LIFE12 ENV/ES/000638
Final Report
Covering the project activities from 01/07/2013 to 30/09/2016

31/12/2016
Slag layers in railway foundations (GAIN)

Project location: Spain, all regions
Project start date: 01/07/2013
Project end date: 30/09/2016
Total project duration (in months): 39
Total budget: 1,301,526 €
Total eligible budget: 1,301,526 €
EC contribution: 650,763 €
(% of total costs): 650,763 €
(% of eligible costs): 50%

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2. EXECUTIVE SUMMARY

Summary of the project objectives and results achieved

In summary, the project goal is to enhance the railway infrastructure sustainability, both economically and environmentally, by the use of recycled slag coming from steel furnaces (SFS-Rail) in the subballast and subgrade layers of the railway foundations.

The project has a clear demonstration character, aiming to boost the replicability and transferability of the results. The main objectives, which are in turn the key deliverables, are listed below:

- Reduction of the use of natural aggregates in railway construction, which turn into the reduction of quarries’ environmental impact.
- Reduction of the transport needs associated to railway aggregates, which turns into fuel savings and reduction of the CO₂ emissions. It is expected that SFS-RAIL will be more accessible to work-sides than natural aggregates, because few quarries fulfill the technical requirements demanded by railway regulations.
- Improvement of the mechanical performance of railway track. Research done up to now on SFS-RAIL shows that the mechanical properties of this product overpass the performance of natural aggregates.
- Reduction of the material cost of railway aggregates. The difference in sale price between natural aggregates and EAFS aggregates increase with the hardness required. Therefore, the savings are higher when EAFS substitutes hard natural aggregates, such as the railway ones.
- Reduction of the volume of black slag’s storage and final disposal. Although landfill disposal of SFS has enormously diminished during the last decades, the final deposit rate could increase in the coming years because of the economic crisis affecting the civil engineering sector.

The objectives and outputs achieved by the actions of the project are summarised in the following table:

<table>
<thead>
<tr>
<th>Action</th>
<th>Objectives</th>
<th>Outputs achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Study of the state of the art regarding EU legislation</td>
<td>Detect differences in criteria and requirements between European national and Community legislation on Railway and Environmental topics</td>
<td>Research and identification of the technical standards for the subballast and the subgrade layers for some European countries</td>
</tr>
<tr>
<td>A2. Identification, study and description of EU steel making plants</td>
<td>Identification of EU steel making plants. Study of the type of installation, production rates and type of the black slag produced</td>
<td>Identification of the main EU producing plants and the different types of installations, production rates and features of the generated black slag</td>
</tr>
<tr>
<td>B1. Adaptation of an existing valorisation plant to produce SFS-Rail</td>
<td>Define a work plan for the establishment of the production line and replication guidelines</td>
<td>The work plan for the establishment of the SFS-Rail production line and its implementation has been done. The replication guidelines to make this project transferrable to other European countries have also been analysed and described</td>
</tr>
<tr>
<td>B2. Management of SFS-Rail stocks</td>
<td>Implementation of the SFS-Rail stock’s management plan</td>
<td>Definition of the classification criteria in terms of granulometry, the space needed to pile up the stocks and the</td>
</tr>
</tbody>
</table>

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<p>| B3. Design of the first field implementation | Characterization of the field tests location. Definition of the track designs. Establishment of a construction methodology. | Two field tests locations have been selected: El Puerto del Musel in Gijón (Asturias) consisting in three sections amounting up to 90 m and a line of ADIF network in Castellbisbal (Barcelona) consisting in three sections amounting up to 150 m. |
| B4. Construction of the field tests | Construction of the control section and three new design sections. Quality checks. | Both field tests have been constructed successfully. The field tests of El Puerto del Musel in Gijón have been constructed according to the schedule, while the field tests of Castellbisbal have been constructed with a delay of 5 months, in October 2015. |
| B5. Development of a calculation software for track design using SFS-Rail | Calculation software to be used as a design tool for dimensioning track layers made of SFS-Rail | The six tasks initially conceived in the proposal have been reorganised, to make more sense, resulting in five tasks, the last one being split into two subtasks. The software has been calibrated with the results of the monitoring activities. All the modules of the software work properly and have been used to define the track solutions catalogue. |
| B6. SFS-Rail Track solutions catalogue | Catalogue of recommended track designs using SFS-Rail in the subballast and subgrade layers | The track solutions catalogue has been successfully elaborated upon the results of the calculation software and the field tests monitoring. |
| B7. Elaboration of the Life Cycle Assessment (LCA) of SFS-Rail | Confection of a Life Cycle Assessment (LCA) and Environmental Impact Assessment (EIA) of the tracks with SFS-Rail | The LCA results show that the tracks with SFS-Rail in the subballast and subgrade layers have a lower impact on the selected categories than the tracks with conventional aggregate. The EIA has been according to the Eco-Indicator 95 unifying the impact categories of the LCA to provide a unique value of the environmental impact for each solution of the track solutions catalogue. |
| B8. Design and implementation of the Quality Control Plan of SFS-Rail | Design of a specific Quality Control Plan for the production of SFS-Rail. Productivity analysis of the SFS-Rail | General and specific tests for the SFS-Rail have been defined and the productivity results report has been done after the construction of the field tests |
| C1. Design of the field tests monitoring | Definition of the parameters to be monitored, topographic equipment and analysis methodology of the collected data | The parameters to assess the performance of the track sections made of SFS-Rail have been defined. The topography instrumentation and analysis methodology for each parameter have been established |
| C2. Monitoring of the Quality Control Plan results | Monitoring and statistical analysis of the Quality Control Plan | The monitoring of the Quality Control Plan results has been done for the SFS-Rail production for the field tests of both field tests. The statistical analysis has also been completed. |
| C3. Socio-economic impact of the project | Assessment of the impact that the project’s actions will have on the local economy and population | The socio-economic impact report has been completed upon the results of the project’s implementation and surveys on site. |
| C4. Monitoring of the field tests | Demonstrate that SFS-Rail is a valid alternative to natural aggregates. Comparison of the evolution of the track geometry, settlement and stiffness. | The monitoring activities have lasted 12 months in each of the field test locations, according to the plan. In the case of Gijón the monitoring lasted from May 2015 to April 2016, and in Castellbisbal from October 2015 to September 2016. The results have been totally satisfactory. |
| D1. Creation and maintenance of the project’s website | Creation and maintenance of the project’s website | The website of the LIFE GAIN <a href="http://www.life-gain.eu">www.life-gain.eu</a> is up and running from 07/03/2014. Indications from the European Commission have been taken into account, such as the translation into Spanish and Catalan languages and the update of the sections according to the project progress. The main dissemination documents are available for download. The website has reached more than 13,000 visits, far more than the 200 visits expected per month. |</p>
<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2. Notice boards informing about LIFE+ GAIN activities</td>
<td>Installation of notice boards informing about LIFE+ GAIN activities</td>
</tr>
<tr>
<td></td>
<td>Three notice boards have been installed: one in ADEC GLOBAL valorisation plant, one in the field tests of El Puerto del Musel in Gijón, and one in the field tests of Castellbisbal, following the instructions of the European Commission.</td>
</tr>
<tr>
<td>D3. Dissemination through brochures</td>
<td>Elaboration of two project brochures</td>
</tr>
<tr>
<td></td>
<td>Two project brochures have been designed, as expected: one at the beginning of the project, explaining the main objectives and tasks, and one at the end of the project, showing the main results and conclusions. They have been delivered to clients and other interested audience in fairs and congresses attended by the project partners. In total 600 copies have been produced, 200 more than the ones foreseen.</td>
</tr>
<tr>
<td>D4. Dissemination through the media</td>
<td>Achieve an effective communication to local and regional population</td>
</tr>
<tr>
<td></td>
<td>3 press conferences and 3 press notes have been released during the project. They have been widespread in several national and international newspapers, on their online editions.</td>
</tr>
<tr>
<td>D5. Dissemination of project’s results through technical publications</td>
<td>Publication of articles in specialised technical publications</td>
</tr>
<tr>
<td></td>
<td>8 articles have been published in specialised articles and magazines, such as FuturEnviro, Revista de Obras Públicas, Journal of Sustainable Metallurgy and proceedings of international congresses specialised in railways and slag valorisation. This is more than the 5 publications foreseen.</td>
</tr>
<tr>
<td>D6. Presentation of project’s results in scientific and technical events</td>
<td>Participation in scientific and technical events</td>
</tr>
<tr>
<td></td>
<td>11 international fairs and congresses have been attended, as foreseen. These include congresses related to slag valorisation and railways.</td>
</tr>
<tr>
<td>D7. Elaboration of Layman’s Report</td>
<td>Divulgation of the objectives, actions and results of the project.</td>
</tr>
<tr>
<td></td>
<td>The Layman’s report has been elaborated, addressed to the general public, summarising the objectives, actions and results of the project. It has been uploaded to the project’s website.</td>
</tr>
<tr>
<td>E1. Project Management</td>
<td>Management of the project while assuring quality of the actions and outputs</td>
</tr>
<tr>
<td></td>
<td>The project management has been carried out smoothly, with a high level of communication between partners and a high quality standard. Meetings have been held every two months, and every six months with the Steering Committee. The consortium has addressed all the requirements by the European Commission and the External Monitoring team.</td>
</tr>
<tr>
<td>E2. After LIFE+ Communication plan</td>
<td>Lead the conservation actions to be undertaken once the project has finished</td>
</tr>
<tr>
<td></td>
<td>The document has been elaborated and uploaded to the project’s website.</td>
</tr>
<tr>
<td>E3. External audit report</td>
<td>To audit the project after its implementation</td>
</tr>
<tr>
<td></td>
<td>The audit has been passed and the external audit report has been attached in section 8.</td>
</tr>
<tr>
<td>E4. Networking</td>
<td>Sharing of experience and information regarding innovation and sustainability in infrastructures</td>
</tr>
<tr>
<td></td>
<td>The LIFE GAIN partners have shared their experience with other LIFE projects. Many contacts have been established during the fairs and congresses attended, even outside Europe, such as Mexico and the USA. The Port Authority of Barcelona is interested in applying SFS-Rail in future works. CELSA (steel producing plant) has plants in Poland interested in valorise SFS.</td>
</tr>
</tbody>
</table>

**General progress**

The work conducted in the project has followed all the milestones and deliverables set in the proposal and the project has ended on time, by 30/09/2016, as expected. However, not all the actions of the project have finished on the due date foreseen in the proposal.

The major difficulty encountered during the project was to find a proper location for the field tests within the network of ADIF. In the early stage of the project, COMSA studied the railway works that was about to carry out in order to choose the best location for the field tests. New railway
construction works, renewal works and maintenance works were considered for analysis. From these possibilities, the best option to construct the field tests was the stretch between Vinaròs and Vandellòs, where COMSA had a contract for the line renewal (track and electrification) and introduction of the UIC gauge. However, given the financial crisis affecting the Euro zone and especially Spain, ADIF postponed the renewal works *sine die*. The LIFE+ GAIN partners, in an attempt to avoid a delay in the execution of the project, looked for other possible locations. The second attempt was in the railway station of Castellbell i el Vilar / Monistrol in the province of Barcelona (Spain), but a geotechnical inspection showed that the existing line did not have either subballast nor subgrade layers to be substituted by SFS-Rail. Hence, for the purpose of this project, this was not a valid test section. The third attempt was in the municipality of Fornells de la Selva, in the province of Girona (Spain), which failed to host the field tests because, at the end, no track possession was allowed by ADIF to carry out the construction works.

Given the accumulation of delays in finding the field tests, Senior Managers of COMSA were involved to speed up the selection of a field test location and to look for other possibilities in rail networks controlled by other Infrastructure Managers. As a result, **the LIFE+ GAIN partners decided to carry out a complementary field test in an ongoing construction site of COMSA in El Puerto del Musel (The Musel Harbour) in Gijón (Asturias, Spain)**. The construction of the field tests in Gijón took place in April 2015.

