elevated temperature, is 'synonym' for the alloy formability. This parameter shows how easy or how difficult is to extrude or to forge one alloy. Figure 3 illustrate formability of the SuPLight model alloys.





*Results based on Gleeble test at 520°C *Results based on experimental trial

Figure 3 Formability of the model alloys with contents of the alloying elements beyond the standard one, and Formability of the model alloys with the increased content of the trace elements

- **Machinability**

  No major challenges were experienced during the machining tests performed on the model alloys with increased content of the alloying elements. Typical behaviors were confronted against principal milling and drilling processes that were put into practice. These conclusions are related to all generic components with regard to neither the model alloy nor the production processing route the components were produced in.

- **Relative quantification of impact of the alloy's recycling chemistry on performances of the product produced through both the conventional and the simplified processing route.**

In this regard, generic components in the standard AA 6082 alloy and in the model alloys of recycling chemistry were produced through both processing routes. Generic components were tested on:

- Static mechanical properties i.e. Yield strength (Rp0.2), Tensile strength (Rm), Elongation (A), and fracture strain (Figure 4 and Figure 5)
- Fatigue – number of cycles to failure; (Figure 6)
- Corrosion resistivity.

The conventional processing route generally gives products of better mechanical properties compared to those produced through the simplified processing route. Copper gave a considerable improvement in the tensile properties independent of processing route. Improvement in fatigue properties was especially significant. The most critical issue for the copper containing alloys is corrosion resistance. The alloy corrosion susceptibility increases with increasing copper content.

- **Static mechanical properties**

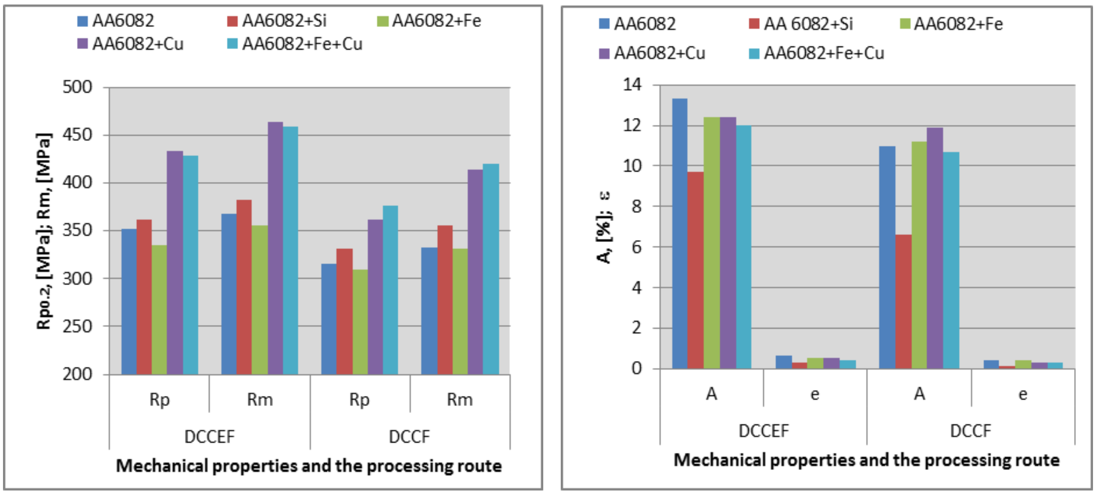


Figure 4 Mechanical properties of the model alloys with the content of alloying elements beyond the standard one

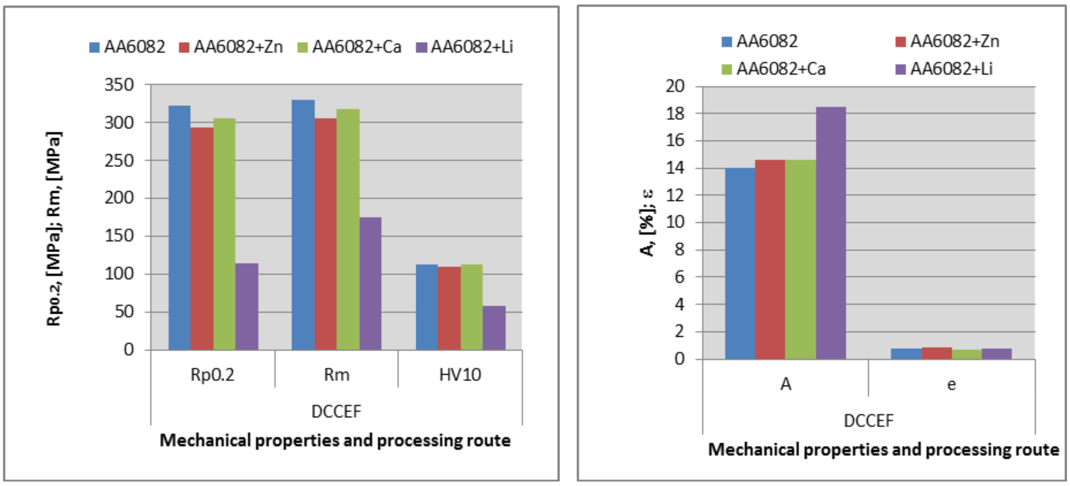


Figure 5 Mechanical properties of the model alloys with increased content of trace elements

- **Fatigue**

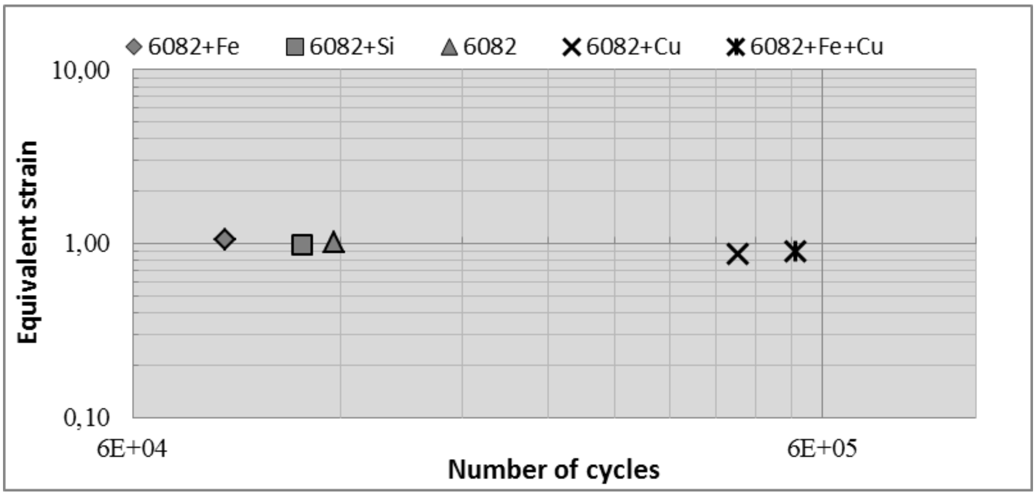


Figure 6 Lifetime of the generic component due to the alloy chemistry (DCCEF)

- **Corrosion resistivity**

  Presence of silicon and copper in the quantity beyond the standard one makes the AA6082 alloy more prone to corrosion. Lithium affects the alloy corrosion resistance in the same way.

- **Potential recycling level of wrought aluminium alloys in high performance products**

  It is found that the objective of using 75% scrap in the automotive component production is obtainable. All the considered scenarios gave savings in the environmental and economic impacts, but the magnitude of the potential saving varied a lot. As one would expect, the most preferred alternative would be to use a certain scrap source, for which the chemical composition is well known (e.g. a take-back system for the automotive component). However, the availability of this type of scrap is limited, and the purchase price of it is also quite high. Another good alternative would be to use the scrap output from sorted shredder scrap, but of course, this is limited by which scrap goes into the shredder and/or the sorting technology. A third alternative, which gives high reduction in the impacts, is the use of medium contaminated scrap, which is refined to the required level of purity by a combination of three-layer electrolysis and fluxing. The barrier for this alternative is a currently low use of this type of technology.

- **Statistical analysis of the Material properties**

  The Analysis represents an example of how archive data mining can prove to be useful in this context. In this case, Raufoss Technology's archive data were analyzed. Data modeling and inference techniques applied during the subsequent statistical analysis contributed to establishment of correlation between the alloy's chemistry and product's mechanical properties and based on this, to provide comparative study of materials delivered by different suppliers.

1.3.2 Simulation based optimisation of light weight solutions

The goal for SuPLight simulation based optimisation of light weight solutions was to establish an open framework for simulation-based optimization – Multi step, multi scale and multi domain model simulation. The framework links several modules called plugins together in order to perform various simulation and optimization tasks on demand. Each plugin provide an individual piece of expert knowledge relevant to part of the engineering design process, including sustainability, social and business factors. The open framework is generic and supports distributed, secure computing within the TAS3 Trust-Platform

(TAS3.eu). Plugins tailor the framework to domain-specific tasks, i.e. by integrating a diverse collection of expert knowledge covering all aspects of simulation-based optimization of light-weight products, in particular products based on recycled aluminium. The information required as inputs for the plugins varies considerably, from measurements and material properties for the more traditional FEM engineering plugins to more subjective evaluations and behaviors in the Ethical and Life cycle models.

Industry standard solutions for integration of computer aided design (CAD), finite element analysis/methods (FEA/FEM) and computer aided manufacturing (CAM) are already used to address some aspects of light-weight products. However, when characteristics originating from large-scale life cycle analysis, environmental sustainability, industrial models and political boundary conditions are included, standard solutions for evaluating the multiple objectives have not been developed. In Figure 7, below, an integration and intercommunication framework is sketched.

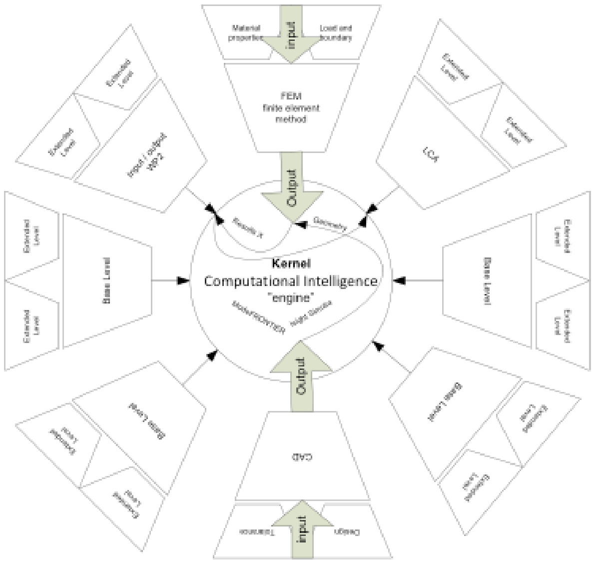


Figure 7 The kernel with fields of expertise communicating through the Kernel. Inputs and outputs relating to the respective expertise are commonly defined to enable independent development/implementation of the calculation modules from the various fields of expert knowledge.

<u>The main achievements are:</u>

- **SuPLigth Framework: Distributed computing through secure & privacy-preserving Trust Platform**

  The SuPLight framework is a web-based ICT system to deliver expert knowledge from many aspects of engineering, business and social policy in a single integrated service. Requirements and specification for the SuPLigth framework architecture, domain-specific extension modules, problem classes, and test criteria for the simulation-based optimization of lightweight solutions has been established. Process, interface and interoperability for common simulation environments were needed for, e.g. Abaqus, Forge3D, VASP, LS-Dyna, LS-OPT, Isight, modeFontier. Based on the different simulation and optimizations tasks within SuPLight the main simulation-scenarios were specified: Material modelling and alloy development, Computer-aided engineering, Process planning, manufacturing and quality control, Live-cycle analysis and recycling, and Industry models.

  Expert models are to be implemented within plugins, and linked to together in different combinations to evaluate the engineering design of components at different levels. Plugins under development within the SuPLight system support, atomic modeling of trace elements, metallurgical properties, FEM analysis, LCA and LCC evaluation, Socio-ethical considerations, reverse logistics and business models. These different plugins provide evaluations at different stages of the product life cycle. The sequences of plugins that are most appropriate to lightweight manufacturing are to be evaluated by holistic life cycle approach and industry models which are considering the application scenarios for SuPLight. Thus, they will evaluate which sequences provide solutions to specific question from the customers and users.

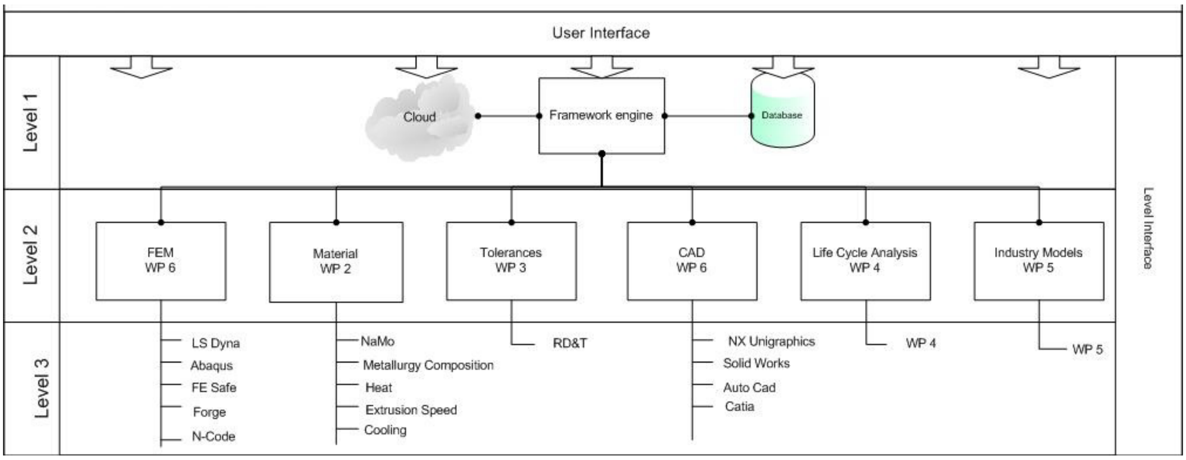


Figure 8 **The framework architecture and breakdown into three hierarchical levels.**

A further breakdown on the framework is shown in Figure 8. The framework's three hierarchic levels are defined as follows. The top level – Level 1 – represents the "User and Communication Interface" that enables the end user to interact with the lower functional system-level components and distributed, remote communication. The lowest Level 3 - "Framework Engine", is collecting and distributing inputs and outputs from the Level 2 "Expert Systems" that implements that the specific applications and in most cases interfaces that serve for interaction with the various expert and domain-specific modules and systems.

> ***Level 3***, as shown in Figure 2, is explicitly representing the various tools used with each field of expertise. In addition to the top level "User and Communication Interface" given at Level 1, there are user interfaces at Level 2 and 3, enabling a more precise access to computational implementations involved.
>
> ***Level 2*** identifies the selected fields of expertise included in the total framework. Therefore this Level 2 will be denoted as the "Expert System". In Figure 2 the current status of the SuPLight characterisation is shown.
>
> ***Level 1*** of the "Framework Engine" incorporates the simulation, multi-objective optimisation and runtime controls that enable searches within the solution space, allowing the creation of a "multi axis solution space" for exploration of the tradeoffs between the different objectives included in light weight solutions based on recycled aluminium.

Technically, SuPLigth implements the distributed computing, communication and data management platform using state of the art user-interface and content-management systems, e.g. web services and established platforms as Drupal. Partner GUC with its long and deep security-technology focus and the backing of one former EC research projects, i.e. TAS3, is able to provide the desired cloud-native personal-data ecosystem including an end2end trust-assurance framework, user-controlled personal data as big data. Moreover, a routable, pluggable analytics framework is capable of offering composite-algorithm workflows to help solve any computational task.

- **Material plugin: Simulations with advanced atomic-scale & material models**

The Material Model Plug-in is partially based on material data provided in experiments performed within SuPLight. The plug-in is aimed for modeling the behavior of the aluminium wrought alloys depending on the chemical composition. This may be found as very beneficial when dealing with the question of development of new alloys or even more the question of aluminium alloys recycling.

Principally, plug-ins data base contains data about chemistry of both selected standard alloys and different model alloys and corresponding material mechanical properties. On request about mechanical properties of some target alloy (alloy chemistry provided as input data from a customer), the plug-in returns the set of material parameters based on alloy selection (simple interface) or on chemical composition (advanced interface).

The plug-in also implements age hardening model, which is available for limited set of target alloys. Such a model simulates the material structure, which depends on its chemical composition and relates the structure with mechanical response of the material.

Innovative with this plug-in is that, by extrapolation, it is possible to predict mechanical properties of the target alloys and not only look for matching between the target alloy and some other alloy from the data base.

The Material plugin provides all the necessary material parameters for simulation tools used within the SuPLight framework based on chemical composition and processing route of selected alloy. The knowledge implemented in the plugin is based on experimental work done on new aluminium wrought alloys, literature sources as well as on the outputs of the material models developed within the scope of the project.

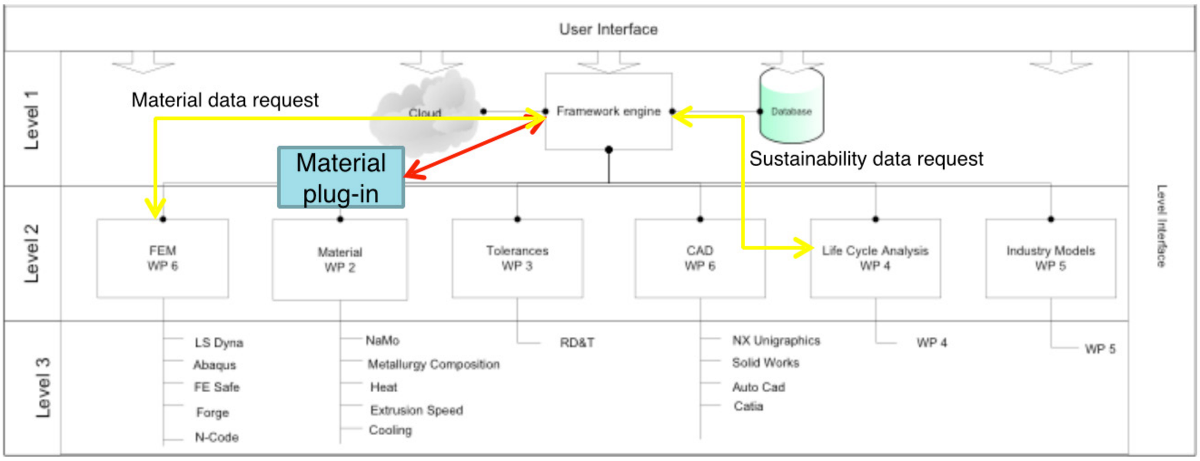


Figure 9 Integration and inter framework communication of the Material plugin.