However, for the sake of replicability of the project’s results and in order to meet the demands of the European Commission as stated on the letter received on 25/11/2014, great effort was put to find a suitable field test location in the network of ADIF. The best location found was the mixed traffic railway line of Castellbisbal, which was constructed in October 2015, i.e. with a delay of 5 months.

The delay in the construction of the field test sections affected, in turn, other actions, such as the monitoring of the field tests, the monitoring of the quality control Plan, the development of the software, the confection of the track solutions catalogue and other minor tasks. Nevertheless, all of them could be fully completed by the end date of the project, including the 12 months monitoring of the field tests, since there was enough margin.

**Dissemination and networking**

Referring to the dissemination actions, the website of the project ([www.life-gain.eu](http://www.life-gain.eu)) is fully operational from 07/03/2014. It is available in English and has been translated into Spanish and Catalan languages to be more accessible to the regional stakeholders and its content has been updated in accordance with the progress of the project, hence meeting the demands of the European Commission on the three letters received on 20/01/2014, 20/05/2014 and 25/11/2014. Its SEO positioning has also been improved to reach a wider audience.

Three notice boards have been erected: one in ADEC GLOBAL’s plant, one in the field tests of Gijón and one in the field tests of Castellbisbal. An initial brochure and a final brochure of the project have been designed, printed and distributed to clients and interested organisations. Besides, three press conferences have been held and six articles have been published on general media and online newspapers. The LIFE+ GAIN partners have also published eight articles in specialised and technical magazines, and have attended eleven international fairs and congresses to widespread the project.
The LIFE+ GAIN partners are committed in creating a network between experts from similar LIFE+ projects and Institutions to share experience and know-how. In this sense, and following the demands of the European Commission, they have shared their experience with other LIFE+ projects, such as “Sludge4Aggregates” and “SNOW”. Many contacts have been established during the fairs and congresses attended, even outside Europe, with representatives from Mexico and the USA. Indeed, the Port Authority of Barcelona is interested in applying SFS-Rail in future works, while CELSA (steel producing plant) has plants in Poland and in the UK interested in valorising SFS.

As a conclusion, one can state that the dissemination and networking of the project has been totally satisfactory. Dissemination and networking actions will continue after the project’s end to widely spread the benefits of SFS-Rail in the railway sector across the EU and on an international basis.

**Financial issues**

The costs incurred in the project are summarised below:

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Budget according to the grant agreement</th>
<th>Costs incurred within the project duration</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Personnel</td>
<td>€ 910,800.00</td>
<td>€ 974,153.59</td>
<td>106.96%</td>
</tr>
<tr>
<td>2. Travel</td>
<td>€ 14,200.00</td>
<td>€ 5,416.31</td>
<td>38.14%</td>
</tr>
<tr>
<td>3. External assistance</td>
<td>€ 187,980.00</td>
<td>€ 101,372.69</td>
<td>53.93%</td>
</tr>
<tr>
<td>4. Durables</td>
<td>€ 0.00</td>
<td>€ 0.00</td>
<td>0.00%</td>
</tr>
<tr>
<td>5. Consumables</td>
<td>€ 52,500.00</td>
<td>€ 27,294.20</td>
<td>51.99%</td>
</tr>
<tr>
<td>6. Other costs</td>
<td>€ 50,900.00</td>
<td>€ 28,611.19</td>
<td>56.21%</td>
</tr>
<tr>
<td>7. Overheads</td>
<td>€ 85,146.00</td>
<td>€ 79,579.36</td>
<td>93.46%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>€ 1,301,526.00</strong></td>
<td><strong>€ 1,216,427.34</strong></td>
<td><strong>93.46%</strong></td>
</tr>
</tbody>
</table>

There have been some transfers from external assistance and other costs to personnel costs, which have been commented with the external monitor. These transfers have been detailed in section 6 of this report. The total personnel costs have increased by €63,353.59 (6.96% of the budgeted personnel costs), which is below the thresholds defined in Article 15.2 of the Common provisions (€30,000 and 10%). Therefore, no amendment has been needed.

**Summary of the final report**

The present report includes an introduction to the project with the environmental problem addressed, an outline the hypothesis to be demonstrated, a description of the technical and the expected results and environmental benefits. Then, a description of the management system of the project is given, with the planning and organigramme. Next section focuses on the technical description, results and evaluation of each task of the project, including the dissemination actions undertaken, followed by the evaluation of the project implementation and the analysis of the long-term benefits. Next section deals with the comments on the financial report, in which the explanations on the main costs incurred during the project, the costs per action and the deviations, are given. Next section includes all the annexes to the report, including the deliverables, dissemination documents, such as presentations and posters, and the table of indicators. Last section includes the financial report and annexes, with the standard payment request and the beneficiaries’ statements.
3. INTRODUCTION

Black slag is an abundant industrial waste product in the European Union; it is estimated that between 8.6 and 14.3 million tonnes of black slag were produced in 2011 by the European steel producers. The project pursues the development of a new alternative of valorisation for the Electric Arc Furnace Slag (EAFS), subtype of Steel Furnace Slag (SFS), by using it as raw material for new recycled aggregates, the SFS-Rail, to be used in the sub-ballast and sub-grade railway foundation layers.

The aim of the project is to extend the market of an industrial waste product by identifying a new field of valorisation which shows good environmental and economic returns. Other goals that are expected to be achieved, derived from the demonstration of the technical and economic feasibility of SFS-Rail are the following:

- Reduction of the use of natural aggregates in railway construction, which turn into the reduction of quarries’ environmental impact.
- Reduction of the transport needs associated to railway aggregates, which turns into fuel savings and reduction of the CO$_2$-emissions. It is expected that SFS-RAIL will be more accessible to work-sides than natural aggregates, because few quarries fulfil the technical requirements demanded by railway regulations.
- Improvement of the mechanical performance of railway track. Research done up to now on SFS-Rail shows that the mechanical properties of this product overpass the performance of natural aggregates
- Reduction of the material cost of railway aggregates. The difference in sale price between natural aggregates and EAFS aggregates increase with the hardness required. So the savings are higher when EAFS substitutes hard natural aggregates, such as the railway ones.
- Reduction of the volume of final disposal and the volume of storage of black slag. Although landfill disposal of SFS-Rail has enormously diminished during the last decades due to its application other applications such as road construction, the final deposit rate could increase in the coming years because of the economic crisis affecting the civil engineering sector.

The technical feasibility of SFS-Rail is proved by its good performance in the demo sites constructed in the project. The procedures implemented to produce SFS-Rail are easily transferrable to other European countries, whilst the valorisation solution proposed is replicable across Europe.
4. ADMINISTRATIVE PART

4.1. Description of the management system

The project is clearly structured in five types of actions: A. Preliminary actions, B. Implementation actions, C. Monitoring actions, D. Communication and dissemination actions and E. Actions related to the management and monitoring of the project progress.

Although actions D and E cover all the time span of the project, the activities and tasks of actions A, B and C relate to some particular phases of the project, which can be established as follows:

- Phase 1: Activities prior to the demonstration (field tests)
- Phase 2: Activities related to the field tests design and construction
- Phase 3: Activities related to monitoring and processing of results

Thus, actions A1 (Study of European Legislation on railways and environment), A2 (Study of European steel making plants) and A3 (Study of European Railway Projects) clearly belong to phase 1, which also includes actions B1 (Adaptation of the valorisation plant), B2 (Management of SFS-Rail stocks), part of B5 (Development of a calculation software for track design), part of B7 (LCA report), part of B8 (Quality Control Plan of SFS-Rail). These actions require a fluid communication between COMSA and ADEC GLOBAL for a proper study of the different issues and for the adaptation of the plant to achieve the expected production of SFS-Rail.

The second phase of the project is focused on the field tests, and thus has a major interaction among the different parties involved in the project, the railway Administration (ADIF) and the civil works and topography departments of COMSA. The activities of this stage are comprised of actions B3 (Design of the field tests), B4 (Construction of the field tests), C1 (Design of the field tests monitoring) and C2 (Monitoring of the Quality Control Plan results).

In the third and last phase of the project, the focus is on monitoring the field tests and processing the results, where the main actions are action C4 (Monitoring of the field tests), B5 (Calibration of the software), B6 (SFS-Rail track solutions catalogue), the quantification of the positive environmental impact of the track sections (Task 2 of action B7), the productivity results report (Task 2 of action B8) and action C3 (Socio-Economic impact of the project). In this phase, the communication and dissemination of results play a key role.

The planning of the project’s activities and tasks has been attached at the end of this section.

The project is coordinated by COMSA, namely, Joan Peset (Project Manager), Miquel Morata (Technical Coordinator) and Carlos Saborido (Financial Coordinator). For internal restructuration reasons, Miquel Morata has replaced Carles Subirós, who has been the Technical Coordinator since the beginning of the project until 16/03/2015. Miquel is a Civil Engineer by the Polytechnic University of Catalonia (UPC) with a specialization course in railway engineering and experience in railway construction works and in R&D projects related to the railway industry. Miquel has been involved in the GAIN project since 2014 and has a great knowledge and experience in the project’s field.

The main project management structure is the Management Team, composed by the project Manager, the Technical Coordinator, the Financial Coordinator and the ADEC GLOBAL Coordinator,
Félix Pedroso. The Management Committee seeks consensus on project direction, resolves any administrative or contractual issues and decides on the management issues, including technical, dissemination, financial, planning and control matters. Meetings are planned on a bi-monthly basis at the COMSA’s headquarters in Barcelona. Until now, the members of the Management Team have met in 12 meetings on the following dates:

- **Year 2013**: 19/07/2013 (kick-off meeting), 02/10/2013, 28/10/2013, 21/11/2013
- **Year 2015**: 26/02/2015, 21/04/2015, 30/06/2015, 08/09/2015, 29/10/2015
- **Year 2016**: 25/01/2016, 25/04/2016, 07/07/2016

COMSA prepares the agenda of the meeting and sends it to ADEC Global at least two weeks before the date. The coordinator also prepares the Minutes of the meeting and distributes it immediately afterwards. The organization of bimonthly meetings has proven to be very productive for the project’s progress.

Moreover, since only two partners are involved in the project, the communication and interaction between the coordinating beneficiary and the associated partner ADEC Global is conducted on a nearly daily basis by telephone or by emails in order to ensure the successful implementation of actions and plans of the project.

Another structure of the project management is the **Steering Committee** composed of one representative of COMSA (Joan Peset) and ADEC Global (Félix Pedroso) as well as an ADIF’s representative (Miguel Rodríguez Plaza, Head of Management Systems for Operation at ADIF). The president of this Committee is the Project Manager (Joan Peset). The Steering Committee meets on a biannual basis to ensure excellence and relevance of the project as well as to give advice on the project development to achieve a maximal output. Until now, the Steering Committee has met in six different meetings on 02/10/2013, 14/04/2014, 25/11/2014, 21/04/2015, 25/01/2017 and on 07/07/2016.

An organigramme has been attached at the end of this section.

### 4.2. Evaluation of the management system

Due to the fact that the consortium for the LIFE+ GAIN project is only composed by two partners located at a distance of approximately 50km, the management of the project has proven to be very smooth, without problems to be encountered and significant deviations to be reported. Moreover, for the time being no amendments to the contract have been issued.

**Four meetings with the external monitor** (Rosana Asensio from ASTRALE at the beginning and NEEMO at present) took place during the project at COMSA’s headquarters. The first three meeting were held on 30/10/2013, on 16/09/2014 and on 29/10/2015, with the objective of monitoring the progress of the project. The **fourth meeting was held together with the European Commission (EC)** after the project’s end, on 10/11/2016, during the audit period and while the partners were preparing this Final Report.

In addition, **seven communications have been received via e-mail or letter from the EC during the project**. The first communication was received on 20/01/2014 after the first monitoring visit by the
external monitor; the second communication was received on 20/05/2014 after the submission of the Inception Report; the third communication was received on 25/11/2014 after the second project visit by the external monitor; the fourth communication was received on 25/06/2015, after the submission of the Mid-Term Report; the fifth communication was received on 13/10/2015 with some comments on the Mid-Term Report, the sixth communication was received on 16/12/2015, after the third visit of the external monitor; and the last communication was received on 09/11/2016, informing on the visit of the EC and the external monitor.

Remarks were made with regard to the website, which was made accessible from 07/03/2014, translated into Spanish and Catalan languages, and updated along the project. Other comments encouraged creating a network between experts of other LIFE+ projects, which has been done by contacting several LIFE+ projects (see action E4 in section 5). A remark was made asking to include the project’s LIFE+ reference and mentioning the EU co-funding in the initial brochures, which were revised and are attached to this report in Annex 7.3. The final brochure has been designed including the LIFE+ reference and mentioning the EU co-funding, and has also been attached to this report.

Finally, other concerns were brought up regarding the delay in the field test implementation, which was solved by constructing the field tests in Gijón, in April 2015, and in Castellbisbal, in October 2015. The notice boards have also been erected, as emplaced by the latest communications. Finally, regarding the comments of the European Commission on timesheets, invoices and the calculation of the hourly personnel cost of COMSA employees, full details of the actions taken can be found in the chapter 6.2 of this report. This includes the revision of ADEC GLOBAL timesheets and signatures, explanations on the calculations of the actual hourly costs and the measures adopted to ensure that the reference of the project is included in all the invoices.

All the meetings gave the partners a very valuable insight to proceed with project’s actions during and after the project.
### Project's planning

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Final report LIFE+ GAIN
Organigramme

European Commission

COMSA (Coordinating beneficiary)

NEEMO (External Monitoring)

ADEC GLOBAL (Associated beneficiary)
5. TECHNICAL PART

5.1. Technical progress per task

This section includes actions A, B, C, E2, E3 and E4. Actions D and E1 are included in section 5.2.

**Action A1: Study of the state of the art regarding European legislation on railway infrastructure and environmental topics**

This action has been completed on schedule, by 31/10/2013.

In this action, the technical standards for the subballast and the subgrade layers for some European countries (Spain, Germany, Italy, France and Portugal) have been researched.

The first stage was to find the naming of “subballast” or “subgrade” in the different countries that have been researched. Then, an intensive research was carried out in order to find the organisms that regulate the standards in each country. In some countries, the standards are dictated by the government and then the different rail administrators transpose these standards into normative documents. In some countries like France the norm documents property of the SNCF are for internal use only and it is very difficult to obtain them. In such cases, information has been searched via internet and information has been found in presentations and technical documents. In some occasions, the normative documents are available but at a certain cost, as the Portuguese REFER, which has been purchased.

The same has been done for the environmental legislation and also the legislation regulating the use of steel slag in each country. Associations such as EUROSLAG, the world steel association or the European environmental agency have been also searched in order to find valuable information.

In general, no major problems have occurred, and the small constraints encountered have been rapidly solved. These constraints were mainly due to the problems in finding the technical specifications in each country, as some rail administrators do not publish their standards making them inaccessible. Another constraint encountered was that most countries have their regulations in their own national language making them difficult to understand.

The objective of this action has been fulfilled and we believe that it is beneficial for the project. In order to place SFS-Rail in the European market, we already know the requirements of national as well as Community European standards and specifications related to both technical and environmental aspects with regard to the intended use.

This action has been explained in more detail in the Inception and in the Mid-Term report.

The deliverable of this action has been attached in Section 7.2 of this Final report.

This action does not have perspectives to be continued after the end of the project.
**Action A2: Identification, study and description of the European steel making plants located in targeted countries and the black slag produced**

This action has been completed on schedule, by 31/10/2013. However, on 31/08/2014 a second version of this report was done by COMSA, with the addition of complementary information, especially regarding black slag, as requested by the European Commission on the e-mail received on 20/01/2014. The development of this second version did not affect any other action, given that action A2 is related to the replicability of the technology while the other undergoing actions where related to the field tests.

Based on an overview of the European steel industry, an exhaustive analysis of the current development of the production of black slag in European steel making plants has been carried out. Thus, it was found that there are several steel producing companies in Europe, which produce the corresponding amount of slag susceptible to be used in this project.

The territorial distribution of steel furnaces in Europe appears to be quite homogeneous and dense. This is an indispensable factor to guarantee the minimisation of transport environmental impacts and costs, making SFS-RAIL even more competitive than natural aggregates.

After analysing the European steel market, the identification, location and description of the main European steel making plants have been carried out. The main top-steel producing companies in Europe are: ArcelorMittal (Luxembourg), Tata steel (Germany), Gruppo Riva (Italy) and Thyssen Krupp (Germany). Other major steel producers that have been selected to be analysed in this project are Acerinox (Spain), Outokumpu (Finland) and CELSA Group (Spain).

All these steel producing companies have many plants in Europe. The work done in this report consisted in locate these plants, provide the main characteristics of their installations and production processes and determine their production rate of waste slag, and in particular of black slag. For instance, the amount of black slag produced by ArcelorMittal per year would be around 4 million tonnes. The EAF slag produced by Tata steel according to the financial year 2011-12 accounted for approximately 14.53% of the crude steel produced by them. And as from Gruppo Riva, in 2012, the overall steel production was 7.8 million tons, from which approximately 12% was EAF slag.

As a conclusion of all the above, we can state that the expected results of this action have been achieved.

This action has been explained in more detail in the Inception and in the Mid-Term report. In Section 7.2 of this report the revised deliverable document related to this action has been attached.
This action does not have perspectives to be continued after the end of the project.

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**Action A3: Study of the state of the art regarding the prospects of European Railway Projects**

This action has been completed on schedule, by 31/10/2013.

In this Action, a review of the Community and National European rail plans was carried out, together with a market analysis, in order to identify the demand forecast of SFS-Rail in the different European targeted countries.

A general overview of the European market (namely Germany, France, Poland, Italy, United Kingdom, Spain, Sweden, Romania, Czech Republic, Turkey, Hungary, Switzerland, Portugal and Lithuania) was achieved, in addition to possible SFS-Rail implementation constraints.

Thus, rail plans in Europe include 5,000 km to be added to Europe’s high speed network until 2020 and 44% projected growth in high speed rail passenger volume until 2020. Concerning this, there are four countries where the railway inversion will be especially high. These are the United Kingdom, France, Switzerland and Germany, where 70% of projected growth in passenger volume is expected until 2020.

In the East-Central European countries (Poland, Czech Republic, Lithuania, Romania, Hungary), the main investment plans for the next years are about the reconstruction and modernisation of existing lines. In some cases, these plans also include the construction of new lines, especially to connect the rest of Europe to these emerging economies. The case of Turkey is special, as their investments are much higher than the other East-Central Europe countries. The other European and more developed countries (Germany, France, Italy, Spain, Sweden, Switzerland, Portugal, and United Kingdom) railway projects are focused on the construction of new and modern lines. In most of the cases, these new lines are high-speed lines, and their main objective is to interconnect all Europe by railway. Although the second list of countries historically has had a bigger investment capacity, and the quantity and quality of their railway connections prove it, the East-Central European countries are emerging economies that are becoming a new market where export and import with the rest of the World is necessary. Thus, the railway connections of these countries with the rest of Europe is planned to be significantly improved in the following years by the construction of new lines and the modernisation of the existing ones.
Concerning the freight transport across Europe, the European Commission’s “Transport 2050” plan promises to get half of all the continent’s medium-distance goods transport off the roads and on to rail (or water) by 2050.

With all, the results of this action clearly show the high replication potential of the project in Europe, being the objective of this action totally achieved.

This action has been explained in more detail in the Inception and in the Mid-Term report.

The deliverable of this action has been attached Section 7.2 of this Final report.

This action does not have perspectives to be continued after the end of the project.

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**Action B1: Adaptation of an existing valorisation plant to produce SFS-RAIL**

This action has been done as planned but the Work plan for the establishment of the production line was not completed on schedule (03/03/2014). There was a short delay in the completing of this deliverable due to a work overload of ADEC GLOBAL from its daily activities, and the deliverable was completed two months after the delivery of the Inception Report (30/04/2014).

As a consequence of this delay, the second deliverable of this action, ‘Guidelines for the replication of the production line’, suffered also a short delay and it was finished by 30/09/2014, though in the initial schedule it was due on 01/07/2014. Nevertheless, these short delays did not affect any other action, since the production of SFS-Rail started in the second term of 2015 for the construction of the field tests in Gijón.

In this Action, the work plan for the establishment of the SFS-Rail production line and its implementation has been done. The replication guidelines to make this project transferrable to other European countries have also been analysed and described. The expected results have been thoroughly achieved.

This action has been explained in more detail in the Inception and in the Mid-Term report.

In Annex 7.2 of this report both deliverable documents related to this action have been attached.

This action does not have perspectives to be continued after the end of the project.
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### Action B2: Management of SFS-RAIL stocks

The deliverable of this action has been completed on schedule, by 01/01/2014. However, other activities related to the management of SFS-Rail stock but beyond the deliverable were done until 30/03/2014.

In this action, the plan for the management of SFS-RAIL stocks in ADEC GLOBAL’s plant has been described. The main topics of this plan are the classification criteria (in terms of granulometry), the space needed to pile up the stocks and the logistics from the plant to the storage site.

Several processes in the stock management plan of SFS-Rail were defined, which represents a needed step prior to the following actions.

With all the above, the objective of this action has been totally fulfilled.

This action has been explained in more detail in the Inception and in the Mid-Term report.

The deliverable of this action has been attached in the Inception Report.

This action does not have perspectives to be continued after the end of the project.

### Action B3: Design of the first field implementation

This action has suffered an overall delay of 6 months (it should be completed by 01/11/2014 and it has been finished by 01/05/2015) due to the difficulties encountered in finding a suitable location for the field tests in the network of ADIF (Spanish Infrastructure Manager).

In particular, the three tasks (and deliverables) of this action have been delayed. The first one, related to the selection of the location of the field tests, was finished by 31/03/2015 instead of 01/06/2014 (10 months delay); the second one (calculation report supporting the new track designs) was completed by...
01/05/2015 instead of 01/09/2014 (8 months delay); and the third one was also completed by 01/05/2015 instead of 01/11/2014 (6 months delay).

Thus, though the first task originated a delay of 10 months, effort has been put on the second and third tasks of this action to reduce the overall delay up to only 6 months, thus minimising the affection to other actions of the project and the envisaged end date, while meeting the demands of the European Commission urging to solve this issue, as stated on their communication received on 25/11/2014.

However, as a consequence of the delay of this action, the construction of the field tests and the beginning of the monitoring activities have also been affected. Measures have been taken into account to minimise the impact of these delays in the planning of the project and its end date. Namely, the affected actions and proposed solutions are:

- Action B4 (construction of the field tests), which started on 01/04/2015 instead of 01/10/2014 and is expected to end in October 2015 instead of June 2015. To reduce the impact of this delay, another field test location not depending on ADIF has been selected, in El Puerto del Musel (Gijón, Asturias). The field tests have already been constructed by 30/04/2015.

- Action C2 (monitoring of the Quality Control Plan results), which started with the construction of the field tests of Gijón on 01/04/2015 instead of the planned date of 01/07/2014. More resources have been allocated in the rest of the months to end the action upon schedule, on 30/04/2016.

Opposite to these delays, action C4 (monitoring of the field tests) has started prior to the planned date (on 01/05/2015 instead of 01/06/2015), as the topographic surveys in the field tests of El Puerto del Musel (Gijón) start right after the construction of the field tests.