Increased content of the recycled material used in melting process raises the level of trace level elements like silicon, iron and copper which lead to changes in material response in the process chain. Therefore it is important to provide simulation tools used in optimization loop with the suitable set of material parameters in order to increase the accuracy of the numerical modes predictions.

The data and literature on influences of trace elements on performances of aluminium wrought alloys is rather scarce and typically covers only specific feature of material performance. Therefore the project contributes to extension of this knowledge by experimental program and with development of material model. First the experimental program performed on new alumnium alloys in SuPLight has contributed new information about the material performance on wider range of parameters based on the variable chemical composition for the target alloys used in this project. Secondly the knowledge about material performance is target of material model for age hardening alloys which is also relevant for the target alloys and relates changes of particle size distribution which depends on its chemical composition with mechanical response of the material.

Based on this knowledge we have designed a material plugin which provide set of material parameters required for different types of FE analysis and sustainability model based on alloy composition and its process route. In this manner the complexity of material parameters dependency on chemical composition will become transparent to the user of the framework.

The numerical model for age-hardening of aluminium is based on work of Myhr and colleges. The model is dealing with age-hardening of Al-Mg-Si alloys under idealized conditions assuming spherical particles with uniform thermodynamic properties. The model has its roots in classical Kampmann- Wagner model but is well suited for the type of alloys that are in focus of this project.

The model can be divided into three major parts:

1. Nucleation law
2. Rate law
3. Particle size distribution

The nucleation law is described by nucleation rate equation which relates the rate to mean solute content so the nucleation stops when the matrix becomes depleted with respective component. Rate law is imposed by equation for critical radius for nucleation. If the radius is bigger than the critical radius then the nucleus grow otherwise its solutes.

Particle size distribution is the part of the model which is numerically complex. Two approaches have been implemented in the model and have been evaluated. Further on, the particle size distribution model has been extended to include a model for plasticity limit and hardness which are evaluated at each time step using current particle distribution. The presented cases are in full agreement with published results in the reference papers.

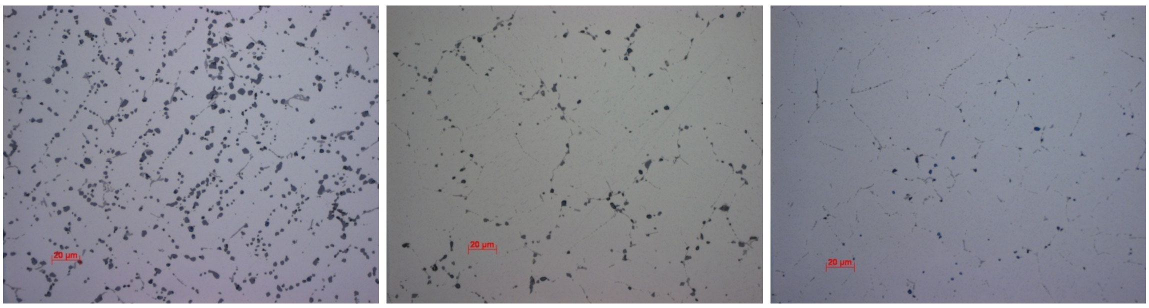


Figure 10 Different distribution of particles are resulting in different material properties.

Due to the known limitations of this model with respect to thermodynamics the additional model SFFK was implemented based on work of Svoboda, Fisher, Fratzl and Kozeschnik. The latter model gives the possibility to overcome limitations of the Myhr approach by allowing modeling of multicomponent and even multiphase systems. Developed framework allows wide range of adaptations of the model and introductions of additional components. Initial testing was performed using the thermodynamic data from literature and other sources.

When making a study of materials at atomistic scales, it is often very useful to apply analytical methods, since it may be hard to make accurate experimental observations at these scales, especially when it comes to strains in an atomic lattice. The development of accurate and reliable methods for electronic structure calculations as well as constantly improving supercomputers has made it possible to do very accurate quantum mechanical simulations of material structures at atomistic level.

In our model we have simulated the strain fields around single atom alloying and trace elements in substitutional phases. However, trace and alloying elements are often bound in larger particles, like atomic clusters, dispersoids or precipitates. We have considered those phases only indirectly, in that they are present in the alloy and thus put constraints on the amount of available matrix for the substitutional phases.

The figures below illustrate the reduction of the strain field when a Zn atom occupies a vacancy in the aluminium matrix. The strain fields of the other species of trace- or alloying elements have also been calculated.

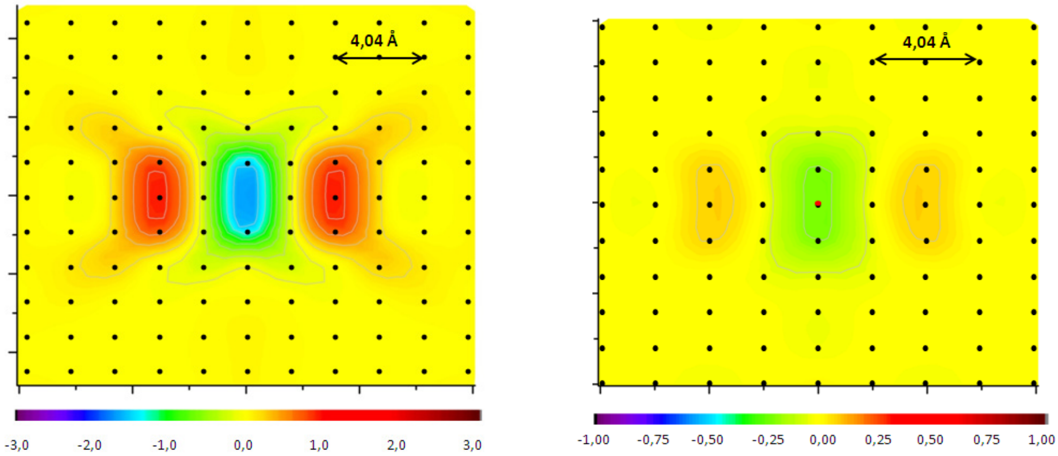


Figure 11 Contour plot of the strain field along the x-axis (horizontally on the figure) in an Al matrix around a vacancy (left) and Zn atom (rigth). The colour scale shows the deviation in percent from the bulk relaxed lattice constant in Al. The black dots designate the atom positions in the Al lattice. Note that the atoms indicated on the figure lie in two alternating planes in the z-direction.

- **Tolerance plugin : Computational efficient tolerance (meta) models**

The problem dealt with in the Tolerance plugin is that all manufacturing processes are afflicted with variation that needs to be considered during design. Along with variation in the manufacturing processes there is also variation in material parameters. Altogether, these variation sources will affect the final shape and size of the components and also the final assembled product. Successful handling of part tolerances and the use of accurate variation simulation to predict its impact on the geometrical quality of an assembled product gain sustainability from as well economical, ecological as social perspectives.

The Tolerance Module uses the simulation software RD&T together with a specially developed PCA-based meta-model to predict how variation in process and material parameters will affect final geometrical variation.

Typical inputs to the whole system are variation in process and material parameters and outputs are variation in part geometries and critical dimensions. Variation simulation in RD&T uses output from FEM-simulations. Here, output from FEM-simulations are a number of deformed meshes that are used as input to the Tolerance Module to create a PCA-based meta-model that is used for Monte Carlo based variation simulation in RD&T. The result from the simulation is variation in all nodes of the geometry which can also be the final output from the whole system. In case were this is not of interest for the users, variation in nodes (or critical points defined as input) can be checked against tolerance and Cp (capability) requirements and a GO/NOGO output can be delivered.

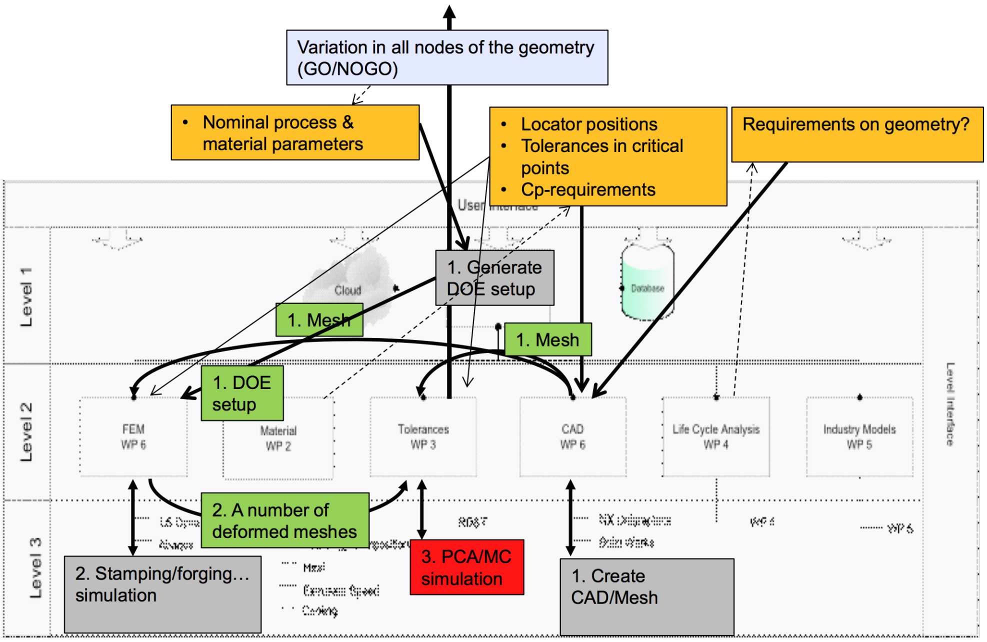


Figure 12 Integration and inter framework communication of the Tolerance plugin.

It has been verified that PCA can be used to capture the information contained in DOEs from both forging and stamping processes, and that variation in material and process parameters leads to geometrical variation. The Tolerance Module is so far focused on handling geometrical variation but can be extended to handle also other type of variation if relevant relationships/models are available.

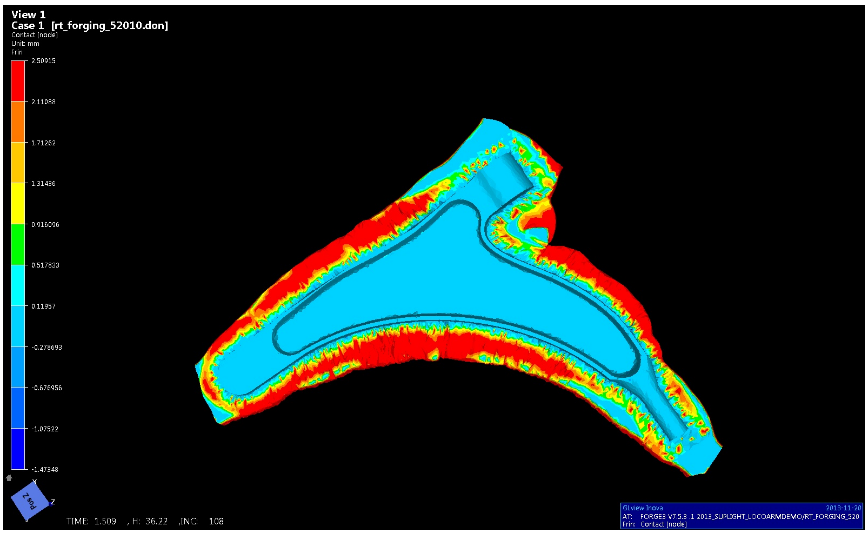


Figure 13 Tolerance Results - SuPLigth Demonstration case.

1.3.3 Holistic life cycle approach

The main objective of SuPLight holistic life cycle approach has been to develop methods and tools to be used for evaluation of sustainability of the lightweight solutions. For evaluation of sustainability it is necessary to have a life cycle perspective which means that all the activities through the life cycle of the product should be taken into account. The whole product lifecycle consists of a set of processes, which are functions or tasks to create, transform, and deliver products. The product lifecycle may be categorized in three major phases; beginning of life (BOL) including conceptualization, definition and realization, middle of life (MOL) including use, service and maintenance, and end of life (EOL) characterized by various scenarios such as: reuse of the product with refurbishing, reuse of components with disassembly and refurbishing, material reclamation without disassembly, material reclamation with disassembly and, finally, disposal with or without incineration. Having a life cycle perspective helps avoiding problem shifting in between the activities throughout the life cycle of the product.

Sustainability is always thought to be related with the environmental impact of the product, however it has three pillars; environmental, economic and social; which makes the evaluation of sustainability a quite difficult task. It is time consuming and data intensive. Holistic life cycle approach, presented in Figure 14, takes into account all life cycle phases/the whole life cycle of a product and generates sustainability performance characteristics (technical, environmental, economic and social) in order to be used for decision making by the life cycle actors.

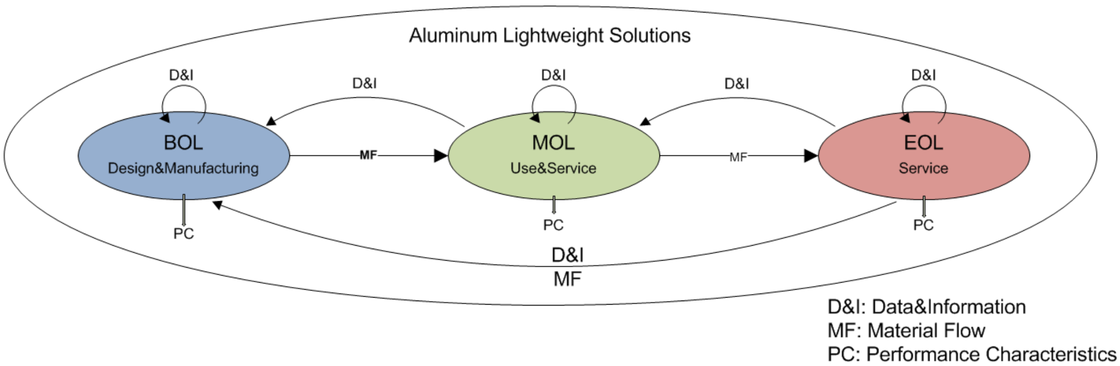


Figure 14 Holistic life cycle approach

Based on the value chain of the wrought aluminum alloys presented in Figure 15, and alternative material and production routes, several scenarios have been determined in order to evaluate the environmental and economic impact of using recycled material and changing the production route. Material and information flows to accomplish the scenarios have been determined and the life cycle inventory for the LCA&LCC tool has been determined.

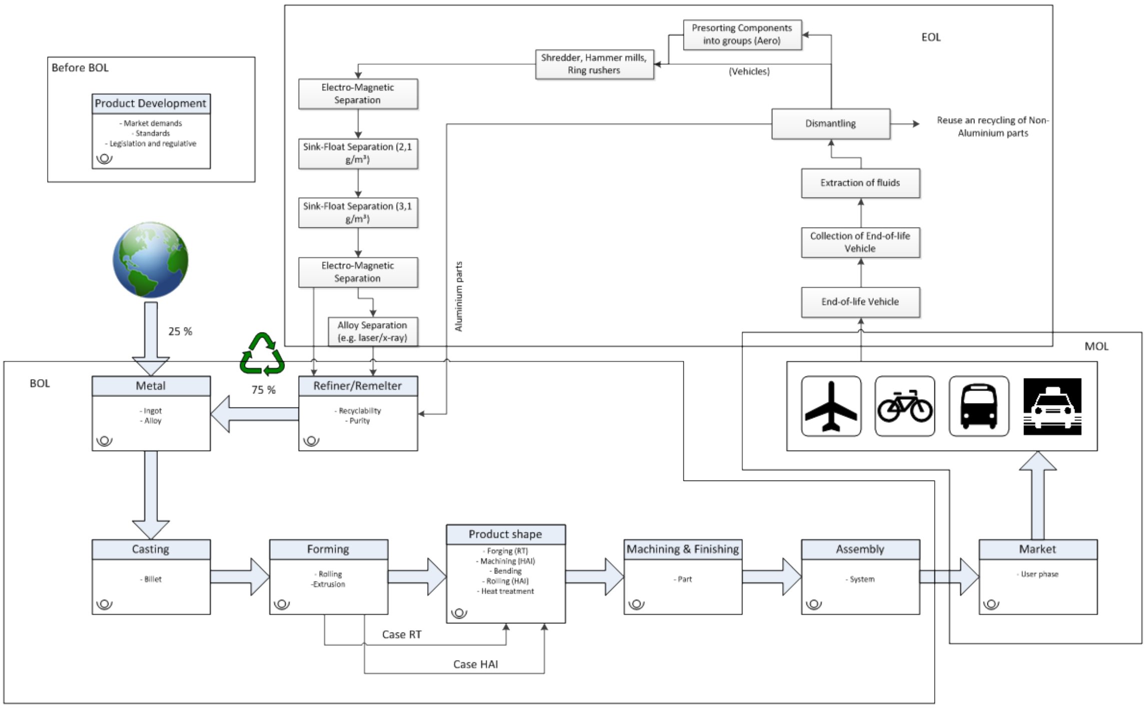


Figure 15 Value chain - Wrought aluminum alloys in transportation

__The main achievements are:__

- **SuPLight life cycle model**
  A life cycle model for the SuPLight case study vehicle front lower control arm has been developed. The model is illustrated in the Figure 16 below. The grey boxes represent materials and the blue boxes represent processes. The green arrows indicate material flows that can be varied when evaluating different scenarios.

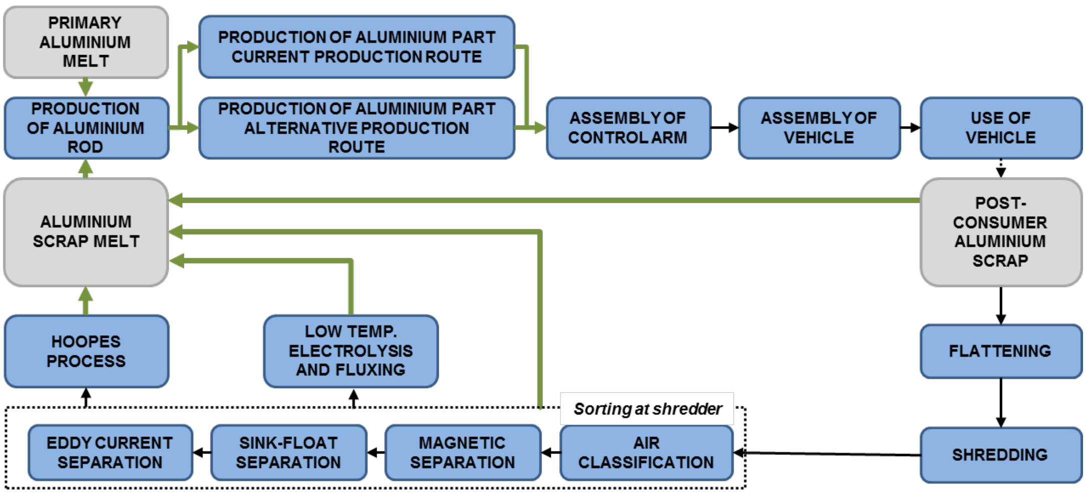


Figure 16 The SuPLight life cycle model

The model includes BOL, MOL and EOL of the vehicle part, covering its relevant characteristics for both LCA and LCC analysis. MOL comprise production of primary and secondary aluminum, production of the aluminum rod and the aluminum part of the control arm, assembly of the control arm and assembly of the vehicle. Production of aluminum scrap can be done with different technologies, from collection of specific post-consumer scrap, sorting and refining (low temperature electrolysis, fluxing and Hoppes). MOL is the use of the vehicle through a lifetime of 200 000 km. EOL comprise of collection and transport of the vehicle to scrap treatment facilities. In Figure 16, the production of the aluminum part of the control arm is illustrated in one single box.

However, this is modelled detailed in the LCA/LCC tool, as depicted in Figure 17. Both the current and the alternative production route of the control arm are included.

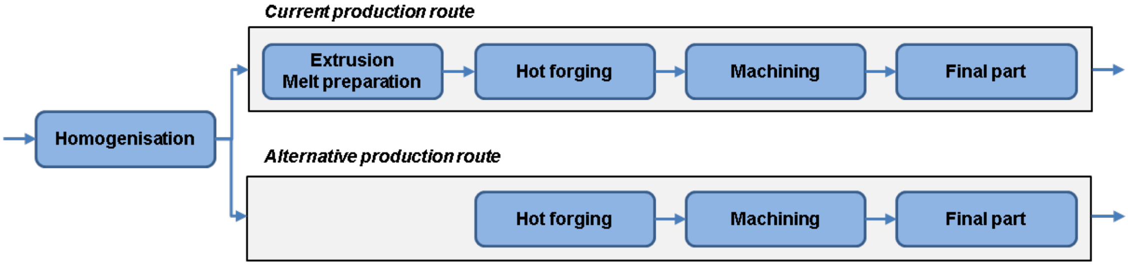


Figure 17 Production of the front lower control arm

In a wrought-to-wrought scenario, the aluminum rod for the control arm is produced from a mix of primary and scrap aluminum. This is in contrast to the current situation, where it is entirely made from primary aluminum. Results from four scenarios compared to the current practice are given in Figure 18, and this illustrates the potential application of the tool.

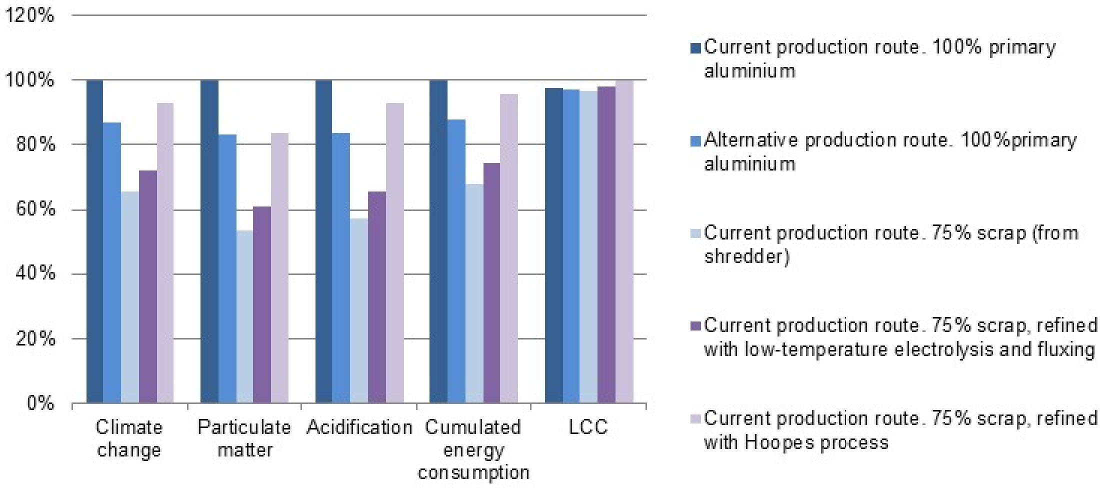


Figure 18 Results for four scenarios compared to current practice

The scenario that performs best in all categories included here is the current production route with 75% aluminum scrap from shredder; with savings in environmental impacts from 55 to 65%. Besides the life cycle costs, all scenarios including use of scrap, and the alternative production route is a better alternative than current practice. The alternative production route performs significantly better than current practice, as this consumes less aluminum per control arm produced. The life cycle costs for the scenarios including refining of aluminum scrap are higher than the other scenarios, as the refining technologies are quite costly. This analysis illustrates that decisions made in production is highly relevant for the environmental and economic life cycle performance of the vehicle front lower control arm. These decisions concern whether to use scrap in production and in this case; which grade of scrap to use, and choice of production route.
A model for the second SuPLight case, the HAI airplane door hinge has also been developed. This model is set up identical to the control arm model, but the production and use phase differs of course. There is only one production route included, which implies that there is no variation in the amount of aluminum consumed here.

- **Reverse logistics and Ecosesign models**

In order to develop a reverse logistics plugin, a framework for RL design was defined based on a literature review. The developed RL design method incorporates two problems: location/allocation of facilities and choice of suppliers. It uses a multi-criteria decision making method: Analytical Hierarchy Process (AHP). The developed plugin supporting this method was used in order to design the RL chain for Raufoss Technology and it was integrated to the SuPLight Platform. It sends and receives data from several SuPLight plugins. Figure 19 summarizes the results of this sub-task: the RL reference framework, the developed RL design method and the developed plugin. The plugin's interface for presenting a scenario is presented in Figure 20.

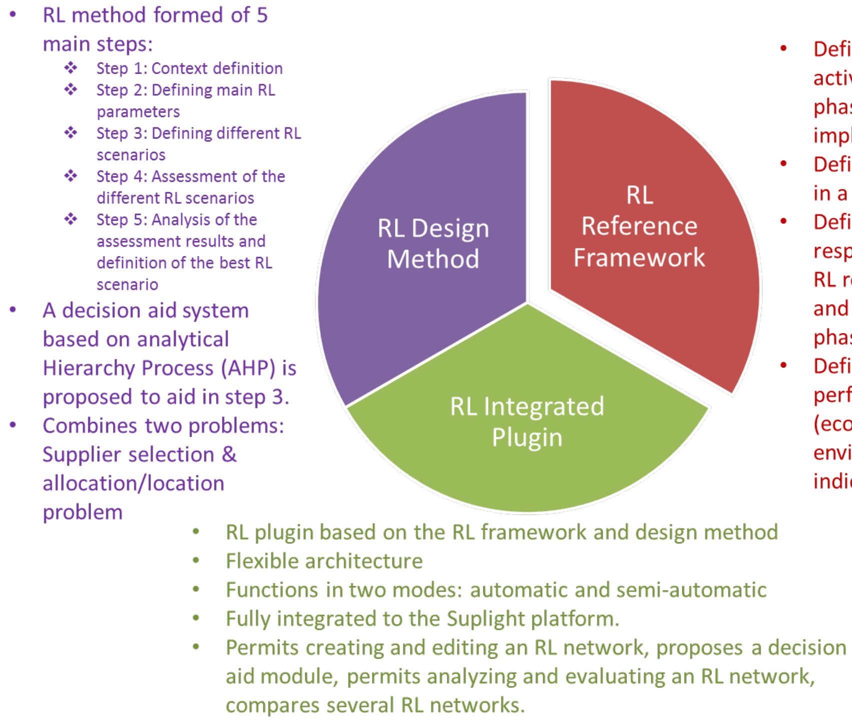
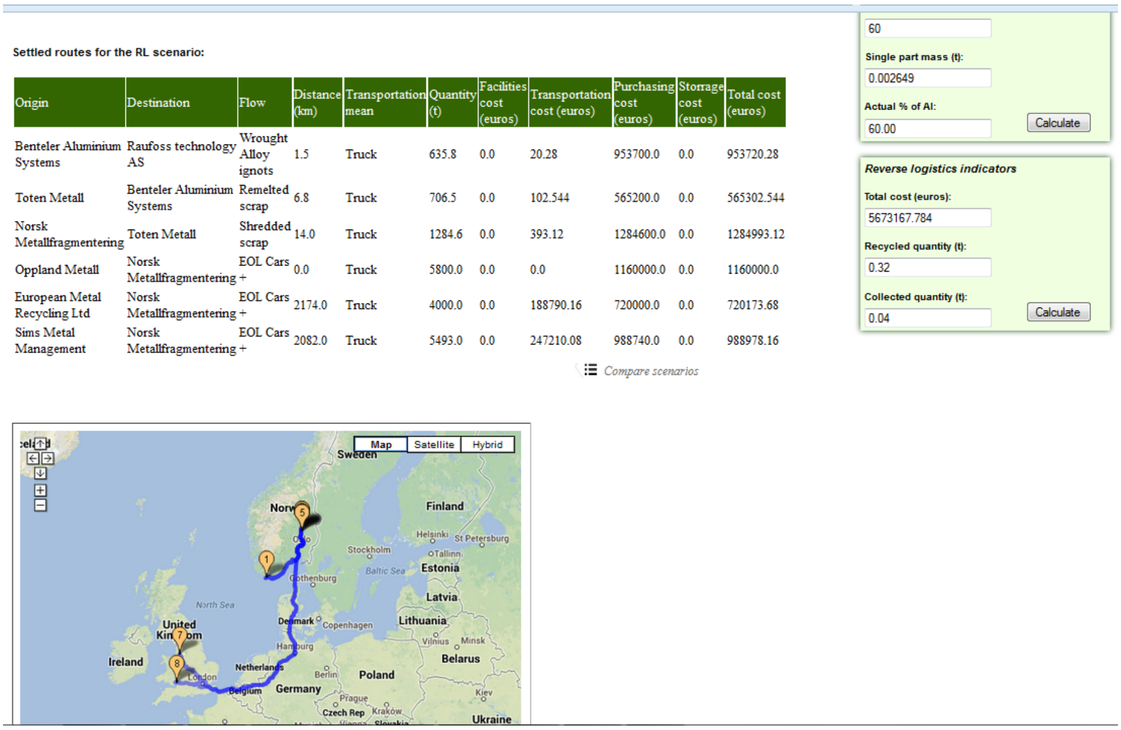


Figure 19 Summary of Reverse Logistics Task results



Settled routes for the RL scenario:

Origin	Destination	Flow	Distance (km)	Transportation mean	Quantity (t)	Facilities cost (euros)	Transportation cost (euros)	Purchasing cost (euros)	Storrage cost (euros)	Total cost (euros)
Benteler Aluminium Systems	Raufoss technology AS	Wrought Alloy ignots	1.5	Truck	635.8	0.0	20.28	953700.0	0.0	953720.28
Toten Metall	Benteler Aluminium Systems	Remelted scrap	6.8	Truck	706.5	0.0	102.544	565200.0	0.0	565302.544
Norsk Metallfragmentering	Toten Metall	Shredded scrap	14.0	Truck	1284.6	0.0	393.12	1284600.0	0.0	1284993.12
Oppland Metall	Norsk Metallfragmentering	EOL Cars +	0.0	Truck	5800.0	0.0	0.0	1160000.0	0.0	1160000.0
European Metal Recycling Ltd	Norsk Metallfragmentering	EOL Cars +	2174.0	Truck	4000.0	0.0	188790.16	720000.0	0.0	720173.68
Sims Metal Management	Norsk Metallfragmentering	EOL Cars +	2082.0	Truck	5493.0	0.0	247210.08	988740.0	0.0	988978.16

Figure 20 RL plugin interface representing a Reverse Logistics network

The eco-design method aims at enabling designers to become aware of environmental issues related to their task and help them assess and generate new design scenarios. It relies on two interconnected activities emphasized by a literature review: (1) a simplified environmental assessment of design alternatives providing results in a visual comparative way; (2) an environmental improvement thanks to dedicated lightweight environmental guidelines and inspirational sheets specific to lightweight applications. Based on the ecodesign method, the eco-design plugin results from the customization of an existing software tool integrated to the SuPLight platform. The structure of the proposed method is presented in Figure 21, and an example of ecodesign guidelines for BOL is presented in Figure 22.

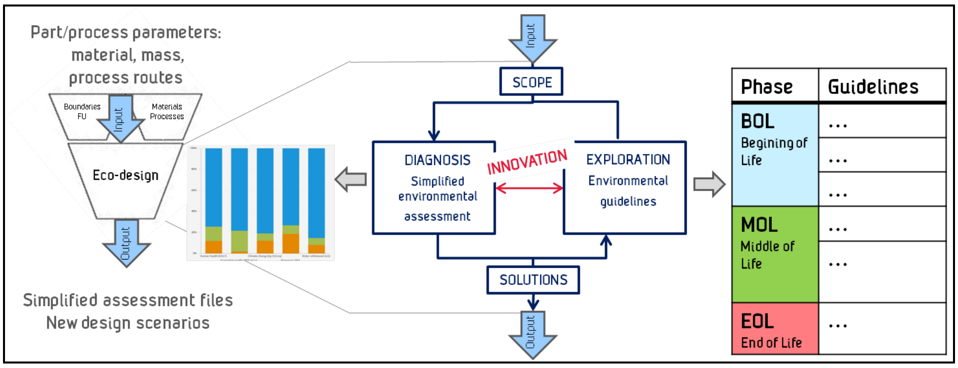


Figure 21 Structure of the ecodesign method

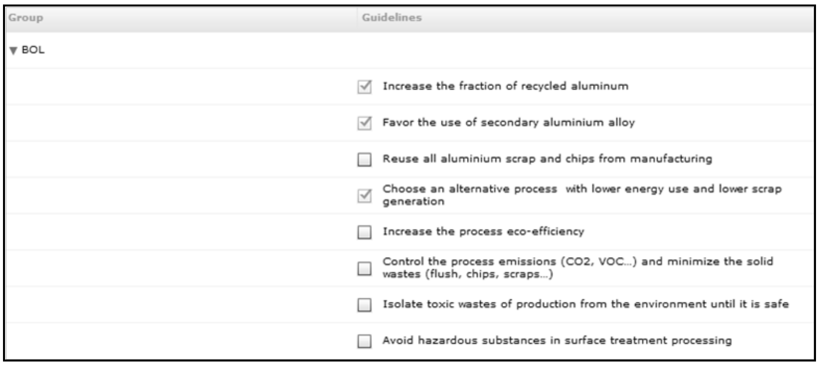


Figure 22 Example of ecodesign guidelines for BOL (Beginning of Life)

- **Socio-Ethical model**

The socio-ethical plugin is used to assess the human and social factors involved in the production of a component. The social and political environment in the companies and countries of origin for the virgin aluminium and also for the sources of recycled material need to be analysed. Their working conditions, health and safety, effects on the local communities and their environment; which are all potentially far from the point of manufacture or use, are still equally important to the social and ethical quality of a product.

The Socio-ethical plugin is expert operated and not necessarily dependent on the earlier plugin sequences. They could however be used to provide the expert user with data for the decision making on appropriate input values for this plugin.

1.3.4 Industry models

Innovation networks

Innovation networks are influenced by multiple factors. Every company which participates in an innovation network provides specific core competencies. The basis for every technology driven innovation network is a technological value proposition that has the potential to result in market revenues for network partners. In the context of this work it is not important whether the technological value proposition concerns a product or a process innovation. There are multiple reasons for cooperating in networks. To name some of them, it can be the lack of financial power, manpower, lack of market know-how or a strategy induced decision not to cover a task or value adding step with own resources. The company might have insufficient technological know-how or improper own technical assets. The search for partners is affected by different parameters. Possible partners need to have a special core competence and in most cases also need technological know-how and resources. As soon as feasible partners are found, it is necessary to commune the technological value proposition. The level of communication changes from an intra-organizational one to an inter-organizational communication. An important factor at this point is the trust between partners since valuable and secret information will be distributed and shared within the innovation network. Additionally judicial framework requirements need to be created.

In this research, self-organizational characteristics of networks play an important role. A network's most valuable resources consist of "already existing core competencies, already internalized complementary assets, and completed organizational learning". To get there, the acquisition of new knowledge plays a superior role. The network needs at least a minimal organization structure providing the ability to identify new possibilities, to share knowledge and to enable self-organization within engineering procedures. The identification and knowledge sharing process aims to provide added value to network partners in one specific technological field. To benefit from this added value, it is essential for partners to have the instruments to combine core competencies and complementary assets and to assess the resulting combinations. Product and process innovations in networks are based upon solving technical problems as part of such a network wide learning process. The main objective of a network strategy is to find the balance between those opportunities and threats that every continuous successful network might be offered or confronted with. Moreover, every member of a network will continuously evaluate new opportunities and threats in order to decide whether to stay in the network or to withdraw from it. The network's ability to recognize the interest and the capability of partners to join or stay within a network is essential to the self-organization abilities of an innovation network. To successfully enable self-organization, corresponding framework conditions are required. These are a common picture concerning technology matureness and the industry life cycle stage and weather there are analogies in other industries. The technological expertise of individual partners, the existence of interfaces and relation matureness between participants and their competitive positions should be made transparent within the network.

Organization of industrial systems

An industrial system can basically be characterized as a complex system. An applicable definition of complex systems is given by businessdirectory.com: "Consisting of many diverse and autonomous but interrelated and interdependent components or parts linked through many (dense) interconnections. Complex systems cannot be described by a single rule and their characteristics are not reducible to one level of description. They exhibit properties that emerge from the interaction of their parts and which cannot be predicted from the properties of the parts." In contrast to chaotic systems there are forms of self-organization within complex systems. The complexity of a system can take two different characterizations disorganized complexity and organized complexity. This duality was emphasized in the litterature, as the key to managing complex systems by framing harmony of both dimensions. Such systems are called 'chaordic' and shaped the term 'chaordic system organization'. The term chaordic system means "any self–organizing, adaptive, non-linear, complex system, whether physical, biological, or social, the behavior of which exhibits characteristics of both order and chaos or, loosely translated to business terminology, cooperation and competition."