Next, the progress of action B3 and the origin of all these delays will be explained in detail.

In the first task of this action, in the early stage of the project, COMSA studied the railway works that was carrying out or about to carry out in the following months to choose the best location for the field test sections. New railway construction works, renewal works and maintenance works were considered for analysis. From all the possibilities, the best option to construct the field tests was the stretch between Vinaròs and Vandellòs, in the South of Catalunya and North of Valencia regions, where COMSA had a contract for the line renewal (track and electrification) and introduction of the UIC gauge. It was chosen given its features and its high volume of mix traffic (freight and passengers).

COMSA contacted with ADIF in order to confirm the construction of the test sections in Vinaròs-Vandellòs and proceed with the preparatory actions. However, given the financial crisis affecting the Euro zone and especially Spain, ADIF postponed the renewal works sine die. COMSA, in an attempt to avoid a delay in the execution of the project, looked for other possible locations where carry out the field tests.

The second attempt of a field test location was in the railway station of Castellbell i el Vilar / Monistrol in the province of Barcelona (Spain). This station, located at 50 km from Barcelona city, is part of the R4 line, which is one of the commuter lines of the Barcelona railway network. A geotechnical characterization in two different points of the selected area was performed during a track possession, at night. The inspection showed that the existing railway line did not have either subballast nor subgrade layers to be substituted by SFS-Rail. The railway line was constructed a long time ago.
and goes through a rocky area, running most of the time in cutting sections, so it the ballast layer was extended directly on the rocky substrate. Hence, for the purpose of this project, this was not a valid test section so other alternatives had to be looked for.

The third attempt of a field test location was in the municipality of Fornells de la Selva, in the province of Girona (Spain), but failed to host the field tests because, at the end, no track possession was allowed by ADIF to carry out the construction works.

The first field test location that finally resulted in a success was in El Puerto del Musel (The Musel Harbour) in Gijón (Asturias, Spain). The reason for choosing this field test location was that the LIFE GAIN partners had difficulties in finding a proper location for the field tests in the ADIF (Spanish Infrastructure Manager) network, as explained above. As a result, most of the time allocated for this action was spent and there was little room for finding a field test on schedule. For this reason, and provided that COMSA was about to execute the track renewal at the North end of the railway station of El Musel, it was decided to execute a first field test there, while seeking another field test location in ADIF’s network.

Note that the entire Musel harbour and, consequently, its tracks, are owned by the Autoridad Portuaria de Gijón (Gijón Harbour Authority), not by ADIF. The field tests of Gijón were decided to be done in the first track, which is the one closer to the road on the East side. (see Figure 1).

This way, the railway traffic affection was minimal, and the existing concrete wall on the East side could be used as a support for the monitoring activities. The track geometry was mainly linear and flat in the field test stretch, with a length of the Track 1 of approximately 90 m, thus allowing three test sections:

- A 30 m long section with the existing conventional aggregates (control section)
- A 30 m long section with the subballast layer made of SFS-Rail and the subgrade layer with the existing conventional aggregates
- A 30 m long section with both the subballast and subgrade layers made of SFS-Rail

The harbour has low traffic during week days and high traffic during the weekends, being directly proportional to the traffic arriving by ship to the harbour. Thus, during week days, it is enough to leave one track open for the passage of traffic. This track must be, of course, the main track, while the rest of the tracks (which are derived from the main one) can be possessed for the renewal works. This makes it possible to work during the day, with a permanent track possession during working days, making this emplacement ideal for the field tests.

For the sake of replicability of the project’s results, the second field test has also been constructed in the ADIF network. The best location found was the mixed railway line (passengers and freight) of Castellbisbal, in Barcelona. A confirmation letter of these field tests has been issued by ADIF and attached to this report in Annex 7.1.

The selected stretch (see figure 11, “Ramal Martorell-Vallès, Ancho Ibérico”) suits the project’s demands, given that there is enough track possession time, there is a wide access for the machinery and the material distribution, a wide zone by the track that can be used as a storage area, being the
overall conditions of the area totally suitable for the logistics and the monitoring operations of the field tests.

Moreover, this emplacement is excellent because it is near the ADEC GLOBAL’s valorisation plant and, hence, minimizes the SFS-Rail transport and associated impact. It is also near the COMSA’s headquarters and near Barcelona, making it easy for frequent visits and inspections.

The selected stretch is in a curve and has a single track. There is a little embankment for the ballast and a flat surface on each side; however, the track goes through a cut area. In general, no changes in the soil stiffness must be considered along the area of the field tests, provided that there are not any underground structures or canalizations crossing the track in the considered stretch.

Given the allowed track possession time, the maximum distance to be constructed was of 100 m, and 50 m of a control section. Hence, three sections of 50 m each will be considered:

- A 50 m long section with the existing conventional aggregates (control section) two subsections of 25 m each (at the beginning and at the end of the stretch).
- A 50 m long section with the subballast layer made of SFS-Rail and the subgrade layer with the existing conventional aggregates.
- A 50 m long section with both the subballast and subgrade layers made of SFS-Rail.

The existing soil in the zone of Castellbisbal has been previously characterised in the Construction Project of the line Castellbisbal / Papiol – Mollet / Sant Fost, also executed by COMSA. The project, dated on October 2006, envisaged the execution of a third rail for the suitability of traffic of either International or Iberian gauge. Several geotechnical tests were done along the track, finding reddish orange brown silt in the uppermost 3 m and reddish brown clay in the deepest part, both with traces of hard sand.

In the second task, a deliverable has been done with the new track designs with SFS-Rail where the geotechnical data of the field test locations, the properties of the SFS-Rail and the requirements for the railway track construction according to the actual legislation have been taken into account. Different scenarios have been analysed, considering conventional aggregates or SFS-Rail in the railway foundation layers, concluding that the use of SFS-Rail is capable to reduce the thickness of the subballast and subgrade layers up to the minimum required by the current norms.

Finally, the third task of this action has been done, in which the technical procedure for the construction of the field tests has been described. It comprises the following steps:

1. Planning of the construction works (track possession, storage area, materials, labour, machinery, budget...)
2. Topographic stakeout
3. Removal and storage of the rail, sleepers, base plates and auxiliary elements of the stretch to be upgraded with SFS-Rail
4. Emptying and storage of the ballast, subballast and subgrade layers
5. Extension and compaction of the subgrade layer made of SFS-Rail
6. Extension and compaction of the subballast layer made of SFS-Rail
7. First extension of the ballast layer
8. Material distribution and track installation
9. Ballast filling, levelling and alignment
10. Rail welding
11. Second levelling
12. Cleaning and finishing

In general, the use of SFS-Rail in subballast and subgrade layers does not vary substantially with respect to natural aggregates, though some modifications may apply due to the considerable increase of the EAFS aggregate weight. Hence, the amount of EAFS aggregates that a dumper can transport has to be controlled to not exceed the maximum stress allowed on the platform, the output of excavators and other machinery used to extend aggregates will be reduced and the compaction of track bed layers where SFS-Rail has been used will be affected.

Given that the construction of the new test sections in Gijón (Asturias, Spain) and Castellbisbal (Barcelona, Spain) will both be done with a permanent track possession (as opposed to daily night track possessions), this will be the procedure selected.

Despite the delay, the objectives of this action have been thoroughly fulfilled and the field tests have been totally characterized for its construction.

The three deliverables of this action have been attached in Annex 7.2 of this report.

This action does not have perspectives to be continued after the end of the project.

<table>
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<td>31/03/2015</td>
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<td>B3.2 Calculation report supporting the new track designs with SFS-Rail</td>
<td>01/09/2014</td>
<td>01/05/2015</td>
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<tr>
<td>B3.3 Technical procedure describing how the new section using SFS-Rail has to be constructed</td>
<td>01/11/2014</td>
<td>01/05/2015</td>
</tr>
</tbody>
</table>

Expected results

| Selection of locations for field tests                                      | 01/06/2014 | 100%       |
| New track designs using SFS-Rail                                            | 01/09/2014 | 100%       |
| Construction methodology                                                    | 01/11/2014 | 100%       |

Progress indicators

| Deliverable B3.1                                                           | 01/06/2014 | 100%       |
| Deliverable B3.2                                                           | 01/09/2014 | 100%       |
| Deliverable B3.3                                                           | 01/11/2014 | 100%       |

Action B4: Construction of the field tests

This action ended on October 2015 instead of June 2015, i.e. with a delay of 5 months.
Due to the fact that the LIFE GAIN partners encountered problems in finding a proper location for the field tests in within ADIF’s network, another field test location was considered in El Puerto del Musel (Gijón, Asturias), the construction of which took place on April 2015 (on schedule). The field tests in ADIF’s network took place on October 2015 in Castellbisbal, allowing for a almost a year of monitoring (Action C4), hence, not affecting the project’s end date.

The construction of the field tests in Gijón started with the topographic stakeout, which was done in a whole scale for all the construction works. To do so, the project topographic references were used. After the topographic stakeout, and once all the signalling devices were disconnected and removed, the first step was to remove the rails, sleepers, fasteners and auxiliary elements to the storage area located in the North of the site. No rail cut was needed, as the rails were not welded but tied with flanges. The emptying of the different granular layers (ballast, subballast and subgrade) was done by a mix machine consisting of a loader and a backhoe. Since all the old material was to be substituted by new material, either natural aggregate/soil or SFS-Rail, it was not necessary to store it in the site. Instead, it was transported to a landfill.

After the excavation, a 30 cm thick and 30 m long section made of SFS-Rail was extended and compacted, with the help of a backhoe and a compaction roller, respectively, to form the subgrade layer. The compaction was more time-consuming than for natural aggregate, since the density of SFS-Rail is notably bigger and more energy was required to obtain a proper compaction of the subgrade layer. After that, a geotextile was laid prior to the extension of the subballast layer. The geotextile was also placed on top of the subgrade layer made of natural soil of the contiguous 30 m long section, after performing the sanitation of the soil. Then, on top of it, the subballast layer made of SFS-Rail was extended and compacted along the 60 m long of the two sections. A marking of the subballast layer was done with the aid of a topographic survey prior to the extension of SFS-Rail.

Once the subballast layer is placed and compacted, a first ballast layer (between 10 and 20 cm thick) was extended, according to the technical procedure described in action B3. After the first ballast layer extension and compaction, the sleepers, which were stored in the storage area, could be loaded and transported by a VAIACAR, which is a machine specially designed to work on rails (see next figure), and positioned on the ballast. Once the sleepers, rails and fasteners were placed, it was time for the ballast filling, levelling and alignment, which took place at the same time. The hopper train discharged the ballast on the renewed track, and it was then profiled.

Topographic measurements were carried out to determine the geometric conditions of the track as a testing of the levelling and alignment works. The tamping was then performed with the VAIACAR with the tamping group. The tamping was done to lift up the rails, sleepers and fasteners as the ballast was positioned at the proper place. This process was done as many times as needed to provide the ballast layer with the required thickness, which was of 30 cm under the sleeper. The field test was then constructed and ready for the passage of trains and the monitoring activities.
For the **construction of the field test sections of Castellbisbal**, the first action of the construction of the field tests was the topographic stakeout. After the topographic stakeout, all the signalling devices were disconnected and the service of the line was interrupted by a pilot from ADIF. The next step was to remove the rails, sleepers, fasteners and auxiliary elements to the storage area located in the North end of the field tests, before the track switch, thus not affecting any other line. The emptying of the different granular layers (ballast, subballast and subgrade) was done by two loaders and dumper trucks. The extracted material was placed in the storage area on the top of the terrain slope, next to the SFS-Rail and the equipment and machinery area, waiting to be transported to a landfill on the subsequent days. After the excavation, a load plate test was performed, one on the subgrade layer and another one on the sub-ballast layer. The results were 130 MN/m$^2$ and 75 MN/m$^2$, respectively.