The main achievements are:

- **Systemic Analysis Methodology**

  For the analysis done in this research a five-step approach has been applied.

  Step 1: A workshop with project end-users resulted in clusters with relevance for innovation planning.
  Step 2: The clusters have been described with mostly empirical factors from several analyses, which build on comparable factor analyses.
  Step 3: Through the multiple-squared-matrix-based mathematical MICMAC approach, direct and indirect cause-and-effect chains have been identified and assessed.
  Step 4: Identification of "impact generators" by graph-theoretical system grid examination.
  Step 5: The identification of causal inter-dependencies is the key to a deeper understanding on how the dynamics work. The most significant dynamics have been explored to allocate single factors to integrative model visualization that is shown in Figure 23.

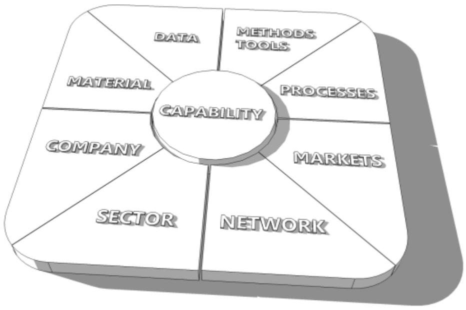


Figure 23: SuPLight industry model mesh

Social platforms gained importance in many remarkable areas of application during the last decade. The paradigm of enterprise 2.0 with its various applications is foremost a way of managing internal collaboration and interfacing with customers. But also over-organizational collaboration in the operative business is currently evolving as an application field. Social platforms function as knowledge repositories with advanced search functionalities, as communication means and as engagement means for establishing and managing relationships – on private, public and industrial level.

- **Actor integration and organization on social platforms**

An interesting joint specification of all social platforms is the form of organization that seems to occur within the users. The platform, unless which functions it has and which purpose it serves, structures the participation of users and channels interactions. Moderation within interaction streams acts as a controlling instance to reduce redundancies and the compliance to some basic rules. Contrary to the classical network organization, users are fairly free in their usage. In that understanding, the organization of social platform has two aspects: chaos and order. This might potentially be an application field for chaordic system organization. In fact, social platforms are self-organized to a major extent. This principle is based on intrinsic motivation and has the ability to lead to successful applications in complex networks. Transparency on participants' competencies and interests in connection with available information and existing networks enable flexible process-oriented information transfer and processing.

Social software allows advanced combination of metadata and content. The creation and editing of links between different information sources reduces redundancies and allows the creation of structures that support users in the handling of information. Social software is mostly modular, task-oriented and data-oriented which offers a high grade of adaptability to specific user requirements. To be successful, social software systems have to be designed in accordance with user activities.

- **Structural composition of the industry model**

Planning a technology based innovation process and the corresponding industry model first of all needs the technological "seed". This will basically be the technological value proposition. If that additional value which shall be delivered by a new technology is known and a first idea of how to bring the technology to daylight exists, a planning process will be launched.

Figure 23 provides a legend for the structure of the subsequent sections. The following sections give an insight on how the planning process might be structured according to the SuPLight industry model mesh.

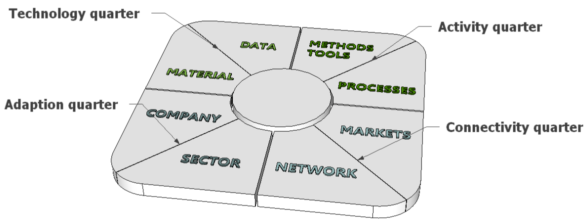


Figure 24: Legend for subsequent sections

To qualify a social platform as a tool for operational planning and development of an innovation, it needs to offer the modular data-handling abilities. This is where the mutual benefits from SuPLight's framework and the industry model perspective evolve. SuPLight's social platform is at the same time the access point to the plug-ins from technical work packages and the organizing instance of an over-organizational innovation planning and development process. This process comprises the planning range of an innovation lifecycle as shown in Figure 25. Plugins that support the lay-out of processes are those that deal with reverse logistics, eco-design, LCA and sustainability in the case of SuPLight.

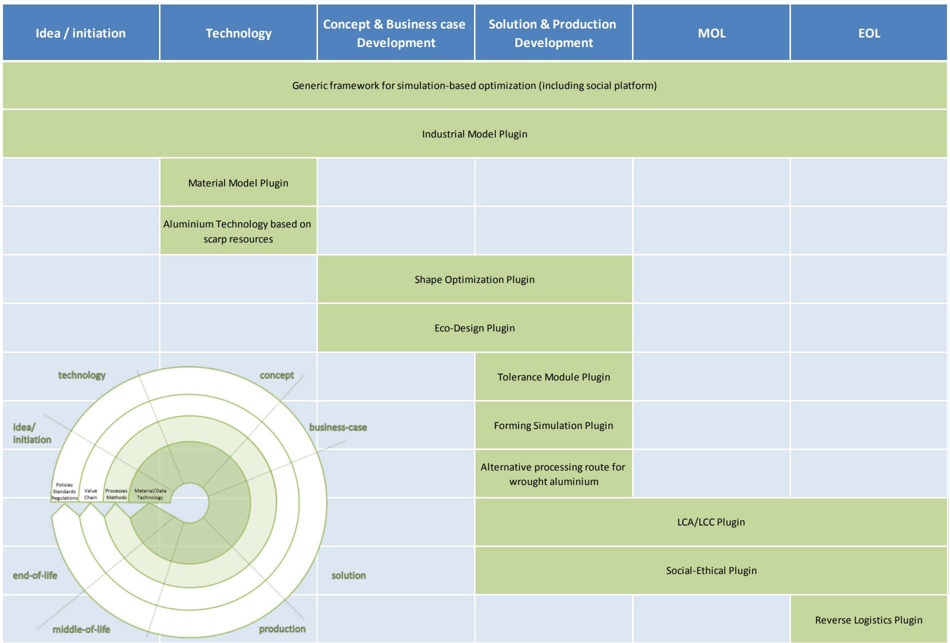


Figure 25: Planning range of SuPLight plugin use

Connectivity Quarter

The connectivity quarter is the tool to plan multi-disciplinary and inter-organizational collaboration between the actors. The driving question for modelling this part of the industry model is: What is the optimum for decentralized engineering and focusing on core competencies? Within SuPLight, the BE@T concept was developed (business ecosystems based assessment of technologies). The networks that evolve on a web 2.0 platform are not contract centric. Hence, those task-oriented partnerships of convenience function similar to conventional B2B ecosystems where the Arthur D. Little (ADL) technology portfolio can be applied. The concept which is schematically shown in Figure 26 makes use of the business ecosystems' strategies and roles and combines the resulting setting to the abilities of network members concerning a certain technology concept. Who will benefit in which way from collaboration, how can a new equilibrium in the value chain be achieved?

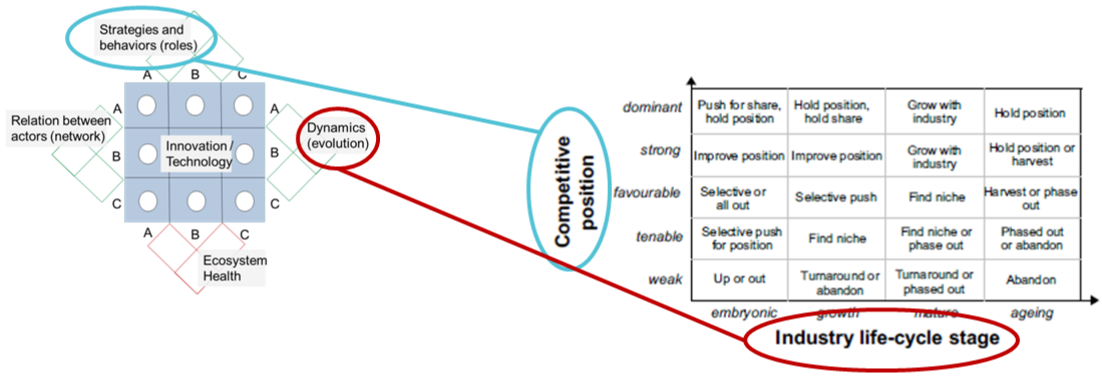


Figure 26: Be@T scheme (left) and assignment to ADL norm strategies (right)

To grant the network the ability to adapt an industry model an easy to use assessment-logic was developed and implemented into a prototypic web application. The input part starts with the classification of the surroundings. The innovation/technology life cycle stage and matureness as well as analogies in other industries (where learning effects can be found) are asked. The next step is the retrieval of partners' individual 'technological expertise'. To get information on the business ecosystem instance 'relation between actors' the (past and future) existence of interfaces between participants and based thereon their roles or ecosystem behaviors in terms of 'competitive position between participants' are classified. The last input step is the request for the 'relation-matureness between participants' for existing interfaces between participants. These are important pieces of information to make conclusions on the network dynamics or its evolution in business ecosystem terms. All collected information are then put in their mutual context and assigned to risk classes and corresponding norm strategies as they can be found in the ADL portfolio. As a summarizing visualization of the ecosystem health a heat-map is generated. Hot spots in this graph refer to connections between companies with a higher risk level for network co-operation and industry model adaption (e.g. asymmetrical power distribution or abilities concerning the technology).

- ## Inspection – Determining the fruition of an industry model

Similar to business models, industry models in the understanding of SuPLight are means to deal with architectural aspects. This fills the gap between strategic planning and operative engineering work in company networks and is aimed to function as a planning tool foremost but also as a framework to inspection of industry model performance. This chapter gives an overview on how permanent inspection of all factors that were classified as relevant functions.

Technology quarter (Materials and Data)

The technology quarter subsumes all primary technology related aspects within an industry model. The inspection of these aspects covers basically three factors: technical firm assets, technology acquisition and degree of technological interweavement. Technical firm assets are being inspected by the individual firm itself in the context of network objectives. The assessment bases on the comparison of nominal and actual values. The efficiency of production facilities, own technological capabilities and infrastructure, as well as potentials for economies of scale and technical experience are subject to the assessment. The assessment of technology acquisition covers the firm's abilities to technology procurement (e.g. by mergers, shareholding and joint ventures) and technology exploitation in line with the network objectives. The degree of technological interweavement is assessed by the network by evaluation of potentials or burdens of technological interdependencies with inter- and intra-organizational customers, suppliers, competitors and other institutions.

Activity quarter (Methods, Tools and Processes)

The activity quarter subsumes all aspects related to process, tools and methods within an industry model. Relevant to be planned and reviewed within the network are the innovation development process and innovation adaption routines. Concerning the innovation development process it is important to define the minimum order of tasks and establish means for progress control. Innovation adaption review means the continuous assessment if the "way to get there" still is the right regarding the current product requirements.

Connectivity quarter (Markets and Networks)

The connectivity quarter subsumes all aspects related to markets and networks within an industry model. The inspection of those aspects has is done by comparison of nominal and actual values for complementary assets and as multi-user direct assessment for competition, the appropriability regime, the dominant design paradigm and partners' degree of network competence. The output of the Be@T method gives indication on the power distribution within the network and entry barriers. The assessment of the factor complementary assets is focused on the grade of complement and completeness of the network from individual participants view. This includes technical, non-technical, specialized and generic assets. Competition in the understanding of one of Porter's five industry forces has two dimensions in this research. Competition might take place on value adding steps and is a matter of network composition and a question within the network if internal competition is valuable. And there is an external dimension of competition with the aspects product characteristics, promotional strategies among rivals, access to distribution channels and service strategies to customers. Appropriability means the ability to capture profits generated by an innovation. The appropriability regime is split into two dimensions: nature of technological and legal mechanisms of protection. At the assessment of dominant design paradigm the focus is on the evolution phase of a dominant design and weather the network takes the right direction to deal with that phase. A new design paradigm will need dedicated instruments and roles to get into the market. An accepted design will shift competition towards design to prices, a whole new set of variables, like economies of scale and learning curves are getting more important. The assessment of network competence is based on relationship-specific task execution and the balance of specialist and social qualifications. The power distribution within a network is assessed company individual on the basis of bargaining power over suppliers and bargaining power over buyers within the BE@T method. Another assessment that is done in the BE@T method is on entry barriers, here the individual and network-wide capability is calculated and visualized as instrument to deal with barriers for potential partners and to increase the network performance to rapidly build external advancement barriers.

Adaption quarter (Company and Sector)

The adaption quarter subsumes company and sector specific factors with high relevance for an industry model. The factors that were selected for the inspection of this quarter of the industry model mesh are cost strategy by comparison of nominal and actual values, external technology procurement by conjunction of Be@T output and comparison of nominal and actual values and innovation determination by multi-user assessment. The inspection of cost strategy links the factor to phases of dominant design and makes a comparison to derived norm strategies. In the case of external technology procurement there are two relevant aspects: procurement within the network and external procurement. Whereas the network-internal technology distribution effects are evaluated by the BE@T Method, external procurement concerns ownership and licensing. Both are closely related to the financial perspective which is not included in this paper. Innovation determination refers to the convergence of strategic aims and is focused on the alignment of all network partners.

Advancement Centre (Capabilities)

The advancement center subsumes factors for individual companies' capabilities with high relevance for an industry model. Factors here, innovation timing and culture for innovation are closely related. The inspection of both factors can only be done by individual companies and serves foremost the creation of transparency within the network and individual corporate learning processes. Innovation timing refers to individual decisive nature concerning the improvement or modification of existing products, the implementation of new process technology, the integration of customers into the development and the market entry of new products and services. Culture for innovation is also very closely related to decision making and includes risk taking and entrepreneurial spirit.

1.3.5 SuPLigh demonstrator

The SuPLIght demonstrator is based on two industrial test cases, and is designed to validate the technology developed in the project. The demonstrator is divided into two parts: Physical and virtual.

The SuPLight Physical Demonstrator is based on pilot scale production of the new materials designed for both automotive and aeronautic components with at least 75% post-consumer scrap as raw material input. The materials used in the demonstrator is designed to simulate composition and impurity levels representative for future commercial materials based on available scrap fractions. The results shows that new materials have manufacturing properties and results in product properties in line with what is used commercially today. However, it should be noted that the number of products produced and tested are limited, and more work is needed in order to develop this technology for an industrial application.

A new processing route for wrought aluminium alloys has been developed in SuPLight, and this is also included for one of the test cases in the physical demonstrator. This production technology has proven superior manufacturing performance in respect of implication of the manufacturing process. This technology is taken further by one of the SuPLight partners and industrial implementation can be expected within 1-2 years.

The SuPLight Virtual Demonstrator is a web-based system to deliver expert knowledge from many aspects of engineering, business and social policy in a single integrated service composition. The underlying information-security architecture and data-privacy protection allows to link expertise from various European stakeholders into a distributed computing and simulation-based optimization service. Figure 27 displays the main architecture of the SuPLight Framework. Technically, SuPLight implements the distributed computing, communication and data management platform using state of the art user-interface and content-management systems, e.g. web services and established platforms as Drupal. Partner GUC with its long and deep security-technology focus and the backing of one former EC research project, i.e. TAS3.eu, is able to provide the desired cloud-native personal-data ecosystem including an end2end trust-assurance framework, user-controlled personal data as big data. Moreover, a routable, pluggable analytics framework is capable of offering composite-algorithm workflows to help solve any computational task.

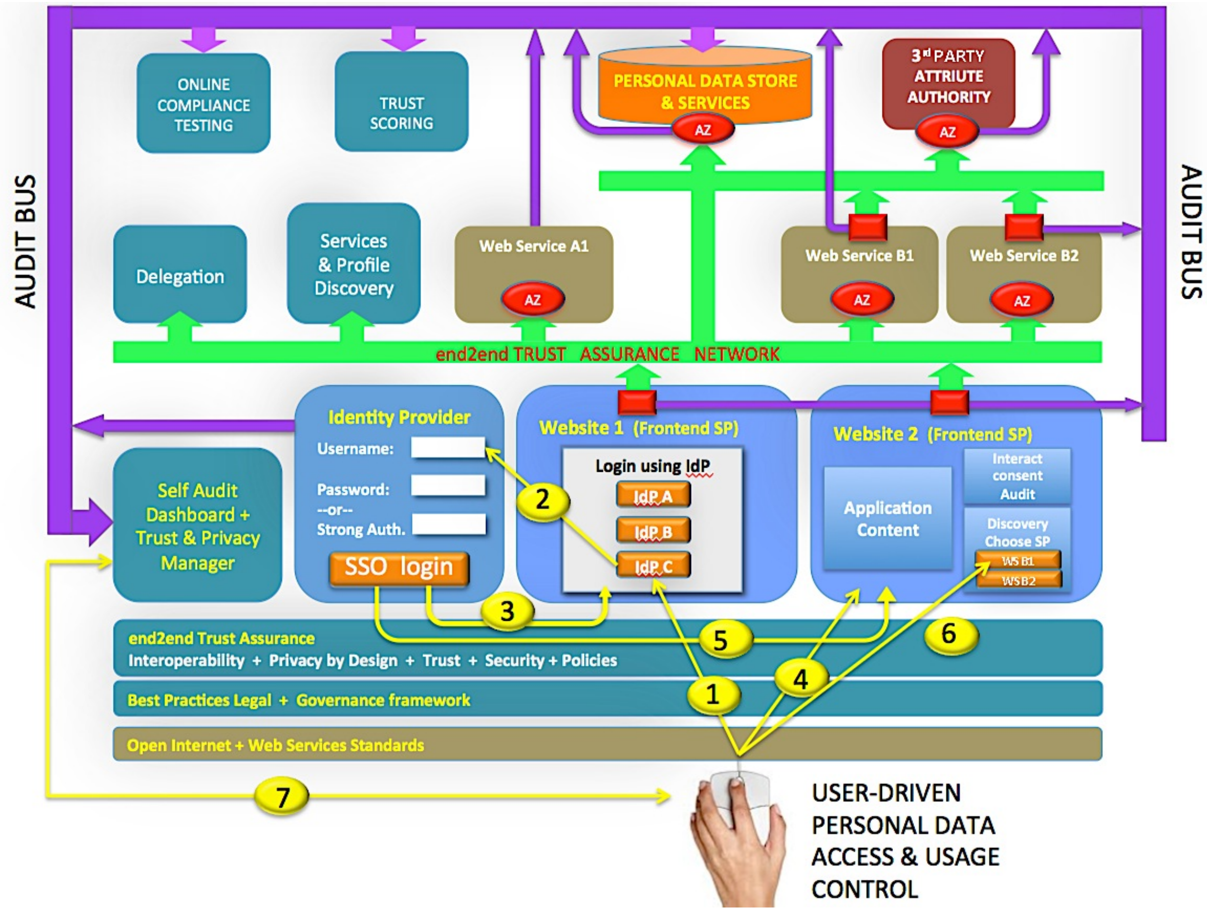


Figure 27 SuPLight Framework supporting distributed, secure computing via the Internet by adopting a secure and privacy-preserving Trust-Platform (TAS3.eu). The frameworks open interfaces enable the integration of newly developed plugins (web services) for material property, geometric design, FEM, sustainability, reverse logistics, eco-design, and industry model optimization.