Once the load plate tests were performed, two load cells were placed to measure the stress under the subgrade layer. After that, the 35 cm thick and 50 m long subgrade layer made of SFS-Rail was extended, watered and compacted, with the help of a backhoe, a water trunk and a compaction roller, respectively.

The compaction was more time-consuming than for natural aggregate, since the density of SFS-Rail is notably bigger and more energy was required to obtain a proper compaction of the subgrade layer. After the compaction, a density and humidity test was performed (see figure 26), in order to compare it against the Modified Proctor analysis carried out previously in laboratory. An average 100% compaction rate was achieved.
Once the subgrade layer was extended and compacted, the tubes to monitor the settlement of this layer were placed on top of it. In addition, the load cells to monitor the stress under the subballast layer were also placed on top of the subgrade layer. Then, on top of it, the subballast layer made of SFS-Rail was extended and compacted along the 100 m long of the two sections.

Density and compaction tests were also performed on top of the subballast layer, once it was extended, watered and compacted. Tubes were also placed on top of the subballast layer to monitor its settlement, in all three sections of the field tests. Later on, a first 10 cm thick ballast layer was extended. After the first ballast layer extension, the track panels were loaded and transported by a VAIACAR and positioned on the ballast.

FIGURE 3. a) TUBES TO MONITOR THE SETTLEMENT OF THE SUBGRADE LAYER, b) PLACEMENT OF THE TRACK PANELS ON THE FIRST BALLAST LAYER
Once the sleepers, rails and fasteners were placed, it was time for the ballast filling, levelling and alignment, which took place at the same time. The hopper train discharged the ballast on the renewed track, and it was then profiled.

Topographic measurements were carried out to determine the geometric conditions of the track as a testing of the levelling and alignment works. After that, the ballast tamping was carried out paying special attention not to interfere with the track settlement monitoring equipment.

The tamping was done to lift up the rails, sleepers and fasteners as the ballast was positioned at the proper place. This process was done as many times as needed to provide the ballast layer with the required thickness, which was of 30 cm under the sleeper.

After a final topographic stakeout, the field tests construction was then finished and ready for the passage of trains and the monitoring activities.

The full report of the construction of the field tests has been attached in Annex 7.2.

This action does not have perspectives to be continued after the end of the project.
Action B5: Development of a calculation software for track design using SFS-Rail

Action B5 began on schedule and finished at the end of the project, once it could be calibrated with the results of the monitoring activities in the field tests.

It should be pointed out that this action has suffered some changes with respect to the initial tasks distribution. The tasks have been rearranged and renamed to make more sense and in order to be in the chronological order of the actual development of the software and its modules. Note that this rearrangement of tasks has not affected the scope of the action.

In the following table, the rearrangement of tasks is summarised:

<table>
<thead>
<tr>
<th>Actual subtasks</th>
<th>Subtasks foreseen in the proposal</th>
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<tbody>
<tr>
<td>Subtask 5.1. Development of the core software</td>
<td>Subtask 5.1. Development of the core software</td>
</tr>
<tr>
<td>Subtask 5.2. Validation of the developed software</td>
<td>Subtask 5.4. Validation of the developed software</td>
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<tr>
<td>Subtask 5.3. Development of an optimization module</td>
<td>Subtask 5.3. Development of a calculation module to allow the identification of the optimal solution by automatically iteration</td>
</tr>
<tr>
<td>Subtask 5.4. Module to predict track settlement along time</td>
<td>Subtask 5.5. Development of a soil degradation module to predict track settlement</td>
</tr>
<tr>
<td>Subtask 5.5. Calibration from the results of the field tests monitoring: 5.5.1. Calibration of the SFS-Rail parameters 5.5.2. Calibration of the track settlement prediction module</td>
<td>Subtask 5.2. Development of a calculation module to obtain SFS-Rail strength parameters from test results Subtask 5.6. Calibration of the degradation model based on monitoring results</td>
</tr>
</tbody>
</table>
All the tasks have been carried out successfully and the results obtained have been fully satisfactory.

In the software, the infrastructure components that have been considered are the rail, base plates, sleepers, and setting bed (ballast, subballast, subgrade and natural soil layers), supported by an infinitely rigid subsoil. The model considers symmetrical behaviour of the track from the vertical plane through its axis.

Regarding loads, the model is able to consider only one wheel load over the rail either two wheel loads (bogie). It is a continuous elastic model, so the setting layers are characterized by their Young modulus and Poisson coefficient. Due to this continuity, the geometry of the layers, in the track bench, had to be defined considering the geometric vertical stress distribution with depth, in order to avoid unrealistic contribution of tensional support in layer areas outside their true charged ones. Therefore, the model has not ballast border, and the side slope of each layer (ballast, subballast and subgrade) has been defined by setting the vertical stress results to values that provide the classic theory. So, the ballast side slope is 2/1 (vertical/horizontal) and the subballast and subgrade side slopes are 2/3 (vertical/horizontal). The same reasons have led the model to consider three sleepers (not more) on each side of the load, because the actual stress distribution goes no further.

In the model, the natural soil layer is a virtual one that relies on infinitely rigid subsoil and whose thickness and material features allow to calibrate the model, especially in terms of the overall deflection of the infrastructure, measured as rail deflection.

The code allows three calculation modes:

- **Mode 0 (First validation):** automatic validation (no data input needed) of load distribution under sleepers and rail deflection. The outputs are virtually identical to the classic theory ones (see section 2.2.A).

- **Mode 1 (General):** It is the mode to freely define all calculation parameters, i.e., rail, base plate and sleeper types, layers thickness, Young and Poisson modulus, and number (one or two) and value of loads. This mode should be used, for example, for the second validation about vertical stresses at certain depth (see section 2.2.B).

- **Mode 2 (SFS-Optimization):** it finds the SFS layer thickness (for subballast and subgrade) in order to respect the soil limit stress value, and it permits to verify that the limit stress values of the other layers are also respected.

The code structure has following sections:

- “General Options”:
  - Drawing outputs on screen or on file;
  - Calculation mode: “First validation” (0), “General” (1), “SFS-Optimization” (2);
  - Rail reference displacement (m): it is simple reference information; it is not used for calculations.
  - Ballast reference stress (Pa): it is simple reference information, when mode SFS-Optimization is used, in order to know the ballast stress value in conventional section, with natural aggregates, before substituting the subballast and subgrade layers by the SFS ones.
- “Load” (data):
  o Load (N) per train axle;
  o Number of loads: one load (one wheel) or two loads (one bogie);
  o Bogie wheel-base (m).

- “Geometric Parameters” (data):
  o Type of rail: UIC 54 or UIC 60;
  o Sleeper:
    ▪ half no supported sleeper length (m);
    ▪ half bearing sleeper length (m);
    ▪ distance between sleeper end and rail (m);
    ▪ sleeper width (m);
    ▪ sleeper height (m);
  o Base plate: geometry automatically defined depending on the type of rail;
  o Ballast:
    ▪ thickness (m);
    ▪ Vertical stress distribution from sleeper end;
  o Subballast and subgrade:
    ▪ Thickness of each layer (m); when the SFS-Optimization mode is used, the code performs calculations for several cases of various layer thicknesses (from 7.5+7.5 cm -subballast plus subgrade thickness- until 20+20 cm); it finds the layer thickness for SFS layers (subballast and subgrade ) in order to respect the soil limit stress value.
    ▪ Vertical stress distribution is defined in the ballast (above sub-ballast) with, at least, 2/1 slope.
    ▪ Vertical stress distribution is defined in the subballast and subgrade (above soil) with, at least, 2/3 slope.
  o Natural Soil: virtual thickness (m).

- “Material Parameters” (data): Young modulus (Pa) and Poisson coefficient for all materials. Then the limit stress value for each layer material is calculated using the Heukelom’s empirical formula for permissible compressive stress.

- “Geometry”: the geometric model features are defined; this definition includes the particular zones and points where the values of stresses or displacements are required; i.e., the stresses in each layer and the displacements of points placed below wheel load and in the higher surface of each layer.

- “Boundary Conditions”:
  o No cross displacements in inner face.
  o No longitudinal displacements in strange faces.
- No displacement in bottom face under natural soil.

- “Solution”: once the geometric model is designed, once the elastic mechanic behaviour is assumed and once the elastic material parameters are defined, the code calculates the stiffness matrix. From this matrix and the boundary conditions, displacements and stresses are calculated. And, finally, the global infrastructure stiffness and also the base plate stiffness.

- “Postprocess”: it shows different drawings about displacements and stresses; also, it gives written outputs.
  
  o Drawings:
    - Static deformation of the model (with a multiplier factor of displacements equal to 75 shifts).
    - Vertical displacement (with a colour code) of each model layer.
    - Vertical stresses (with a colour code) of each model layer.
  
  o Written outputs:
    - All data.
    - Load distribution percentages between sleepers.
    - Limit vertical stress to respect in each layer.
    - Maximum vertical stress in each layer.
    - Vertical displacement under each load and in each layer.
    - Global static infrastructure stiffness.
    - Static base plate stiffness.

In the following figure, the 3D track model developed by COMSA is shown.

![3D track model](image)

**FIGURE 5: FINITE ELEMENT 3D TRACK MODEL DEVELOPED BY COMSA**

The track settlement prediction along time is also shown next.
The deliverable with the description, calculations, assumptions and achievements of all the tasks, together with the code of the software is attached to Annex 7.2 of this Final report.

This action does not have perspectives to be continued after the end of the project.

<table>
<thead>
<tr>
<th>Deliverables</th>
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<th>Actual</th>
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<td>B5.1 New software for track design using SFS-Rail</td>
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<tr>
<td>Software development</td>
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</tr>
<tr>
<td>Software calibration</td>
<td>01/03/2016</td>
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</tr>
</tbody>
</table>

**Action B6: SFS-Rail Track solutions catalogue**

Action B6 has suffered a delay of 5 months, as it has been done once the results of the monitoring activities have taken place and the software has been fully calibrated. The catalogue considers:

- 3 natural soil qualities: poor ($E_m=30$ MPa), moderate ($E_m=45$ MPa) and good ($E_m=80$ MPa);
- 2 segments of UIC traffic groups: $T_f \leq 2 \cdot 10^5$ kN/day, $T_f \geq 2 \cdot 10^5$ kN/day.
- 2 kind of track section: natural aggregates section (conventional track) and SFS section.

All this with an optimum global stiffness: $k_G = 75$ kN/mm, for conventional track, and $k_G$ between 73 kN/mm and 83 kN/mm for SFS section. Results are shown next:
(1) Calculations done with following data:
- Two loads of 130 kN and bogie wheel base of 2,800 m of length;
- Rail 54E for 5-6 UIC Traffic Groups and Rail 60E for 1-4 UIC Traffic Groups;
- Base plate Stiffness: 100 kN/mm;
- Sleeper: DW-Renfe, 2,600 mm length.


In conclusion:
- In spite of the high stiffness of the SFS-Rail layers, the global track stiffness is kept in the range of optimal values (50 to 100 KN/mm), below 83 kN/mm.
- The use of SFS layers allows reducing the track cross section thickness of the reference track between 5 cm and 45 cm (these cases are due to constructive restrictions).

The track solutions catalogue has been attached in section 7.2 of this report.

This action does not have perspectives to be continued after the end of the project.
Action B7: Elaboration of the Life Cycle Assessment (LCA) of SFS-Rail

The first task of the action, which consists of a Life Cycle Assessment (LCA), was completed by 02/03/2015, according to the schedule. Both COMSA and ADEC GLOBAL have participated to carry it out. COMSA has provided its knowledge in the elaboration of LCA while ADEC GLOBAL has provided the raw data for the manufacturing of SFS-Rail.

The primary goal of the LCA is the comparison of the environmental aspects between SFS-Rail and the conventional aggregates and soil employed in the subballast and subgrade layers of railway lines, in accordance with ISO 14040:2006 and ISO 14044:2006 standards.