Various expert knowledge and models are implemented in so-called SuPLight plugins that can extend a the generic SuPLight Framework and customize it to domain-specific tasks, i.e. simulation-based optimization of lightweight solutions and sustainability assessments. Plugins can be linked together in different sequences to evaluate, for example, the engineering design of lightweight components at different levels. SuPLight plugins under research and development are atomic modelling of trace elements, metallurgical and mechanical material properties, geometric design optimization, FEM analysis, Tolerances, LCA and LCC evaluation, Socio-ethical considerations, reverse logistics and business models.

The SuPLight-plugin sequences are accessible from a server which provides user-access control and graphical dashboards for the sequencing of SuPLight and future newly developed plugins to the framework. Subsequently, plugins sequences can be created and executed according to specific demands.

SuPLight Framework

The implementation of the SuPLight framework enables the creation of generic non-branded plugin dashboards (Figure 28, Figure 29). The screenshot provided demonstrate the overview panel and data definitions of the Reverse Logistics plugin as an example. These panels can be created and accessed by an authenticated user.

Figure 28 General information screen for SuPLight plugins

Each partner of the SuPLight project has defined one or more plugins in this manner that perform discrete parts of the simulation-based optimization sequence, such as those discussed in this section. Just as individual plugins may be defined the plugins may then be added to a defined sequence (see Figure 29) Plugins may be used in multiple sequences and may appear in a different order. The order of linkage is not unrestricted but some groups of plugins may be placed in differing order if their authors design for it. Input parameters for a plugin may be a combination of user inputted values and parameters passed form the output of previous plugins, Figure 30.

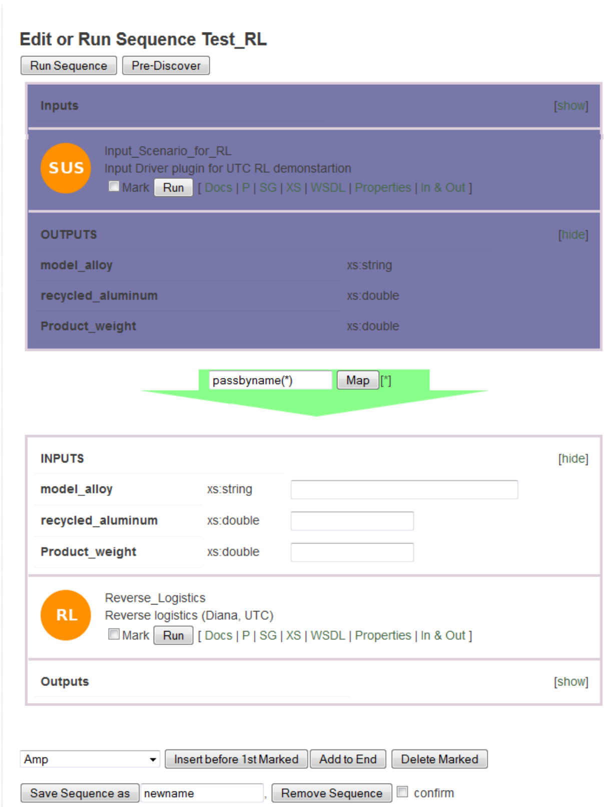


Figure 29 Defining a plugin sequence with data passing within the SuPLight framework

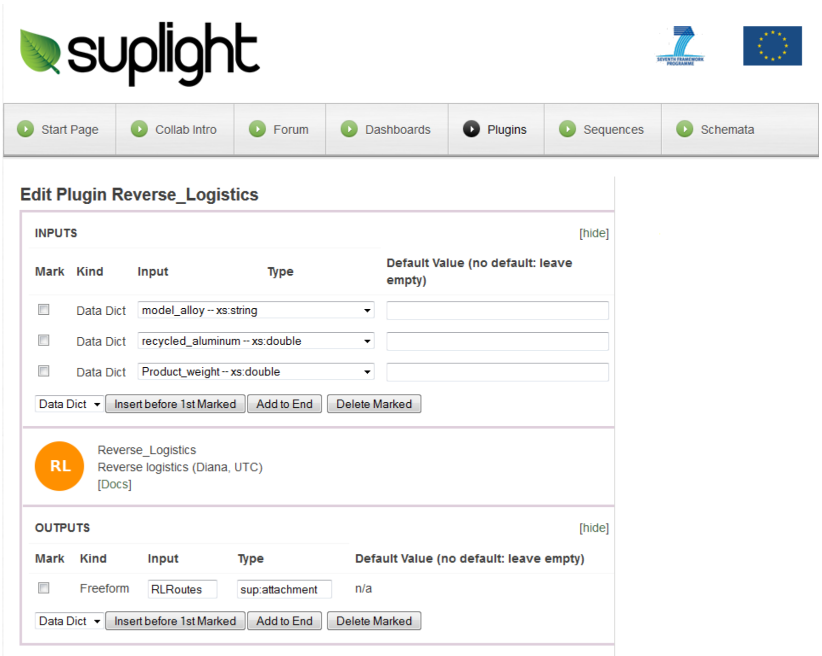


Figure 30 Defining input and out parameters for a SuPLight plugin

Of the full set of plugins that have been researched, designed and evaluated as part of the SuPLight project a selected number was identified as part of a potential BOL to EOL evaluation of lightweight products, i.e.:

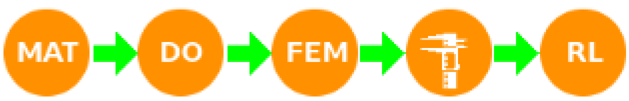
Material -> Design Optimisation -> FEM -> Tolerance -> LCA/LCC -> Reverse Logistics -> Eco-Design -> Socio-Ethical

Other partial sequences of this full sequences may have also been practical and the sequence had some potential reordering, e.g. the Reverse Logistics, Eco-Design and Socio-Ethical Plugins running prior to the Material plugin providing constraints for the input, instead of performing a post-design evaluation.

Issues arose during research and plugin development that led to some of the plugins currently implemented with offline functionality only. It implies that such plugins require manual intervention for either part of their runtime sequence or for the transfer of data to and from the framework.

The set of plugins with the potential to be framework ready form the sequence shown below, i.e.

Material -> Design Optimisation -> FEM -> Tolerance -> Reverse Logistics (inc. reduced LCA).



The Material and Reverse Logistics plugins are implemented as web services located on servers in Slovenia and France, respectively. The other three plugins are located on three remote locations in Norway. These plugins integrate multiple applications and servers, e.g. modeFontiers and NX, that are accessed via SuPLight / TAS3 installation with an apache server running within a Cygwin environment.

1.3.6 Evaluation of Optimization Results

In the following one example of the results from SuPLight demonstrator optimisation is presented. 3 scenarios are compared to the present design and technology.

The scenarios are:

1. New alloy based on 75% post-consumer scarp
2. Optimised product & process with respect to weight
3. New alloy based on 75% post-consumer scarp + Optimised product & process with respect to weight

The optimisation results are summarised in Table 2.

Table 3 SuPLight Demonstrator optimisation results

Plug-in	Material		Product optimisation			Process optimisation	
				Shape optimisation	Topology optimsation		
	Base line	Recycling level	Base line	Product weigth	Product weigth	Base line	Optimised initial preshape weight
Results	AA6082	New alloy 75% recycling	100 %	93,74 %	93,59 %	100 %	82,67 %

The results from LCA, LCC and Revers Logistics & Eco-design evaluation in the SuPLight framework is presented in Table 3 as fractions of environmental and cost factors of the present design and technology. The product optimisation based on shape optimisation is used in this test case due to ability to run atomised optimisation feasibility of the optimisation results.

Table 4 Environmental and cost factors relative to present design and technology

Plug-in	Factor	Scenario 1	Scenario 2	Scenario 3
LCA	Climate change	0,81	0,69	0,60
	Ozone depletion	0,88	0,88	0,79
	Human toxicity, cancer effects	0,70	0,40	0,30
	Human toxicity, non-cancer effects	0,72	0,52	0,39
	Particulate matter	0,76	0,58	0,48
	Ionizing radiation HH	0,72	0,45	0,35
	Ionizing radiation E (interim)	0,72	0,45	0,35
	Photochemical ozone formation	0,83	0,77	0,67
	Acidification	0,78	0,61	0,52
	Terrestrial eutrophication	0,82	0,74	0,65
	Freshwater eutrophication	0,70	0,40	0,30
	Marine eutrophication	0,80	0,68	0,59
	Freshwater ecotoxicity	0,71	0,49	0,36
	Land use	0,86	0,91	0,80
	Water resource depletion	0,77	0,79	0,63
	Mineral, fossil & ren resource depletion	0,79	0,95	0,76
	Cumulated energy consumption	0,82	0,72	0,63
LCC	LCC	0,96	0,97	0,94
Revers Logistics & Eco-design	Non renewable energy	0,70	0,91	0,6
	Climate change	0,75	0,91	0,65
	Fresh water consumption	0,5	0,87	0,45

1.4 Potential impact

As a general average, 75 to 80% of aluminium is used for wrought products, e.g. rolled plate, sheet, foil, extrusions, tube, rod, bar and wire. Wrought aluminium alloys are generally classified into two groups: wrought non-heat treatable alloys and wrought heat treatable alloys. Each group behaves differently, with composition and structure dictating the working characteristics and subsequent properties that are developed.

Aluminium wrought heat treatable alloys, more precise Al-Mg-Si/Zn alloys (6xxx and 7xxx series), has been in focus of the SuPLight. These alloys are widely used as medium- and high-strength structural alloys. The 6xxx series alloys are used for the majority of extrusions. Good formability and property requirements of these alloys are based on their low composition level. Because of that the majority of these alloys are produced by virgin aluminium, somewhat scrap and alloying additions. High percent of virgin aluminium in any high–end lightweight product is not in conformity with today's actual concept of transition to a sustainable technology-based society. The smae situation applies for 7xxx series alloys where 100% of the raw material for the aeronautic industry applications is virgin aluminium.

So far problems relating to the trace elements (Na, Ca, Pb etc) in the alloys and their effect on product performance have been rather unknown. In all standards, the trace elements are usually marked as "unspeci¬fied other elements". Their quantity in the wrought aluminium alloys is up to 0.15%. It means that they are present in material on an "atomic" grade. Without regard to its minor quantity, it is believed that the trace elements cause variation of the quality of the materials, especially regarding ductility, fatigue and their corrosion resistance. Input material with a higher percent of re-used material can cause still greater trouble. Better understanding of this issue is of great importance for the light metals community.

In case of metals, this concept is based on saving metal ore supply, reducing energy consumption and reducing the emission of greenhouse gasses, compared to extraction of novel metals. Polmear has illustrated this for recirculation of aluminium:

(i) It is estimated that a recycling rate of 50% will expand the aluminium reserves to last from 160 to about 320 years, whereas with a recycling rate of 80% the reserves will last for more than 800 years.

(ii) The primary production of aluminium is a highly energy intensive process, while the remelting of scrap requires only about 5% of the energy needed to extract the same weight of primary metal from bauxite.

(iii) The recycling of aluminium has been well established for many years, and the current ratio of secondary (scrap) to primary aluminium is around 30%.

The SuPLight technology can be an enabler for a step-change in the use and recycling of wrought alloy aluminium for lightweight solutions. With a post-consumer recycling of 75%, this means huge saving in energy consumption. Lightweight vehicles are especially important for the new concepts for sustainable transport such as electric or hydrogen cars. The expected impacts from SuPLight can by summarised by the following bullet-points:

- Closed-loop recycling: Increased reuse and recycling of aluminium with 95% less energy consumption and preservation of natural resources trough: (I) methods and a competence platform for development and manufacturing (II) robust processes for low grade aluminium manufacturing (III) knowledge on effects from impurities and chemical compounds in wrought aluminium alloy (IV) maps of process and product performance tradeoffs (V) alternative raw material sourcing
- Providing step-change lightweight structural solutions based on wrought alloys for a more sustainable transportation; (I) holistic product-process weight/performance optimization through multiple FEM simulations with heuristic parameter optimisation (II) Eco-Design methods with holistic view on product lifecycle (III) tolerance analysis tools
- Sustainable manufacturing with Holistic Life cycle Approach: (I) new use for existing of ecodesign methods and sustainable product development methodologies (II) design of new eco-friendly lightweight products incl. materials and manufacturing processes
- SuPLight industry models and business solutions Novel sustainable industry models with a holistic life cycle view (I) novel transferable modelling canvas for sectoral industrial model generation (II) SuPLight industrial model (III) information platform especially supporting SMEs in the aluminium sector

The exploitable results of SuPLight project are regarded by the consortium to be the following:

- R1. Generic framework for simulation-based optimization
- R2. Tolerance Module Plugin
- R3. Material Model Plugin
- R4. Forming Simulation Plugin (Solid works – Forge)
- R5. Shape Optimization Plugin (Solid Works – Nastran)
- R6. Reverse Logistics Plugin
- R7. Eco-Design Plugin
- R8. Social-Ethical Plugin
- R9. LCA/LCC Plugin
- R10. Industrial Model Plugin
- R11. Social Platform Plugin
- R12. Aluminium Technology based on scarp resources
- R13. Alternative processing route for wrought aluminium

When the results and the potential impacts listed above is compared with the SuPLight goals presented in chapter 1.2 in this report, the consortium consider all goals to be fulfilled. Based on this the potential impacts are elaborated in the following.

The SuPLight project aimed at a step-change in the performance of European aluminium industry. The project has focused on developing new knowledge and methods allowing economically and ecologically compatible product design and production systems with optimised weight/performance ratio for high-end load bearing wrought alloy component. The ability to accept more than 75 % recycled material opens for a more efficient use of material resources. Novel business models with a holistic life cycle view and higher reactivity to customer contribute to a better impact for the new methods and technology developed in the project.

A more sustainable society is one of the most important for the Grand Challenges for Europe. The European Commission identifies “Sustainable Growth” as one of three key drivers for the new economic strategy for Europe towards 2020. (Europe 2020 and EC Press release IP/10/225) The Commission propose a series of s.k. Flagship initiatives, a.o. “Resource Efficient Europe: Quote: “Resource-efficient Europe - supporting the shift towards a resource efficient and low-carbon economy. Europe should stick to its 2020 targets in terms of energy production, efficiency and consumption. This would result in €60 billion less in oil and gas imports by 2020.”

The main properties which make aluminium a valuable material for a sustainable society is its lightweight, strength, recyclability, corrosion resistance, durability, ductility, formability and conductivity. Due to this unique combination of properties, the variety of applications of aluminium continues to increase. One of the problems is, however, the high energy consumption when manufacturing aluminium. Secondary aluminium production (remelting) on the other hand saves 95% to 98% in energy use compared to primary production. Unfortunately, current recycling ratios are too low, especially for wrought alloy aluminium. In 2003, a total of 4.1 million tonnes of tolled and purchased scrap were melted in Western Europe, of which 2.5 million tonnes by means of refining and 1.6 million tonnes by remelting. The share of old scrap reached 28% while new scrap was at 49%, approximately 960 000 tonnes have yet to be identified as new or old scrap. From the companies reporting for 2003, it can be concluded that only 8% of the refiners scrap intake is in form of tolled scrap, while for remelters this ratio is 43%.

By applying the results from SuPLight, the aluminium industry can increase the reuse and recycling of aluminium ant thereby both save energy as well as increase the sustainability rating of aluminium in an sustainability focused marked. The aluminium industry directly provides close to 300 000 jobs in Europe not including application sectors. Thus aluminium production and dependent industries accounts for a considerable part of the labour market. Rising energy prices in Europe has recently led to a production volume decline in Europe and relocation to regions with low energy prices. E.g. Gulf Cooperation Council States (GCC) wants to achieve an increase of their market share from 7% to almost 37% in the primary aluminium production. Europe’s strategy to keep the internal supply with aluminium alloys upright has to consider methods and industrial models to utilise increasing shares of recycled aluminium. Moreover, with an increased focus on lightweight solutions for increased sustainability, wrought aluminium could win new markets shares if the recycling issue can be solved. The SuPLight project findings include technology methods and sustainable industrial models to enhance and sustain the number of jobs in the aluminium industry, but also enabling new lightweight components for the application sector such as automotive, aerospace and buildings. The reuse of aluminium is one important factor for the ability of European Aluminium Industry to remain competitive in the global market while increasing sustainability in product lifecycle.

In the VISION 2030 initiative, the European aluminium industry set itself the deadline of 2030 to attain its vision of what it calls the “sustainable aluminium society”. The SuPLight project results can be an important contribution to this vision. Main drivers behind this initiative are the twin objectives of sustainability and competitiveness, which seek to ensure maximum eco-, cost and material efficiency by the year 2030. Driven by this VISION 2030 initiative, the European aluminium industry aims at addressing long-term industry challenges by stimulating, integrating and accelerating collaborative research and technological development (RTD) activities in Europe. The ultimate goal is to provide long-lasting, energy-saving, highly functional and optimally competitive solutions to a variety of future needs. A new technology platform is the instrument to mobilise and maximise the impact of RTD investments of joint interest to the aluminium value chain.

Total demand for wrought and semi fabrication is about 12.4 million tonnes in Europe, whereof 90% in the European Union. Finally the total aluminium metal is processed into 4.8 million tonnes rolled products by 57 rolling mills, into 3.3 million tonnes extruded products by around 300 extrusion plants into 3.4 million tonnes of castings by more than 2400 users of casting alloys, and another 1.0 million tonnes is produced in the form of wire, slugs, powder and some other applications. The transport, building and packaging sectors are the most important markets for aluminium products. The remaining part goes into applications such as electrical and mechanical engineering, office equipment, domestic appliances, lighting, chemistry and pharmaceuticals.
The SuPLight project has focused its test cases on Aerospace and Automotive sectors in the validation of the results, however the results are regarded to also be relevant for manufacturing of aluminium in general. In the SuPLight project, the use of advanced genetic optimisation algorithms has been used for optimisation of wrought aluminium alloy based product design and manufacturing processes. SuPLight has resulted in innovation in material science and manufacturing processes with increased robustness against impurities and chemical composition in wrought. The technology enables to dynamically determine the best settings for both the product design and the production processes, according to the characteristics of the raw material composition. This technology can ensure dramatic increased weight/performance ratio and at the same time enable the use of more than 75% post-consumer recycled aluminium even for high-end components.

Furthermore, the open framework and the ability to include dedicated simulation tools and optimisation algorithms have broader impact possibilities. During the project two other application areas has been developed and new activities has been initiated.

The dissemination of project work and –results in SuPLight has been focused on activities towards the scientific community, industry (especially SMEs) and, to some extent, the general public. Several different established networks have been used to gain the trust and the valuable time of top management in Norwegian SME and an Industry Innovation Development Group (IDG) was established for stakeholders with special interest of the SuPLight-project. The Industry Innovation Development Group had to cancel the first meeting as reported mid-term. It was later re-established in a new form with on line conferences (webinars). There has been two webinars in the IDG with participation from the IDG-members. A recorded version of the webinars was published on the web site.

The project established a dissemination plan within the first months of SuPLight. The dissemination plan has been updated and revised during the period. Dissemination of results has been conducted in both academic and popular channels, through papers, articles, presentations etc. SuPLight has been presented five times in different SME forums. SME dissemination has been conducted through established networks, such as TotAl-gruppen, Maritime Clean Tech West and the SuPLight IDG-group, in addition the project was presented to academic networks on more than three occasions. SuPLight has produced a newsletter every six months in order to inform stakeholders about the project progress. The newsletters have been published on the web page as well as sent by email to members of the IDG and other stakeholders.

The scientific community has got a lot of attention of the dissemination activities of the project.

- 10 conference papers presented
- 4 journal papers published or will be published shortly
- 1 white paper published, and 1 will be published shortly
- more papers in pipeline to be published (after the project period)
- master thesis in shape and topology optimization (completed) in NTNU
- SupLight Optimization tools are implemented in one mandatory NTNU course TMM4155 with 60 students each year

To continue the good network established during the SuPLight Project an IMS-project was established and will continue its activity throughout its project period. The IMS project was established some time into the SuPLight project with partners from Europe, Mexico and the US. SuPLight results were presented in the IMS Projects Workshops in Charleston, USA, in May 2013 and in Barcelona, Spain in February 2014. A SuPLight workshop was also planned to take place at NIST in conjunction with WMF 2013 in Washington DC in USA, but it was cancelled because the WMF 2013 event was cancelled to the known budget restrictions in US. However, contacts have been created with the Lightweight solutions lab of NIST and the planed workshop with NIST is expected to be organised by the interested parties (SINTEF, NIST, EPFL, Mexican partners) at a convenient place and time in the future, after the end of the project, since the interest of the involved partners remains strong and valid.

In order to analyse the potential implementation of the SuPLight technology the business modelling tools developed in the project have been applied. The SuPLight framework is integrated with a social networking platform suitable for businesses throughout the supply, manufacturing and recycling industries. The concept of this user front-end grants a low barrier access to the plug-in connected to the framework. The industry modelling is based on the data made available in the network from the different plug-ins, such as reverse logistics chain actors, plug-in providers and framework users as well as collaborating network users. The model explores available partners within the network to propose supply chains that can satisfy a required set of business parameters as shown in Figure 31.

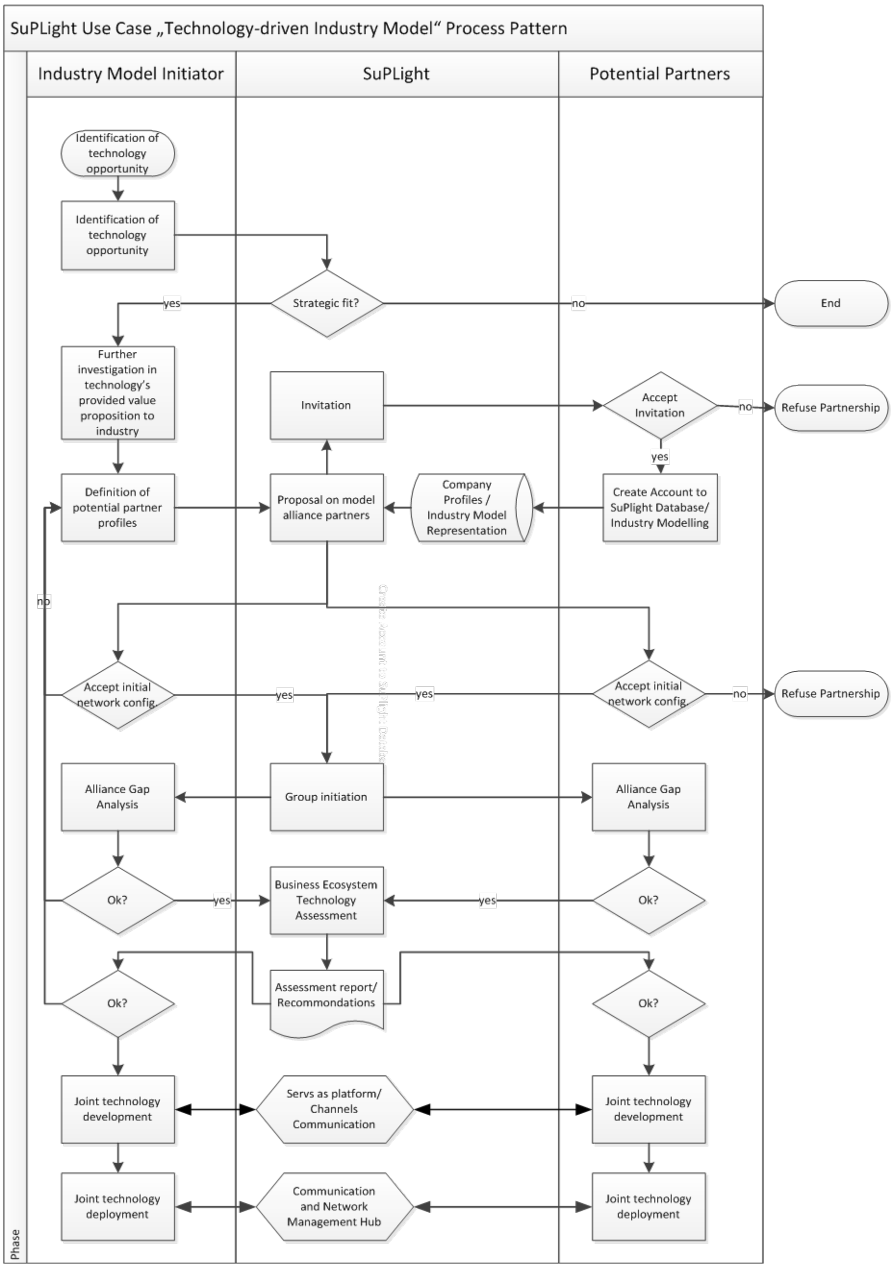


Figure 31: Use case network formation

Business ecosystems based assessment of technologies (BE@T): Accompanying the generation of networks this concept which is also implemented as mock-up tool to assess generated networks. The driving question for modelling this part of the industry model is: What is the optimum for decentralized engineering and focusing on core competencies? The networks that evolve on a web 2.0 platform are not contract centric. Hence, those task-oriented partnerships of convenience function similar to conventional B2B ecosystems where the Arthur D. Little (ADL) technology portfolio can be applied. The concept which is schematically shown in Figure 4 makes use of the business ecosystems' strategies and roles and combines the resulting setting to the abilities of network members concerning a certain technology concept. Who will benefit in which way from collaboration, how can a new equilibrium in the value chain be achieved?

To grant the network the ability to adapt an industry model an easy to use assessment-logic was developed and implemented into a prototypic web application. The input part starts with the classification of the surroundings. The innovation/technology life cycle stage and matureness as well as analogies in other industries (where learning effects can be found) are asked. The next step is the retrieval of partners' individual ‘technological expertise’. To get information on the business ecosystem instance ‘relation between actors’ the (past and future) existence of interfaces between participants and based thereon their roles or ecosystem behaviors in terms of ‘competitive position between participants’ are classified. The last input step is the request for the ‘relation-matureness between participants’ for existing interfaces between participants. These are important pieces of information to make conclusions on the network dynamics or its evolution in business ecosystem terms. All collected information are then put in their mutual context and assigned to risk classes and corresponding norm strategies as they can be found in the ADL portfolio. As a summarizing visualization of the ecosystem health a heat-map is generated as shown in Figure 32. Hot spots in this graph refer to connections between companies with a higher risk level for network co-operation and industry model adaption (e.g. asymmetrical power distribution or abilities concerning the technology). The concept has three risk classes and outputs the mentioned norm strategies to classify single inter-organizational relations.

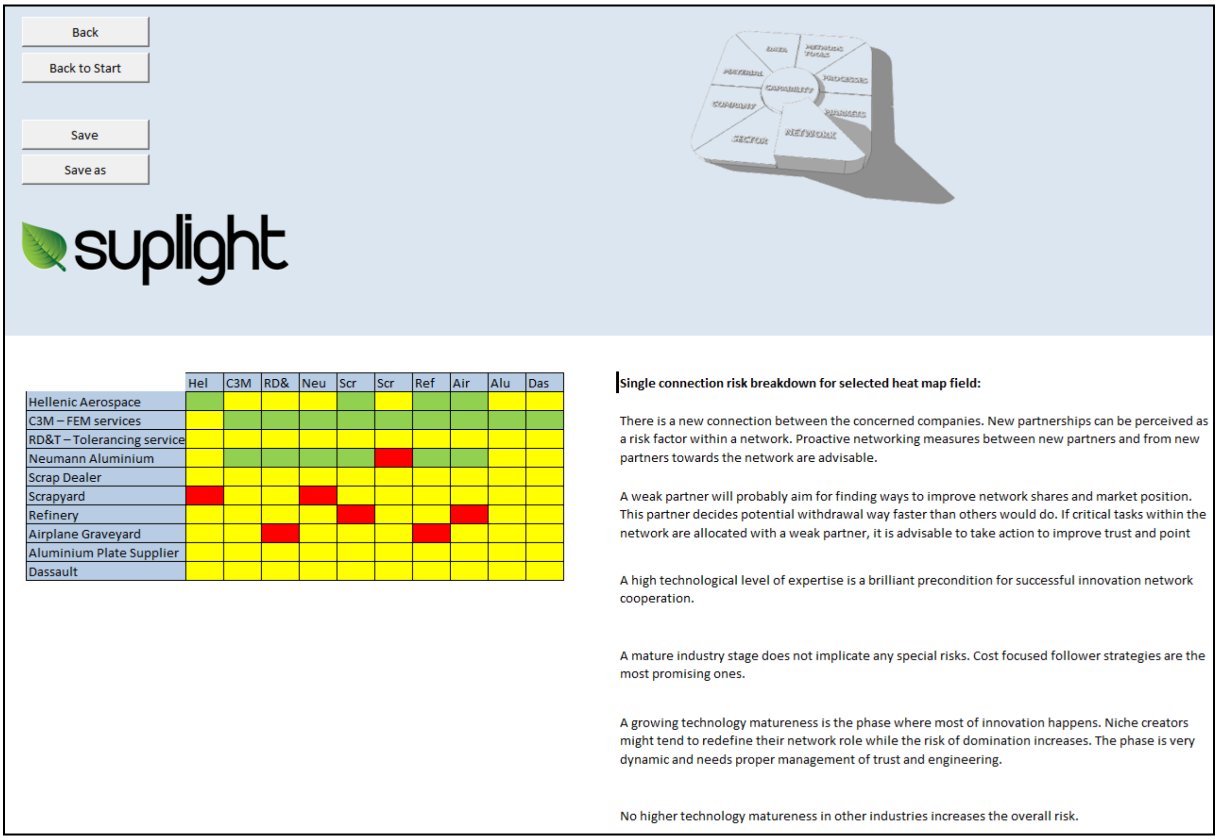


Figure 32: BE@T heat map screenshot of HAI use case scenario

The framework is integrated with a social networking platform suitable for businesses throughout the supply, manufacturing and recycling industries. The concept of this user front-end grants a low barrier access to the plug-in connected to the framework. The industry modelling is based on the data made available in the network from the different plug-ins, such as reverse logistics chain actors, plug-in providers and framework users as well as collaborating network users. The model explores available partners within the network to propose supply chains that can satisfy a required set of business parameters

The analysis of use case scenarios covers the well examined technology and process perspective described within previous sections. The dedicated analysis of yet experimental (not all relevant roles are represented in the project consortium) value chain settings shows that “hot spots” might appear especially in the reverse logistics partners chain. The reasons are:

- There are currently no strategically planned technology advancement processes for higher levels of recycling alloys in wrought alloys (see also SuPLight deliverable D1.1)
- The current market prices for recycled aluminium do not justify technology invests (see also SuPLight deliverable D1.1)
- There is currently no value chain pull for correspondent alloys within global aluminium flows (see also SuPLight deliverable D1.3)

Hence, the formation and optimization of a closed loop industry value chain would need most attention on technological advancement in the recycling chain.

Strategic alignment between engineering and manufacturing sides of the industry value chain is exposed to uncertainties due to following reasons:

- Price pressure driven by OEMs
- Own strategic aims for value adding share

To keep up the level of strategic alignment during operations (engineering and manufacturing) phases, a network management instance has positive effects in experimental settings (referred as SuPLight business model in deliverable D5.2 experimental MACTOR analyses).

1.5 Project public website and contact information

The SuPLight website can be found here: http://www.suplight-eu.org/

SuPLight contact information:

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2 Use and dissemination of foreground

Section A (public)

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[3] (if available)	Is/Will open access[4] provided to this publication?
1	*Improved extrudability of high strength alloys using an optimization method based on a combination of experiments and FEM software*	*Stanka Tomovic-Petrovic, Rune Østhus, Ola Jensrud*	*Key Engineering Materials*	*585*	*Trans Tech Publications*		*2013*	*165-171*	*10.4028 /www.scientific.net/ KEM.585.165*	*yes*
2	*Aide à la decision pour la conception d'une chaine logistique inverse pour l'aluminium*	*Daaboul J, Le Duigou J., Penciuc D., Eynard B.*	*Revue Gestion Industrielle*	*Vol. 33(1)*	*ARFGI*		*2014*	*9-33*	*ISSN 0242-9780*	*yes*

[3] 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).
[4] 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[5]	Main leader	Title	Date/Period	Place	Type of audience[6]	Size of audience	Countries addressed
1	*Paper in proceedings of a conference*	*Rikard Söderberg , Kristina Wärmefjord , Lars Lindkvist*	*Tolerance Plugin Module in Integrated Design*	*4-7/08/2013*	*Volume 3B: 39th Design Automation Conference*	*Scientific Community*		*International*
2	*Paper in proceedings of a conference*	*Kristina Wärmefjord, Rikard Söderberg, Peter Ottosson, Mats Werke, Samuel Loring, Lars Lindkvist, Fredrik Wanderbäck*	*Prediction of geometrical variation of forged and stamped parts for assembly vatioation simulation*	*2-5/06/2013*	*International Deep Drawing Research Group Conference 2013, IDDRG2013*	*Scientific Community*		*International*
3	*Paper in proceedings of a conference*	*Daaboul J., Le Duigou J., Eynard B*	*Aluminium Reverse Logistics chain: the SuPLight project*	*9-12/09/2013*	*International Conference on Advances in Production Management Systems:*	*Scientific Community*		*International*

[5] 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.