The GaBi software has been used to perform the calculations of the LCA. In the following figures, the flow diagram considered for the SFS-Rail and the conventional aggregate scenarios are shown.
A cradle-to-gate approach has been considered, which means that the study only focuses on the raw material acquisition, materials manufacture, production, mixture and transport to site.

The impact assessment is based on the methods and data compiled and includes the following LCIA categories:

- **GWP (Global Warming Potential)** is a warming of the atmosphere, which causes climate changes, which may include increased global average temperatures in the lower atmosphere and sudden regional climatic changes.

- **AP (Acidification potential)** is caused by acids and compounds which can be converted into acids. When emitted to atmosphere and deposited in water and soil, may eventually result in a decrease of the pH, and so an increase in acidity. Mainly affects the environment in a regional scale.

- **EP (Eutrophication Potential)** is also called nutrient enrichment; it affects the function and structures of the ecosystems by exerting toxic effects on the organisms that live in them. Predominantly it affects local and regional scales.

- **HTP (Human Toxicity Potential)** covers a number of different effects (acute toxicity, irritation effects, allergic effects, etc.) and exposure via different media (air, water and soil) related with human health. It does not include indoor consumer exposure or work environment.

Results of the LCIA are given for a cradle-to-gate approach for the subballast and subgrade layer of a 1 km long single railway line. Figure 9 represents the total impact of each category by the two scenarios (SFS-Rail and conventional aggregate) for the subballast layer.

As it can be seen, for all the environmental categories considered, the impact produced with 75% SFS-Rail + 25% natural aggregate is lower than that obtained using only natural aggregates. Similar results are obtained if considered the subgrade layer instead of the subballast layer. The use of SFS-Rail is even better if the location of the valorisation plant is close to the construction site, since the environmental impact associated to road transport diminishes, which is the major contributor to most of the impact categories considered.
The second part of this task consists of an Environmental Impact Assessment (EIA), which was done by the end of the project, once the track solutions catalogue was finished. It shows that for all the environmental impacts taken into account with the Eco-Indicator 95, SFS-Rail achieves a lower impact per ton at every single category, except for the pesticides. When it comes to the comparison per km, there is even a major reduction in the environmental impact, since SFS-Rail layers can be thinner than the ones from the conventional aggregates because of its higher stiffness.

Thus, one can conclude that beyond its technical improvements, SFS-Rail is a better solution for the environment than the conventional track section employing natural aggregates/soil in the subballast and subgrade layers of railway lines.

The full reports of the LCA and the EIA have been attached in the annex 7.2 of the present report.

This action does not have perspectives to be continued after the end of the project.

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<td>B7.2 Environmental Impact Assessment (EIA)</td>
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<td>EIA report</td>
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**Action B8: Design and implementation of the Quality Control Plan of SFS-Rail**

This action is divided in four tasks. The first three tasks of the action deal with the control of source quality, control of production quality and control of aggregate handling, and have been completed by 18/12/2014 instead of the planned date of 01/10/2014, as the responsible of ADEC GLOBAL was out for a period of two months. However, this delay did not affect any other action of the project, as the dependent action C2 (Monitoring of the Quality Control Plan results) started on 01/04/2015 due to the
absence of a field test confirmed before. The fourth task of action B8 was completed according to the schedule, by 02/05/2016.

In the first three tasks of this action, the main steps to follow are shown in order to ensure the quality of the Plan SFS-Rail. SFS varies depending on the type of steel produced in each steelworks, provided that depending on the function of the steel product (e.g. steel profiles, laminated steel, corrugated steel, wire rod, cold stamping, steels cementing…), the quality of SFS is very different because of the type of scrap used in the oven to melt. Depending on the variability of products or types of steel performed in a steelworks, the SFS will be more or less homogeneous, since the steel composition is variable and so it is its chemical composition, which directly affects its behaviour. Although the major applications in the SFS market are intended for civil works, the SFS behaviour and applications are highly variable (e.g. as asphalt, concrete, granular layers…), as determined by the SFS chemical composition and their physical and mechanical behaviour.

To ensure that the SFS are up to the standards for each of the applications that are to be used, the following has been taken into account:

- Environmental behaviour.
- Results of the mechanical tests to meet all requirements of the CE product marking.
- Compliance of the construction materials Technical General Bidding.

General and specific tests for the SFS-Rail have been defined in this task. Nevertheless, it should be noted that environmental regulations are different in each country, even in the different communities within the same country, so one must clearly understand the environmental regulations to be referred to in order to obtain the required SFS quality.

The fourth task of this action deals with the monitoring of the SFS-Rail productivity rate and shows the productivity analysis results in ADEC GLOBAL’s plant. The suggested steps to study the productivity indexes are the following:

1. Set up the flux diagram of the productive process
2. Establish the consume table
3. Select the most appropriate units for quantifying consume and indexes.
4. Calculate the productivity indexes

This analysis returns a production of 28,000 tonnes per hour.

The two deliverables of this action have been attached in section 7.2 of this report.

This action does not have perspectives to be continued after the end of the project.
**Deliverables**

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**Action C1: Design of the field tests monitoring**

Action C1 is the first action of the monitoring of the impact of the project actions, and deals with the design of the field tests monitoring.

It is important to remark that the field tests monitoring were initially conceived to be carried out continuously, with expensive equipment to be permanently installed on site and controlled remotely. However, it was agreed with the external monitor that the monitoring of the field tests would be done manually and periodically in order to avoid vandalism and because recent monitoring activities for other projects had proved that the expected measurements were significant only in the long term.

This action has been divided in three main tasks:

- Definition of the track parameters to be monitored
- Selection of the topographic technology to be used during monitoring
- Establishment of the analysis methodology of the data to be collected during the monitoring

All three actions have been carried out by COMSA and have been finished according to the schedule.

In the first task, the most important features of the subballast and subgrade layers have been studied, and the parameters that characterise them have been clearly identified so that the monitoring activities can be designed to quantify them. This way the performance of tracks with SFS-Rail can be directly compared to railway lines with conventional aggregates.

On one side, the main functions of the subballast layer are:

- To distribute homogeneously the stresses transmitted to the platform, reducing them by increasing the area of distribution
- To contribute to the improvement of the dynamic performance
- To evacuate rainwater towards transversal drainage elements
- To separate physically the ballast and the platform, avoiding the contamination of the ballast by vertical migration of the material from lower layers and protecting the platform against particle attrition and possible ballast water leaks
- To protect against erosion and frost and to keep the track geometry throughout service life.

On the other side, the subgrade layer must:

- Support the track structure above it and remain stable under traffic loads
- Provide the roadbed upon which all other components of the track structure are placed.
For these reasons the subgrade has a significant impact on the track’s ultimate quality and required maintenance.

From the different parameters characterizing these functions and properties (density, compaction, gradation of the material, angularity of the material, abrasion resistance, wearing resistance, thickness of the compacted layer, moisture content, drainage capacity, permeability, material quality, gradation, stratification, soil’s bearing capacity, soil’s modulus...) the most representative and common parameters have been chosen to simplify the methods and technology to be used during the monitoring.

Hence, the parameters to be monitored are:

1. **Track settlement and geometry**, as a measure of the track alignment, thickness of the compacted layers, strength, density (compaction) and moisture.
2. **Subballast and subgrade stress under traffic**, as a measure of the capability of distributing the stress towards the platform, which relates to the track strength (bearing capacity)
3. **Rail deflection under traffic**, as a measure of the track stiffness (soil modulus) and its elastic deformation.

In the second task of this action, the topographic technology to be used during the monitoring of the above mentioned parameters has been defined. A state of the art review regarding the techniques to monitor each of the selected parameters has been done and, upon this information, the most suitable technology has been chosen for each case.

To measure the track settlement and geometry, a topographic survey with a total station has been selected, given its simplicity and high accuracy. First of all, and prior to the construction of the field tests, a previous topographic work will be done with a dumpy level to benchmark several base points in the working area in order to perform a topographic survey. After the construction of the field tests, a second topographic survey will be done, and from then on, a periodical topographic survey with a total station will be performed to assess the track geometry and the global settlement. To do so, and in order to not interfere with the traffic, targets at 90º (as shown in Figure 8 left) will have been previously fixed on the rail web every 5 m, so that a thorough monitoring can be done with a total station being set up at only one place, preferably at half the length of the test section, in the inner curve of the track, at a safe distance from the train’s circulation.

For the measurement of the subballast and subgrade settlement, topographic targets have been screwed on the top of steel rods, which have been nailed into the subballast and subgrade layers reaching half the thickness of the layer in question (see Figure 8 right). This way, the periodical topographic surveys will allow measuring not only the track’s global settlement, but also the settlement of the subballast and subgrade layers.

For the measurement of the stress in the subballast and subgrade layers, vibrating wire pressure cells have been used, since it is the best option to detect the existing pressure in soils. Six pressure cells have been placed in total: two in the subgrade layer made of SFS-Rail and two in each of the two subballast layers made of SFS-Rail.

To measure the rail deflection under traffic, the selected option has been the topographic survey with a total station and topographic targets. Therefore, the total station and the targets on the rail web that are
used to perform the measurements of the track settlement are also used to measure the rail deflection under traffic. This allows the topography staff to work in safe conditions without entering the track domain and, therefore, without interfering the circulation of trains, which would compromise the monitoring activities.

In the third task, the data to be collected in each measurement and the analysis methodology has been defined. Thus, for the track settlement and geometry several reference points have been selected, such as the targets placed on the rail web and other relevant benchmarks. For the subballast and subgrade track settlement, the targets placed on top of the steel bar rods nailed into the different infrastructure layers will also be conveniently identified. The different test sections will be clearly delimited in order to associate each point to each section. The 3D data collected during the track settlement monitoring measurements will be gathered in a datasheet, clearly associating each measurement to its reference point. With the bimonthly topographic surveys to be performed during the monitoring period, successive columns will be added to the datasheet for each reference point, so that the temporal evolution of their cumulative settlement can be depicted.

For the measurement of the stress in the subballast and subgrade layers, the oscillation frequency of the vibrating wire is read and displayed by the readout unit when connected to the cables embedded in the medium. This measurement will be written down by COMSA’s topography personnel on site for its later conversion into pressure units. Since at least two readout units will take measures at the same time, it will be possible to compare the stress on the different layers of a given test section under the same load (the same train), and to compare the stress on the same layer of different test sections under the same traffic. However, the traffic circulating in the railway line of Castellbisbal should not vary significantly, so the results obtained with different trains should be comparable.

For the measurement of the rail deflection under traffic, the most convenient target placed on the rail web has been chosen to perform the monitoring of the rail deflection. The data collected during the monitoring activities for the several measured points will be used to determine the evolution of the rail deflection, as well as to characterize the global track stiffness, in the different test sections.

Finally, the analysis of all the data obtained from the field tests monitoring has been used to calibrate the software developed in action B5.

The proposed topographic technology has been used for the field tests of Castellbisbal (Barcelona), which is part of the ADIF network. In the case of the field tests of El Puerto del Musel in Gijón (Asturias), due to the tight schedule for planning the monitoring activities, only the global track settlement and geometry have been monitored.

The objectives of the action have been totally achieved and the full reports of the three tasks have been attached in Section 7.2.