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

					Sustainable Production and Sevice Supply Chains			
4	*Paper in proceedings of a conference*	*Fatih Karakoyun, Dimitris Kiritsis*	*Closed-loop lifecycle management of automotive components: Holistic life cycle approach as Decision support system*	*20-22/05/2014*	*8th International Conference on Society & Materials (SAM8)*	*Scientific Community*		*International*
5	*Paper in proceedings of a conference*	*Fatih Karakoyun*	*Holistic Life Cycle Approach for Evaluation of Sustainability of a Product*	*26-29/01/2014*	*6th Doctoral Workshop, Product and Asset Lifecycle Management (PALM2014)*	*Scientific Community*		*International*
6	*Paper in proceedings of a conference*	*Fatih Karakoyun, Dimitris Kiritsis, Kristian Martinsen*	*Holistic life cycle approach for lightweight automotive components*	*25- 27/04/2013*	*7th International conference on Society & Materials (SAM7)*	*Scientific Community*		*International*
7	*Paper in proceedings of a conference*	*Fatih Karakoyun, Dimitris Kiritsis*	*Closed-Loop Life Cycle Management Concept for Lightweight Solutions*	*24- 26/09/2012*	*Competitive Manufacturing for Innovative Products and Services: Proceedings of the APMS 2012 conference, Advances in Production Management Systems*	*Scientific Community*		*International*

8	*Paper in proceedings of a conference*	*Johanne Hammervold, Johan Pettersen*	*WROUGHT-TO-WROUGHT STRATEGIES: ECONOMIC ANDECOLOGICAL ASPECTS REGARDING ALUMINIUM RECYCLING*	*26- 28/08/2013*	*The 6th International Conference on Life Cycle Management in Gothenburg 2013*	*Scientific Community*		*International*
9	*Master Thesis*				*Trondheim, Norway*	*Scientific Community, civil society, Other*		*International*
10	*Master Thesis*				*Trondheim, Norway*	*Scientific Community, civil society, Other*		*International*
11	*Master Thesis*				*Trondheim, Norway*	*Scientific Community, civil society, Other*		*International*
12	*Paper presented in Conference without published proceedings*	*Daabooul J, Le Duigou J, Eynard B*	*Aluminiium closed loop supply chain: the SuPLight project*	*13-15/02/2013*	*14éme Congrés de la Société Francaise de Recherche Opérationelle et Aide de la Décision, Troyes, France*	*Scientific Community, Industry*		*International*
13	*Paper presented in Conference without published proceedings*	*Messaadia M, Le Duigou J, Karakoyun F, Kiritsis D, Eynard B*	*Vers une chaine d'écoconception et de valorisation de solutions durables pour l'aluminium forgé*	*13-14/11/2012*	*Virtual PLM 2012, Reims, France*			*International*

14	Presentation	Sverre Gulbrandsen-Dahl	SME Dissemination TotAl-gruppen	15/08/2013	Brumunddal	Industry		Norway
15	Presentation	Sverre Gulbrandsen-Dahl	SME Dissemination Maritime Clean Tech West	11-12/09/2013	Stord	Industry		Norway
16	Presentation	Sverre Gulbrandsen-Dahl	SME and R&I institute presentation		Brussels	Industry, Scientific Community		International
17	Popular Press	Sverre Gulbrandsen-Dahl	Local magasin Vestre Toten Kommune fra omstilling til utvikling		Raufoss			Norway
18	Press	Sverre Gulbrandsen-Dahl	EU Researcher		EU			International
19	Press	Manuel Kern	Stuttgart University media		Germany			Germany
20	Web	Emma Østerbø	6 Newsletters during project period		Web	Industry, Scientific Community		International
21	Workshop	Dimitris Kiritsis	IMS	May 2013	Charleston, USA	Industry, Scientific Community		International
22	Workshop	Dimitris Kiritsis	IMS	February 2014	Barcelona, Spain	Industry, Scientific Community		International

23	*Webinar*		*Industry Innovation Development Group, Webinar no1*	*12/04/2013*	*Web*	*Industry, Scientific Community*		*International*
24	*Webinar*		*Industry Innovation Development Group, Webinar no 2*	*26/09/2013*	*Web*	*Industry, Scientific Community*		*International*

Section B (Confidential[7])
Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[8]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)

[7] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[8] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2

Type of Exploitable Foreground[9]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[10]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
General advancement of knowledge, Commercial exploitation of R&D results	Open framework for simulation-based optimization	Yes	01/07/2015	Generic framework for simulation-based optimization	1. Computer programming, consultancy and related activities 2. Manufacturing 3. Human health and social work activities	2014 2016 2018	NA	GUC (owner)
General advancement of knowledge, Commercial exploitation of R&D results	The tolerance plugin module aims at controlling if the geometrical variation requirements on part level are fulfilled.	No	NA	Tolerance Module Plugin	Manufacturing	2014	NA	RD&t (owner)
General advancement of knowledge, Commercial exploitation of R&D results	Provides all the necessary material parameters for simulation tools based on chemical composition and processing route of selected alloy.	Yes	01/07/2016	Material Model Plugin	Manufacturing	2015	NA	C3M (owner)

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.
[10] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Type of Exploitable Foreground[9]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[10]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
General advancement of knowledge, Commercial exploitation of R&D results	The plugin will read the CAD file of the desired end product and create the CAD files for the upper and lower tool.	Yes	01/07/2016	Forming Simulation Plugin (Solid works – Forge)	Manufacturing	2016	NA	SINTEF (owner)
General advancement of knowledge, Commercial exploitation of R&D results	The design and optimization plugin links NX (design and simulation) with ModeFrontier (Optimization)	Yes	01/07/2018	Shape Optimization Plugin (Solid Works – Nastran)	Manufacturing	2016	NA	NTNU (owner)
General advancement of knowledge, Commercial exploitation of R&D results	Identify and visualize a RL network, and evaluate	Yes	01/07/2016	Reverse Logistics Plugin	Manufacturing	2016	NA	UTC (owner)
General advancement of knowledge, Commercial exploitation of R&D results	Tool to document: current environmental regulations; strategies to implement environmental actions; interactions between processes/act	Yes	01/07/2016	Eco-Design Plugin	Manufacturing	2016	NA	UTC (owner)

Type of Exploitable Foreground[9]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[10]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	ivities and environmental impacts.							
General advancement of knowledge, Commercial exploitation of R&D results	Tool to enter and analyze social and ethical data and information.	Yes	01/07/2018	Social-Ethical Plugin	Manufacturing	2016	NA	SINTEF (owner)
General advancement of knowledge, Commercial exploitation of R&D results	Evaluates the life cycle environmental and economic performance of a vehicle component	Yes	01/07/2016	LCA/LCC Plugin	Manufacturing	2016	NA	MISA (owner)
General advancement of knowledge, Commercial exploitation of R&D results	Tool to help in the initiation and management process of a technology driven industry model.	Yes	01/07/2016	Industrial Model Plugin	Manufacturing	2018	NA	USTUTT (owner) GUC
General advancement of knowledge, Commercial exploitation of R&D results	Can be used to build everything from personal blogs to enterprise applications.	Yes	01/07/2015	Social Platform Plugin	Manufacturing	2016	NA	GUC (owner) UTSTUTT
General advancement of knowledge, Commercial exploitation of R&D results	Production of high-end structural components in the wrought	Yes	01/07/2016	Aluminium Technology based on scarp resources	Manufacturing	2018	NA	SINTEF (owner)

Type of Exploitable Foreground[9]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[10]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	aluminium alloys based on scrap resources.							
General advancement of knowledge, Commercial exploitation of R&D results	An alternative processing route for production of the high-end structural components in the wrought aluminium alloys. Technology of the processing route assumes a fusion between casting and forging.	Yes	01/07/2018	Alternative processing route for wrought aluminium	Manufacturing	2015	NA	RT (owner) SINTEF

In the tables below each result is evaluated with respect to exploitation and impact.

Exploitable result	*R1. Generic framework for simulation-based optimization*
Brief Description	*One of the main deliverables of SuPLigth is the establishment of an open framework for simulation-based optimization – Multi step, multi scale and multi domain model simulation. The framework links several modules called plugins together in order to perform various simulation and optimization tasks on demand. Each plugin provide an individual piece of expert knowledge relevant to part of the engineering design process, including sustainability, social and business factors. The open framework is generic and supports distributed, secure computing within the TAS3 Trust-Platform (TAS3.eu). Plugins tailor the framework to domain-specific tasks, i.e. by integrating a diverse collection of expert knowledge covering all aspects of simulation-based optimization of light-weight products, in particular products based on recycled aluminum.*
Main features and benefits	*Various expert knowledge and models are implemented in so-called SuPLight plugins that can extend a the generic SuPLight Framework and customize it to domain-specific tasks, i.e. simulation-based optimization of lightweight solutions and sustainability assessments. Plugins can be linked together in different sequences. New expert models can be implemented within plugins, and linked to together in different combinations to evaluate engineering designs of components at different levels in the future. Moreover, process, interface and interoperability for common simulation environments are provided, e.g. for Abaqus, Forge3D, VASP, LS-Dyna, Phonix. Commercial (LS-OPT, iSight, modeFontier).*
Innovation factors	*Networks of small and medium-sized SMEs, and even individual professionals without the capacity to address larger job yet highly specialized expert knowledge. This framework encourages collaboration as equals rather than outsourcing situations* *SMEs may join to create larger virtual companies to be more competitive.*
Target customers	*Computing infrastructure and service providers*
Target markets	*All domains requiring shared online services and predictive analytics for big data, i.e. healthcare and well-being, labor market, engineering and manufacturing, national security and forensics.*
Main competitors	*According to a market survey on Trusframeworks conducted by Ann Cavoukian, Information and Privacy Commissioner of Ontario, Canada, The TAS3 framework is as per today the most comprehensive privacy-preserving trust framework in academia and industry. Regarding simulation platforms for engineering, modeFrontier and Phonix providing none or only very immature networking capability. ISight from DS as upper-market leader does not provide solutions feasible for SMEs, in particular modeFontier and iSight have extreme license policy were costs increase very rapidly for each additional plugin.*
Maturity level	*The underlying Trusframework is the result of a previous EC project www.tas3.eu . The reference implementation is open source and available via www.zixd.org . The code is professionally maintained and extended by Synergetics in Antwerp, Belgium (www.synergetics.be) who supported the project with their resource. The trust framework is one highly mature, i.e. commercial level.* *The plugin-framework is the significantly advanced and re-implemented version of a forensic tool developed during a four-year governmental project, i.e. WANDA project http://dl.acm.org/citation.cfm?id=998038.998141 nevertheless, the plugin framework is still in a pre-product stage and will be further developed by GUC in close cooperation with Synergetics.*

Exploitable result	*R.2. Tolerance Module Plugin*

Brief Description	*This specific deliverable/result proposes a tolerance plugin module to be used in a framework for multi objective optimization. The tolerance plugin module aims at controlling if the geometrical variation requirements on part level are fulfilled. The variation in the part stems from variation in material and process parameters and the relationship between variation in process and material parameters is estimated using designed computer experiments. Moreover, the tolerance plugin module offers an automatically generated meta-model, based on principal component analysis, for handling part variation that allows for faster Monte Carlo simulations and a format that can be used in variation simulations in succeeding assembly steps.*
Main features and benefits	*The tolerance plugin uses/defines DOE setup for individual manufacturing process simulation and uses the output to automatically generate a PCA-based meta model for part variation. Part variation can then be checked against defined manufacturing tolerances. The meta model, describing part variation, can also be used in further steps for Monte Carlo based variation simulation of assemblies.*
Innovation factors	*Manual, software based tolerance analysis, is frequently used in manufacturing industry. This plugin provides a novel simplified but automatic way to describe part variation and check tolerances on part level.*
Target customers	*Manufacturing industry*
Target markets	*Manufacturing industry*
Main competitors	*Unknown*
Maturity level	*High (>TRL 7)*

Exploitable result	*R.3. Material Model Plugin*
Brief Description	*The Material Model plugin provides all the necessary material parameters for simulation tools used within the SuPLight framework based on chemical composition and processing route of selected alloy. The objective of the plugin is that the complexity of material parameters dependency on chemical composition becomes transparent to the user of the framework.*
Main features and benefits	- *The plugin returns set of material parameters based on alloy selection (simple interface)* - *The plugin returns set of material parameters based on chemical composition (advanced interface)* - *The plugin provides a complete standard set of physical properties required for simulation tools, sustainability tools etc… based on literature sources and results of experimental program performed in WP2* - *Plugins implements age hardening model which is relevant for target alloys. The model relates changes of particle size distribution which depends on its chemical composition with mechanical response of the material.*
Innovation factors	- *The material plugin takes into account the content of trace level elements like silicon, iron and copper which lead to changes in material response in the process chain.* - *Inclusion of different material processing paths* - *Age-hardening model implementation*
Target customers	- *Industrial users (extraction of material data sets for simulation tools)* - *Researchers (extraction of material data sets for simulation tools)*
Target markets	*Aluminum industry and research*
Main competitors	*Commercial material and thermodynamics database providers (MatCalc, Thermo-Calc)*
Maturity level	*Level 2: the plugin is still at a demonstrator phase and requires development to become acceptable for commercialization.*

Exploitable result	*R.4. Forming Simulation Plugin (Solid works – Forge)*
Brief Description	*The main feature for the plugin is to assist the user to evaluate the forgeability of a given optimized design.*
Main features and	*The plugin will read the CAD file of the desired end product and create the*

benefits	*CAD files for the upper and lower tool. Furthermore the plugin will prepare the setup and launch the forging analysis based on best practice settings. Finally the plugin will do some of the postprocessing for easy evaluation. The plugin is based on the use of four commercial available software, Solidworks, Forge2011, GLview Inova and ModeFrontier.*
Innovation factors	*The innovation is the plugin is the flow and automatic creation of tool parts from CAD models to meshed surfaces and bodies. This preprocessing set up together with the automatic launch of solver and postprecessing features.*
Target customers	*Development departments and manufacturing SMEs in Europe*
Target markets	*Europe*
Main competitors	
Maturity level	*Level 2. The plugin is in a demo phase and needs development to be robust enough to be adapted by other users.*

Exploitable result	*R.5. Shape Optimization Plugin (Solid Works – Nastran)*
Brief Description	*The design and optimization plugin links NX (design and simulation) with ModeFrontier (Optimization)*
Main features and benefits	*The plugin combines the modeling and simulation features of NX with the multidiscipline optimization features of ModeFrontier to optimize the mechanical properties and integrity of components or assemblies*
Innovation factors	*The plugin supports multidiscipline and multiobjective optimization of CAD models in a distributed network*
Target customers	*Product development companies (electromechanical)*
Target markets	*Automotive, aerospace, aviation, offshore and consumer goods*
Main competitors	*Phoenix Integration and Dassault/iSight*
Maturity level	*The plugin must be configured for each case. The software and procedures are documented with A3 knowledge briefs.*

Exploitable result	*R6. Reverse Logistics Plugin*

Brief Description	*The RL plugin permits to the user to:*
	• *Identify a RL network by:*
	    o *Defining all routes*
	    o *using a multi criteria decision aid method*
	    o *using optimization option*
	• *visualize a RL network (visualize all the identified routes; integration of Google map services)*
	• *evaluate the performance of a RL network (including life cycle assessment)*
	• *compare different RL networks*

Main features and benefits	• *The plugin has been designed with a flexible architecture in order to allow portability and interoperability with any external application.*
	• *The plugin integrates the expert knowledge and point of view in the definition of best choice for the RL network.*
	• *The plugin incorporates a multi-criteria decision making method: Analytical Hierarchy Process.*
	• *The plugin permits sending/receiving data from LCA software.*
	• *The plugin is user friendly.*
	• *The plugin permits comparing different RL networks.*
	• *The user may choose the automatic mode or the semi-sutomatic mode:*
	    o *Automatic mode: does not require human intervention*
	    o *Semi-automatic mode: requires human intervention in order to define RL network.*

Innovation factors	• *Considering two main decisions simultaneously:*
	    o *Supplier selection*
	    o *Location/ allocation of facilities*

	• *Integration of life cycle assessment in the evaluation of an RL network.*
Target customers	• *Researches: researchers in the field of reverse logistics might be interested to test their theories using the plugin.* • *Industries: any industry wanting to put in place reverse logistics might be interested in the plugin.* • *In its current version, it is best fitting for metals.*
Target markets	*Europe*
Main competitors	*Multi-criteria decision aid software.*
Maturity level	*Level 2: the plugin is still at a demonstrator phase and requires development to become acceptable for commercialization.*

Exploitable result	*R.7. Eco-Design Plugin*
Brief Description	*The ecodesign plugin results from the customization of the current 'Impulsio' software (owned by Quantis consultancy). The interface has been carefully drawn up to allow the implementation of a clear and an easy-to-follow ecodesign approach for any designer with a minimal training requirement. The adaptation of the software tool is based on the following aspects: specifications, configuration and development of new features to match the SuPLight requirements in terms of context (automotive and aeronautics field), semantics, data exchange with material or process plugins, and pre-modeled templates for ease of modeling.*
Main features and benefits	*This ecodesign plugin is structured into four workflows corresponding to a complete ecodesign or eco-innovation loop:* • Phase 1: **Scope,** define the project objective and the system boundary, • Phase 2: **Diagnosis,** frame the case parameter and implement the initial environmental assessment, • Phase 3: **Exploration,** analyze results, select environmental improvement guidelines and generate new design scenarios, • Phase 4: **Solutions** compare new design scenarios with the baseline. *In order to exploit the results, it is possible to export both intermediate and final outputs to Excel files and to create snapshots of graphical results. Moreover, some information sheets are proposed next to the main features. They aim to document the users about: current environmental regulations; strategies to implement environmental actions; interactions between processes/activities and environmental impacts.*
Innovation factors	• *Integrate an environmental approach to a traditional engineering design approach.* • *Combine into a single application several tools and actions needed to achieve an innovative approach to eco-design lightweight solutions.* *So far the implementation of eco-design initiatives in industry has required a considerable amount of materials and human resources such as environmental experts, environmental assessment tool(s), and environmental improvement tool(s) to achieve ecodesign tasks. The ecodesign plugin is devoted to mitigate these strong resource requirements. This will result in time and resource savings while guaranteeing the commitment of designers in terms of understanding environmental issues and improving the environmental performance of new designs of lightweight components.*
Target customers	*Manufacturing industries (suppliers of metal parts); researchers in ecodesign and LCA field.*
Target markets	*EU*
Main competitors	*Ecodesign software tools developed by LCA consultancies (for instance E-DEA by EVEA consultancy).*
Maturity level	*Prototype stage. The demonstrator will include key features and potential database updates in the near future.*

Exploitable result	R.8. Social-Ethical Plugin
Brief Description	To facilitate the assessment of social and ethical aspects for various material alternatives for high end structural components, the Social Web Matrix has been proposed as a tool to enter and analyze social and ethical data and information. The tool also provides a Social Web for each life cycle stage for a product, and also an aggregated social web for all life cycle stages together.
Main features and benefits	These social webs can be used to: • Compare different design alternatives and value chain actors with a provided baseline scenario. • To learn and identify options for reducing potential negative impacts through product design and manufacturing in global value chains through risk management. • Is meant to support internal decision-making for social responsible companies.
Innovation factors	Combines the rapid risk ranking approach known in the industry with state-of-the-art concerning social and ethical assessments from academia. It is is a new screening tool for product designers to learn and identify hotpots or risky behaviour for a simplified product system in global value chains.
Target customers	Industrial designers and product development engineers in social responsible companies.
Target markets	The screening tool is tailored the specific value chain using recycled low-grade wrought alloy aluminium in high end structural components, but can easily be modified for any market or value chain.
Main competitors	The social hotspot analysis module in Simapro, but this tool is far more comprehensive and will attract other customers.
Maturity level	Low – the tool is made in excel. Should be developed into a more sophisticated tool.

Exploitable result	R.9. LCA/LCC Plugin
Brief Description	The LCA/LCC tool evaluates the life cycle environmental and economic performance of a vehicle component

Main features and benefits	• LCA and LCC integrated in the same tool
	• The tool enables comparison of scenarios with certain variables:
	    ○ such as chemical composition
	    ○ scrap treatment technologies
	    ○ scrap share in production of component
	    ○ production process routes
	    ○ component weight
	• Optimization of the life cycle environmental impacts and costs, given a set of constraining conditions for the variables
	• Few user inputs required

Innovation factors	• One tool for evaluating LCA and LCC simultaneously • Custom-made sustainability assessment of lightweight solutions
Target customers	Researchers, automotive and aerospace component producers
Target markets	European market
Main competitors	LCA software
Maturity level	• The current version of the tool handles the vehicle control arm only. Adjustments will allow for evaluation of any vehicle and airplane aluminium component (e.g the baggage door hinge of HAI) • Requires SimaPro license for use

Exploitable result	R.10. Industrial Model Plugin
Brief Description	This plugin aims to help in the initiation and management process of a technology driven industry model. The user-sided process is an initiation of a “social network” based practice to identify partners, assess the strategic fit, ecosystem assessment and seed group initiation.