This action does not have perspectives to be continued after the end of the project.
### Deliverables

<table>
<thead>
<tr>
<th>Deliverables</th>
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</tr>
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<tbody>
<tr>
<td>C1.1 Definition of the track parameters to be monitored</td>
<td>02/03/2015</td>
<td>02/03/2015</td>
</tr>
<tr>
<td>C1.2 Topographic technology to be used during the monitoring</td>
<td>01/05/2015</td>
<td>01/05/2015</td>
</tr>
<tr>
<td>C1.3 Analysis methodology of the data to be collected during the monitoring</td>
<td>01/05/2015</td>
<td>01/05/2015</td>
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### Expected results

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</tr>
<tr>
<td>Monitoring parameters selection</td>
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<td>100%</td>
</tr>
<tr>
<td>Definition of topographic technology</td>
<td>01/05/2015</td>
<td>100%</td>
</tr>
<tr>
<td>Analysis process methodology of data</td>
<td>01/05/2015</td>
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</table>

### Action C2: Monitoring of the Quality Control Plan results

This action could not start on time (01/07/2014) because the construction of the field tests (in Gijón) was delayed until 01/04/2015. Hence, this action started on 01/04/2015, with a delay of 9 months. However, more resources and effort were allocated in order to end the action upon schedule on 30/04/2016. The communication received on 13/10/2015 encouraged us to emphasis the effort that was needed to finish on time.

A monitoring of the Quality Control Plan results has been done for the SFS-Rail produced for the field tests of Gijón and Castellbisbal. Quality tests have been done for the different granulometries required (0 - 5 / 4 - 11 / 10 - 20) mm. In particular, the following parameters have been analysed in each case:

- Granulometry
- Content of fine material
- Sand equivalent of the fine aggregate
- Density, porosity and water absorption
- Material retained by the 0.063 mm sieve
- Stability front of sulphates
- Chloride, sulphur and organic material content
- Methylene blue
- Content of soluble sulphates in acid
- Alkali silica reactivity
- Adhesiveness to bituminous binder fine aggregates
- Volume expansion
- Sand friability coefficient
- Dicalcium silicate and iron disintegration
The results of the Quality Control Plan have all been satisfactory according to the applicable norm in each case.

The statistical analysis results have been included in Section 7.2.

This action does not have perspectives to be continued after the end of the project.

<table>
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<tr>
<td>Detailed report</td>
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<td>100%</td>
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<tr>
<td>Progress indicators</td>
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**Action C3: Socio-economic impact of the project**

Action C3 has started on 01/10/2014 instead of 01/07/2014, because at the beginning, this study was supposed to be subcontracted to a university or a specialized company, but after analysing it, it was decided to be carried out by COMSA’s personnel. The reason for this modification was that COMSA was able to carry out this study, which allowed a more direct and easy communication and a better resource efficiency.

The expected delivery date was the same as scheduled (02/06/2016) because more effort was put to complete the action successfully and on time.

In the socio-economic impact analysis, a study of the project’s influence zone is presented, focusing on its territory and demography. A description of the structure, distribution and evolution of the population affected has been done to get a better characterization of the region inhabitants. In addition, the active population of the area has been analysed, which will be, a priori, the most affected group by the generation of economic activity because of the project actions. The local business network has been studied in order to quantify the contribution of each industrial sector in the economic activity of the region and bear out the importance of the steel making sector in the two areas of analysis: Asturias and Catalonia. The labour mobility patterns of the population in the influence zone are analysed to identify the main poles of attraction. Besides, to complete the analysis, an anonymous survey to the population of the region has been carried out to know the opinions about the project.

A detailed analysis of the steel industry and field test influence zone has also been carried out. During this analysis we have characterised and delimitated the steel manufacturing sector of Asturias and Catalonia and its economic contribution in the whole country concluding that both of them are two of the most important Spanish steel manufacturing areas. The waste generation of the sector and the waste recycling techniques are also described, as it will helps to quantify and evaluate the innovations introduced by the project and how they affect the amount of waste landfilled and the different uses that black slag have in the present.

The different impacts of the project and its consequences in the topics explained above have been described. A summary of the main impacts in the different topics is presented, such as the impact of
the foreseen investment, the increase of steel slag recycling, the decrease of industrial waste, the reduction of the quarries activity and the increase of jobs.

The conclusions drawn are summarised next:

- We can affirm after the analysis of the social and economic impacts of the project that the main objective, which is to extend the market of an industrial waste product by identifying a new field of valorisation, is well accepted for the society and it is possible in economic terms, taking into account that the general impacts of the project have positive effects in the different areas studied.
- The valorisation of black slag into SFS-Rail for its use in subballast and subgrade layers of railway lines is viable for distances between the valorisation plant and the railway construction site shorter than 90 km. Upon this distance, the costs are not competitive, since quarries can be found nearer to the railway construction site.
- The location of the field tests were correctly chosen since the tests are placed in important industrial areas, where the siderurgy sector is one of the main participants in the GDP of the area. In the case of the Catalonia, it is near the slag valorisation plant in order to minimize the transport costs and emissions, hence reducing its negative impact.
- The subdivisions of the Baix Llobregat made for the study of the influence zone allow us to have a better characterisation of the region in terms of mobility, distribution of the population and population growth, which finally help us to identify the different possible effects that the LIFE GAIN project have on the territory.
- From the analysis of the population we can conclude that the influence zone of the project is an area that is suffering an important demographic development in the last years and a significant amount of population will be directly affected by the project consequences.
- The two analysed areas, Gijón and Baix Llobregat-Vallès Occidental, have a significant contribution in the industrial productive structure of its respective regions. What’s more, the siderurgy is one of the most developed industrial sectors, so that the impacts of the activities that improve the productivity in this industrial area will be considerable higher in comparison with the application of these actions in other sectors, which have not such volume of production and GDP participation. The construction of the field test and the valorisation of the ADEC GLOBAL plant will contribute to impulse the economy of the area having positive effects and, without doubt, are actions in consonance with the development trends of the area.
- The project has a high social acceptance and most people think that this project should be carried out for its environmental, social and economic benefits. The population see the slag valorisation as an important activity for the development of the industrial sector and bet for the replication and transferability of the project technology and results around the whole Europe.
- From the impact of the investment and the computation of the economic indicators we could deduce that the profitability of the project is high enough to carry out the activities and develop the technology proposed in the LIFE GAIN. The NPV of the project reach the 264,277 € according to the analysis done for the next five years after the project’s implementation, this indicates that the project will generate gains above the profitability required (5%). In the same way, the low initial investment needed for the adaptation of the valorisation plant, and the economic benefits from the SFS-RAIL selling, gives us an IRR of 70%, which shows the incredible profitability of the project that present a payback period of just 1.5 years.
- Considering the potential impact of the project in the next years, the social benefit obtained in economic terms will be 772,233 € per year.
Otherwise, considering just the impact of the field tests construction, the local social benefit of the project in economic terms will be 4,965 € during the first year.

The potential impact of the LIFE GAIN activity in terms of reduction of industrial waste is 216,000 tonnes, which will suppose that all the production of the plant is used for SFS-RAIL. In this way, the project allow us to manage more than the 16% of the total Spanish annual slag production, solving a considerable percentage of the industrial waste management problem. This impact could be increased with the transferability of the project technology to adapt other valorisation plants of the country.

The quality of life indicators of the population will be improved because of the reduction in the industrial waste and the reduction in the quarries activity.

The jobs created by the project activity will reduce the number of unemployed population. What’s more, it will affect to the demographic distribution in the next years and the mobility induced for the job creation will increase the intraregional and interregional daily trips.

The full socio-economic impact is included in section 7.2.

The action does not have perspectives to be continued after the end of the project.

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<th>Deliverables</th>
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</tr>
<tr>
<td>Progress indicators</td>
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</table>

**Action C4: Monitoring of the field tests**

This action has suffered some changes, as explained in action C1, since the monitoring activities were initially foreseen to be done continuously, with expensive equipment remotely controlled, but it was finally done manually and periodically in order to avoid vandalism and because the expected measurements were significant only in the long term.

The monitoring of the field tests started immediately after their construction, i.e. on May 2015 in El Puerto del Musel (Gijón) and on October 2015 in Castellbisbal. This means that the overall action started in one month ahead of schedule and ended three months after the expected date. However, it did not affect the project’s end date.

The monitoring activities consisted in periodic measures of:

- Track settlement and geometry
- Subballast and subgrade stress under traffic
- Rail deflection under traffic

In Gijón, however, only the track settlement and geometry were measured.

Regarding the track geometry and overall settlement, the results obtained show that the settlement is more pronounced where SFS-Rail is employed in both layers, since the conventional aggregates have
not been replaced and they are already compacted. Regarding partial settlements of SFS-Rail layers, the readings show as these layers collaborate on 8% of total settlements, in the section with only subballast of SFS- Rail, and the collaboration is 6% and 8% respectively in the section with subballast and subgrade of SFS- Rail.

Regarding the stress measured under traffic, results show that the stress measured under the subballast and subgrade layers made of SFS-Rail are admissible (values under 0.15 MPa) while evincing a reduction on the stress of the subgrade compared to the subballast layer, hence proving SFS-Rail bearing capacity and its capability to distribute stress.

Finally, regarding rail deflection, the measurements indicate a compaction of the infrastructure with time while manifesting acceptable values (under 2 mm) and a reduction in deflection when SFS-Rail is used, which demonstrates the increase in soil modulus (track stiffness) with respect to conventional aggregates.

This action has three deliverables, all of which have been included in section 7.2 of this report. The first deliverable regards the SFS-Rail characterisation for the calibration of the software, while the other two are the monitoring results in the first six months and during the entire twelve months, respectively, for each field test location.

In conclusion, the results obtained have been totally satisfactory, fulfilling the Spanish and European railway norms.

This action will be continued after the project ends.

<table>
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<td>C4.2 Monitoring results from months 0-6</td>
<td>01/01/2016</td>
<td>31/03/2016</td>
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<tr>
<td>C4.3 Monitoring results from months 0-12</td>
<td>30/06/2016</td>
<td>30/09/2016</td>
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<td>SFS-Rail validity demonstration</td>
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<td>Show SFS-Rail offers better performance</td>
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<tr>
<td>Final report (C4.3)</td>
<td>30/06/2016</td>
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</tr>
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</table>

**Action E2: After-LIFE+ Communication plan**

This action does not have budget; however COMSA has allocated personnel (without incurring these hours to the project) to prepare the document. The document has been included in section 7.3.2 of this Final report and is also available on the project’s website.
In order to guarantee the communication of the Project after its end, the website of the project will remain active, so it will be possible to access all the information related to the project, objectives, scope, technical description, results, gallery of pictures, etc. Some documents are available for download, such as the project’s final brochure and some of the technical publications in specialized articles.

Besides, presentational actions will also take place after the project’s end, such as workshops. Moreover, several companies and Public Administrations are interested in using SFS-Rail in their projects. Hence, the LIFE+ GAIN participants will invite these companies, if they agree to it, to visit the ADEC GLOBAL’s plant, where SFS-Rail is processed, and to visit the field tests where SFS-Rail has been implemented. Technical information on the SFS-Rail will be provided together with the main results of the project so that the benefits of using valorised steel slag in railway foundations is clearly understood, all doubts are clarified and, hopefully, reluctances to employ this new material in railway infrastructure are dissipated.

<table>
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### Expected results

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<tr>
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</table>

**Action E3: External audit report**

COMSA has put much effort to prepare all the documentation necessary for the project’s audit. The allocation of hours has been concentrated in the last trimester of the project, i.e. from July 2016 to September 2016, although more effort has been put after the end of the project (without incurring these hours to the project), during the months of October and November, while the audit has taken place.

The External audit report is included in section 8 of this Final report.

The main deviations as stated by the audit report are summarised below:

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Declared by the beneficiaries</th>
<th>Certified by the auditors</th>
<th>Difference</th>
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<tr>
<td>Travel and subsistence costs</td>
<td>5,416.31 €</td>
<td>5,416.31 €</td>
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<tr>
<td>External assistance costs</td>
<td>101,372.69 €</td>
<td>38,545.73 €</td>
<td>62,826.96 €</td>
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<tr>
<td>Consumables</td>
<td>27,294,20 €</td>
<td>27,294.20 €</td>
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<tr>
<td>Other costs</td>
<td>28,611,19 €</td>
<td>17,429.30 €</td>
<td>11,181.88 €</td>
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<tr>
<td>Personnel</td>
<td>974,153,59 €</td>
<td>884,396.84 €</td>
<td>89,756.75 €</td>
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<tr>
<td>Overheads</td>
<td>79,579,36 €</td>
<td>68,115.77 €</td>
<td>11,463.59 €</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,216,427,34 €</td>
<td>1,041,198.15 €</td>
<td>175,229.18 €</td>
</tr>
</tbody>
</table>

The differences in **external assistance** costs are:
By COMSA (30,673.86 €): due to the subcontracting of machinery for the field tests construction and auscultation, and the subcontracting of Ideas2Value for technical assistance and dissemination of results.