Main features and benefits	The integrated assessment method for technologic innovation and business ecosystem configuration forms the centre of this plugin concept.
Innovation factors	• New approach to ad-hoc partnering in engineering chain. • Classical networking schemes might be applied (but not limited to) • Opens "door" to the SuPLight framework.
Target customers	All stakeholders of engineering processes of products with closed loop potentials.
Target markets	• Production of metal supplier parts/ products. • Market specification is mostly defined by other plugins.
Main competitors	For network management: Sector specific EDI (Electronic Data Interchange) or (PRM) Partner Relationships Management tools (Mainly OEM-specific and run by those, suppliers are necessitated to access OEM system)
Maturity level	Concept level

Exploitable result	R.11. Social Platform Plugin
Brief Description	For it portal SuPLight uses the Drupal.org open source WCMS (web content management system). Drupal can be used to build everything from personal blogs to enterprise applications.
Main features and benefits	Thousands of add-on modules and designs allow Suplight to build and extend the ecosystem front-end: - Personal blogs, Wikis and Forum areas - Partner home pages and microsites - Suplight Optimisation results sharing This Drupal install is secured in the sense that all user or service access uses the TAS3 INFRAstructure and the Suplight ROLE and GROUP Access Control INFOstructure.
Innovation factors	The requirements for securing the SuPLight Services follow the guarantees stated in the collaboration levels. In that sense User identities are carried over (deep) web service calls. This is an area where traditional SOAs (service Oriented Architectures) are rather weak, but the SuPLight end2end Trust Assurance framework fully supports this. The SuPLight e2eTA framework secures the communications between all SuPLight ecosystems components including the communications between its web-based front-end and server- side and between its server-side and the various Plugins.
Target customers	Computing infrastructure and service providers
Target markets	All domains requiring shared online services and predictive analytics for big data, i.e. healthcare and well-being, labor market, engineering and manufacturing, national security and forensics.
Main competitors	Drupal is one of the leading and most widely used content management systems (CMS) in the world (June 2014). For an overview and feature comparison for CMS one may visit http://www.cmsmatrix.org/
Maturity level	Professional. Drupal is an open source content management platform powering millions of websites and applications. It's built, used, and supported by an active and diverse community of people around the world. As per June 2014 Drupal community comprises about 1,069,634 registered people in 230 countries.

Exploitable result	R.12. Aluminium Technology based on scarp resources
Brief Description	Production of high-end structural components in the wrought aluminium alloys based on scrap resources.
Main features and benefits	• Use of end-of –life scrap as input material for production of high-end structural components. • Increased closed loop potentials. • Less consumption of the primary aluminium.
Innovation factors	Expert knowledge. Quantification of impact of the alloy's recycling chemistry on both the production process and the product performances.
Target customers	Any industry dealing with production of high-end structural components based on aluminium wrought alloys.

Target markets	*All participants in aluminium value chain.*
Main competitors	*Primary aluminium industry.*
Maturity level	*Level 3.* *State-of-the-art is on a demonstrator level. A full scale test is missing.*

Exploitable result	*R.13. Alternative processing route for wrought aluminium*
Brief Description	*An alternative processing route for production of the high-end structural components in the wrought aluminium alloys. Technology of the processing route assumes a fusion between casting and forging.*
Main features and benefits	*The alternative processing route does not include the extrusion step, the most demanding step in the conventional forging value chain. Absence of the extrusion step:* • *makes the process more robust and less sensitive to the alloy chemical composition;* • *simplifies thermomechanical regime (less energy consumption);* • *makes better logistic with a possibility for the casting and forging plants have been merged in one;* • *makes the forging value chain less expensive;* • *less investment.*
Innovation factors	*Expert knowledge. Quantification of interdependencies between alloy's recycling chemistry and performances of the product produced in the alternative processing route.*
Target customers	*Any industry dealing with the conventional forging value chain.*
Target markets	*Structural components manufacturing industry.*
Main competitors	*Any industry dealing with production of structural components.*
Maturity level	*Level 2.* *Experimental data regarding product performances were collected by partial testing of the generic component. More detailed testing is required in order to adjust and define the optimal process parameters for serial production.*

Summary:

The table below summarises the intended use of the exploitable results. The usage is divided into the following groups:

- *MS: making and selling exploitable results*
- *UM: using the exploitable results internally in order to make something else for sale*
- *L: licensing the exploitable results to 3rd parties*
- *C: using the exploitable results in order to provide services such as consultancy...*
- *R: using exploitable results for further research activities.*

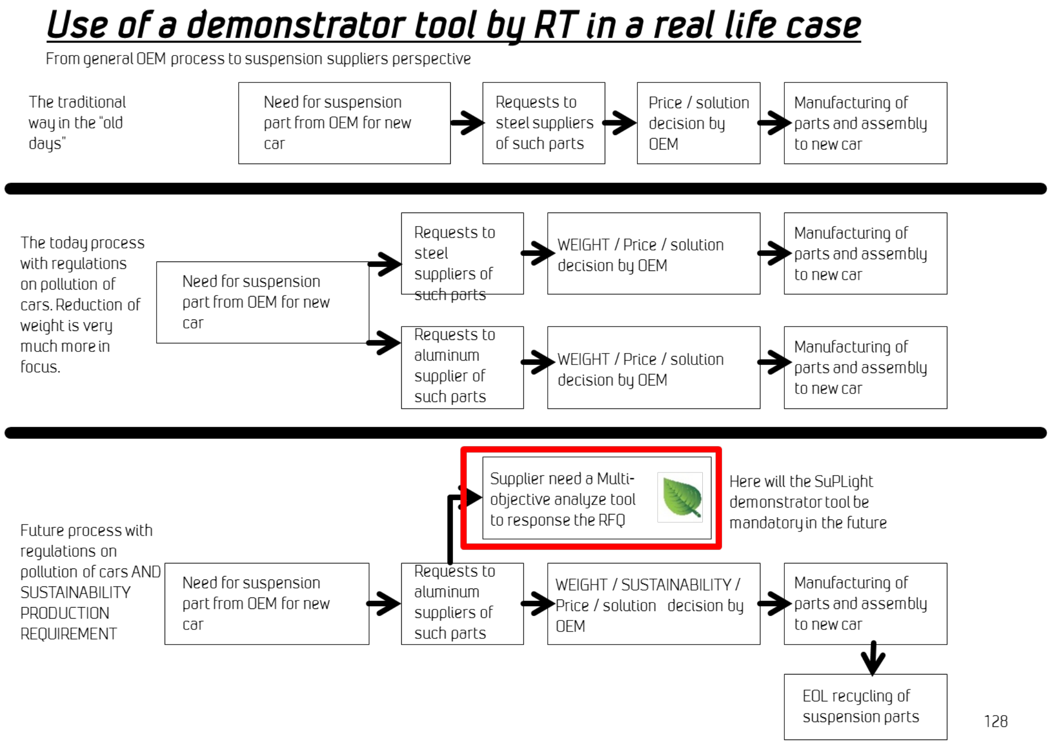
From the table it can be seen that there exist plans for exploitation of all identified SuPLight results. There is identified potential and need for further research on all topics, either by single partner or in cooperation. In this respect new European initiatives are discussed within the consortium. In particular the interdisciplinary research of SuPLight has been identified to have a larger research potential, and is needed for a broader exploitation.

	R1. Generic framework for simulation-based optimization	*R2. Tolerance Module Plugin*	*R3. Material Model Plugin*	*R4. Forming Simulation Plugin (Solid works – Forge)*	*R5. Shape Optimization Plugin (Solid Works – Nastran)*	*R6. Reverse Logistics plugin*	*R7. Eco-Design Plugin*	*R8. Social-Ethical Plugin*	*R9. LCA/LCC Plugin*	*R10. Industrial Model Plugin*	*R11. Social Platform Plugin*	*R12. Aluminium Technology based on scarp resources*	*R13. Alternative processing route for wrought aluminium*
SINTEF	R; UM	R; C	R; UM; C	C; R	R; UM; C	R; UM; C	R; UM; C	C; R; UM	R; UM; C			R; UM; C	R; UM; C
GUC	C; UM; R										C; UM; R		
RT						UM						MS; R	MS; R
Misa AS									C; R				
USTUTT	R							C; UM; R		C; UM; R	C; UM; R		
RD&T		UM; R	UM; R	UM; R	UM; R				UM; R				
EPFL	UM		UM	UM	UM			UM; R	UM; R			R	R
UTC			UM	UM	UM	UM; R	L;C; UM; R	R	R				
C3M		R; UM	C; R; UM	R; UM	R; UM							R; UM	R; UM
HAI					UM; R							MS; R	
NTNU	R; UM	R; C	R; UM; C	C; R	R; UM; C	R; UM; C	R; UM; C	C; R; UM	R; UM; C			R; UM; C	R; UM; C

Commercial exploitation of results are expected both in the sense of products and services as indicated as MS, UM and C in the table. In this evaluation one of the industrial partners of SuPLight have provided the following statement:

- The different plug-ins can be quite beneficial during the negotiation phase providing more accurate figures and cost estimation.
- During the detail design phase of the different components, multiple analyses can be implemented, investigating various scenarios of material and shape applications, focusing on an optimized result.
- Even though the results of 6082 and 7075 testing proved an alloy with degraded properties, within this project the route of integrating of recycled aluminium to the different alloys of aerospace industry was recognized. Probably, some geometry modifications at the investigated hinge could exhibit potential further application of the recycled alloy, since other features like machinability and quality surface were positively evaluated.
- The LCC/LCA and Reverse Logistics plug-ins can be proved quite fruitful methodologies of each individual component's lifecycle. The development of a closed-loop production process (production→recycling→production→recycling) can have a significant effect on the cost, overall energy usage etc.
- Environmental impact and issues concerning human rights are matters of high priority in EU agenda. The Eco-Design and Social-Ethical plug-in could provide data that until now was not taken into consideration. These features can change not only designer's philosophy and manufacturing approach but also companies' policies and mentalities

The two industrial partners have both illustrated the exploitation of SuPLight results in their organisations, and this is presented in Figure 33 and Figure 34.



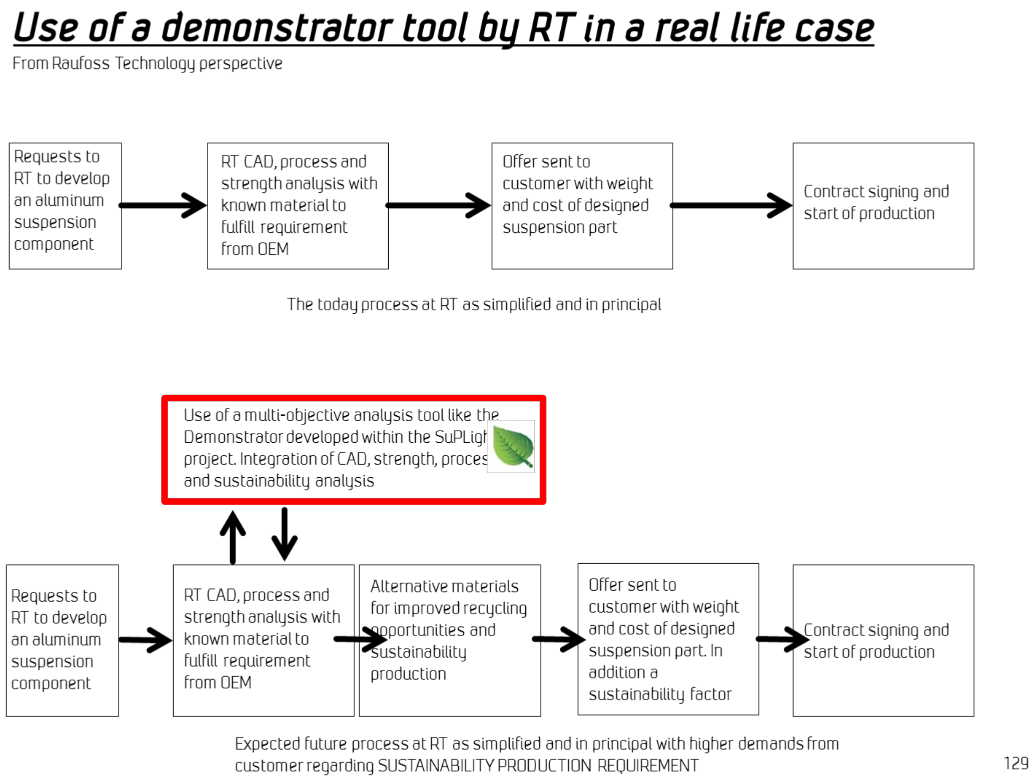


Figure 33 Exploitation of SuPLight results in the perspective of Raufoss Technology

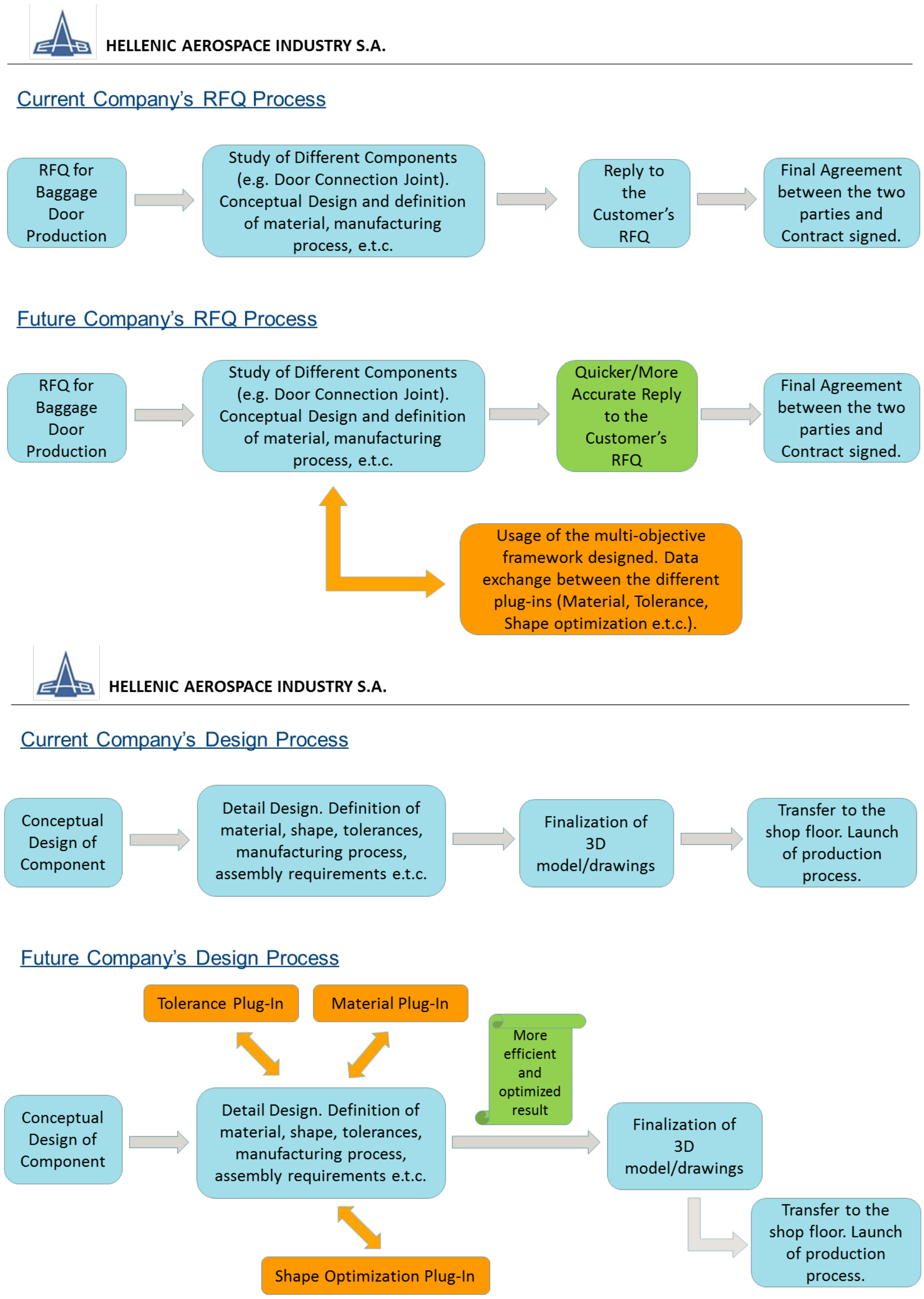


Figure 34 Exploitation of SuPLight results in the perspective of Hellenic Aerospace Industry

3 Report on societal implications

A General Information *(completed automatically when **Grant Agreement number** is entered.*	
Grant Agreement Number:	263302
Title of Project:	SuPLigth – Sustainable and efficient Production of Ligth weight
Name and Title of Coordinator:	Sverre Gulbrandsen-Dahl. Chief Scientist

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*** ***0Yes 0No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	No
• Did the project involve patients?	No
• Did the project involve persons not able to give consent?	No
• Did the project involve adult healthy volunteers?	No
• Did the project involve Human genetic material?	No
• Did the project involve Human biological samples?	No
• Did the project involve Human data collection?	No
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	No
• Did the project involve Human Foetal Tissue / Cells?	No
• Did the project involve Human Embryonic Stem Cells (hESCs)?	No
• Did the project on human Embryonic Stem Cells involve cells in culture?	No
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	No
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
• Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No
• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	No
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	No
DUAL USE	
• Research having direct military use	No

• Research having the potential for terrorist abuse	No

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	1
Work package leaders	3	4
Experienced researchers (i.e. PhD holders)	5	14
PhD Students	2	3
Other	1	6

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

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

- ○ Yes
- X No

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

	Action	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	○ ○ ○ ○ ○
X	Actions to improve work-life balance	○ ○ ○ ○ X
○	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)?

- X Yes- please specify: Master and PhD thesis
- ○ 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?

- X Main discipline[11]: 2.3
- X Associated discipline[11]: 1.1
- X Associated discipline[11]:1.4

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)*

- ○ Yes
- X 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

[11] 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)

- ○ 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)
- ○ 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		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- ○ European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**2/2**
To how many of these is open access[12] provided?	**All**
How many of these are published in open access journals?	**4**
How many of these are published in open repositories?	
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
❑ 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[13]: ……………	

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).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	**0**	
	0	
	0	

17. How many spin-off companies were created / are planned as a direct result of the project?	**0**
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
X	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	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:*

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

Difficult to estimate / not possible to quantify	X

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?

X	Press Release	X	Coverage in specialist press
❑	Media briefing	X	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	X	Coverage in international press
❑	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?

X	Language of the coordinator	X	English
X	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]