- By ADEC GLOBAL (32,153.10 €): due to the subcontracting of external laboratories for the quality control of the slag.

The reasons for the inclusion of these costs are explained in section 6 of this final report.

The differences in other costs are due to the invoices of fuel for the field tests. The reasons for including these costs are explained in section 6.

The differences in personnel are:

- By COMSA (68,466.15 €): due to bonuses, production premiums and other concepts like diets, travels and plus that some employees have received during the period of the project. From this amount, 59,491.40 € correspond to gross salaries and 8,723.97 € correspond to social charges. There are also some minor differences in the productive hours (53.66 €) and charged hours (197.13 €) of Roger Marin and Jordi Casals. The breakdown of the persons contributing to the mentioned deviation is detailed in the Audit’s report.

- By ADEC GLOBAL (21,290.60 €): due to some additional invoices of Félix Pedroso on May 2013, May 2014 and April 2015 (which amount to 6,034.37 €), as well as diets, km and linear increase on December 2014 of Juan Tuset (14,211.74 €) and some declared costs of Diego Aponte (1,044.49 €).

It should be noted that the production premiums and bonuses of COMSA’s personnel have been included because, although they are differentiated in the pay sheets, they are part of the real retribution of the employees and accomplish the following two requirements:

- They are paid on a general basis to all the employees upon a certain category.
- The only reason why they appear differentiated in the pay sheets is because they are paid at a different periodicity (monthly, quarterly, biannual) depending on the employee’s category.

More clarifications on the personnel costs are explained in section 6 of this final report.

Finally, the differences in overheads are the 7% flat rate of the above differences, which amount up to 11,463.59€.

<table>
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<td>31/12/2016</td>
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Deliverables

Foreseen: 30/06/2016
Actual: 31/12/2016

Expected results

Foreseen: 30/06/2016
Achieved: 100%

Report elaboration

Foreseen: 30/06/2016
Achieved: 100%

Progress indicators

- 100%
Action E4: Networking

As requested by the European Commission in the three communications received on 20/01/2014, 20/05/2014 and 25/11/2014, the partners of the LIFE+ GAIN project are committed in creating a network between experts from similar LIFE projects and Institutions to share experience and know-how.

Hence, other LIFE+ projects were contacted during the lifespan of the LIFE+ GAIN project in order to share experiences and join efforts for the development of sustainable materials. The communication of the results is essential for companies and organizations to be aware of developments in terms of technology, materials and environmental processes to incorporate them in their industrial structures.

In this context, INTROMAC, organised a networking day, where the LIFE program was presented in addition to their project LIFE + SLUDGE4AGGREGATE followed by a session of presentations of related LIFE+ projects, in which the LIFE+ GAIN project was included.

The diverse projects involved in the networking meeting were:

- Valorisation of Waste Water Treatment Plants and aggregates processing sludge for lightweight aggregates production (SLUDGE4AGGREGATES).
- Demonstration installation for manufacture of lightweight aggregate from sewage sludge and waste silica (DIM-WASTE).
- Integrated Planning and Sustainable Management of Sanitation Infrastructures through innovative precision technology (LIFE SANePLAN).

Besides the networking day, other projects have also been contacted, such as SNOW-LIFE, which deals with an Innovative system for 100% recycling of white slag and for ZERO WASTE electric steel production (SNOW-LIFE).

In addition, thanks to the dissemination of the LIFE+ GAIN project in the several attended fairs and conferences, numerous experts and researchers have been contacted. This way, contacts have been made on the 4th Slag Symposium held in Leuven, such as Susanne Schüler from MAU (Max Aicher Umwelt, Germany), Arno Keulen from van Gansewimkel (The Netherlands) and Dirk Mudersbach from Institut für Baustoff Forschung (Germany). Furthermore, Íñigo Unamuno, from the R&D of Gerdau Aceros Especiales Europa, S.L. in the Basque Country (Spain) contacted us for further information on the project.

In the EUROSLAG Congress, contact was made with the Department of Environment, Energy and R & D + I of UNESID (Spanish Steel Association) are working on a document of the state of the art for slag and identifying new uses and areas to regularize and normalize the new use of slag. It was agreed to send them information on the LIFE GAIN project so that they could include our experience in that report to advance in the regulation of slag in railway infrastructures. Besides, HARSCO (Brazil) and DEACERO (Mexico) have already implemented treated steel slag in the infrastructures of their respective countries, but they have had (and are still having) some difficulties, so they are looking for assistance of experienced companies to work with them. In this line, the expertise of COMSA and
ADEC GLOBAL with the LIFE+ GAIN project is a plus that they are willing to consider. Finally, contact was established with the Department of Environmental Engineering of Tube City IMS (United States), who was also very interested in the project development.

In the 3rd International Conference on Railway Technology several experts were contacted, all of them related to the railway sector. For instance, researchers of the University of Granada, the Polytechnic University of Valencia and the Centre of Studies and Experimentation for Civil Works (CEDEX) in Spain. They had, in turn, presented their projects’ results in the conference and were very interested in the LIFE GAIN project, since the research lines were much related and the results of one project could benefit from the other.

Moreover, the Authority of the Port of Barcelona is interested in using SFS-Rail in their future railway construction works and cited representatives of COMSA to talk about the results achieved in the project. COMSA will further investigate the Spanish and European norms and regulations that have to be adapted to allow for the use of valorised slag in the railway foundations.

Finally, CELSA (Steel producing plant) has plants in Poland that are interested in valorising SFS, so that they can avoid landfilling this industrial waste. Some plants in Cardiff (United Kingdom) are also interested.

This action will be continued after the project finishes.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Foreseen</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>E4.1 Networking activities undertaken through the project lifetime</td>
<td>01/07/2016</td>
<td>30/09/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected results</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network creation with stakeholders</td>
<td>01/07/2016</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
</table>
5.2. Dissemination actions

5.2.1 Objectives

The main objective of the dissemination actions is to provide the information obtained from the monitoring of the field implementation in the Spanish network during the project to demonstrate the suitability of SFS-Rail as railway construction material. The aim is to maintain updated the project’s target audience with the most relevant results obtained.

Different methods of dissemination will be used accounting for each target audience. Hence, COMSA has taken profit of its presence in ADIF’s CTF to maintain a fluent and collaborative communication with ADIF. COMSA has also taken advantage of its participation in several European Railway Technological Platforms, such as Spanish Railway Technological Platform PTF or the European Federation of Railway Track Contractors ERTC, to disseminate the benefits of SFS-Rail. In turn, ADEC GLOBAL has provided its knowledge of steel furnace industry and valorisation plants, besides providing its contacts with industrial companies and public administrations.

The LIFE GAIN partners have attended to specific congresses about railways and slag valorisation in order to arrive to the widest audience possible. Several articles have been published and different press notes have been released and spread by many online news portals to make the objectives and results of the project well-known by the public Administrations, companies and the whole society.
5.2.2 Dissemination: overview per activity

Please note that action E1 has been included in this section.

**Action D1: Creation and maintenance of project's website**

The website of the LIFE GAIN is accessible on [www.life-gain.eu](http://www.life-gain.eu) from 07/03/2014.

Although this action has been successfully completed (with 3 months delay) there has been a little change from what it is said in the proposal. In the description of the task, it is said that the creation of the website would be outsourced, whereas in the end, the website was developed by personnel of COMSA as reflected in the time sheets for the corresponding period of this action. The reason for this modification was that COMSA was able to carry out the website, which allowed a more direct and easy communication and a better resource-efficiency. However, this change produced some delay. A communication was received on 20/01/2014 remembering that website creation should speed up, 46 days later website was ready.

The LIFE+ Logo is totally visible in each page of the website. The website is available in English and has been translated into Catalan and Spanish languages to be more accessible to the target audience of the region, as requested by the European Commission on the e-mail received on 20/05/2014 and 25/11/2014. Also in response to the European Commission, pages under construction have also been updated with information of the progress of the project’s actions, such as the adaptation of an existing valorisation plant to produce SFS-Rail, the Life Cycle Assessment of the SFS-Rail, the construction of the field tests and the calculation software for track design. Photos of the undertaken actions have also been uploaded on the gallery.

Finally, the indicator of progress of the website was the number of page views, which up to now is of 13,687 (see next figure with the monthly visits), far beyond the expected 200 views per month that were considered in the proposal.

![FIGURE 10. LIFE+ GAIN WEBSITE VISIT STATISTICS](image-url)
We believe the project’s website has been and will be (it will remain active after the project’s end) a very useful tool to disseminate the project’s objectives, work done, results and, the most important, the benefits of the SFS-Rail in order to be used in future railway works. The number of visits per month has been higher than expected, proving the good performance of such an online tool for the dissemination of the project.

In Annex 7.3, screenshots of the website are shown.

This action will be continued after the project finishes, at least three years after the project’s end.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Foreseen</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1.1 GAIN Website</td>
<td>02/12/2013</td>
<td>07/03/2014</td>
</tr>
<tr>
<td><strong>Expected results</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Website to inform the public and enable dissemination of the project results</td>
<td>02/12/2013</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Progress indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of unique visitors per month</td>
<td>200/month</td>
<td>350/month</td>
</tr>
</tbody>
</table>

**Action D2: Design, elaboration and installation of notice boards**

Three notice boards have been placed: one in ADEC GLOBAL valorisation plant and one in each of the two field test locations of the project, i.e. El Puerto del Musel, in Gijón, and Castellbisbal.

This satisfies the requirements of the European Commission as indicated in the letters received on 20/01/2014, 20/05/2014, 13/10/2015 and on 16/12/2015, while being in compliance with the article 13.5 of the Common Provisions of the Grant Agreement.

Two notice boards were expected to be installed during the project, however three notice boards have been installed.

Pictures of the three notice boards are included in annex 7.3.3 of this Final report.

We believe the notice boards have implied a positive impact in the dissemination of the Project, since they are placed on site, where the SFS-Rail has been used, and can be seen by all the users of the commuter line R7 in Barcelona, and the workers of el Puerto del Musel in Gijón.

This action will be continued after the project finishes.
Deliverables | Foreseen | Actual
--- | --- | ---

Expected results | Foreseen | Achieved
--- | --- | ---
Provide information to public about the activities carried out in LIFE GAIN project | 15/01/2015 | 100%
Focus the public attention to specific areas created for this purpose | 15/01/2015 | 100%

Progress indicators | Foreseen | Achieved
--- | --- | ---
Number of notice boards installed | 2 | 3

**Action D3: Dissemination through brochures**

Two brochures have been designed and printed showing the main objectives and results of the project: one at the beginning of the project (initial brochure) and one at the end (final brochure).

The initial brochure was designed explaining the objectives of the LIFE+ GAIN project, focusing on the properties and advantages of the new SFS-Rail. The information leaflets allowed the partners of the project to present it in regular conferences and fairs, besides in the usual contact with customers and suppliers.

The initial brochure was modified according to the communication of the European Commission received on 20/05/2014 asking to include the explicit acknowledgement of the EU funding and to bear the project LIFE+ GAIN reference. The revised version has been included in Section 7.3.3 of this report.

A total of 400 copies were confectioned for this first brochure (200 copies on 28/02/2014 and 200 copies more on 22/09/2014, which doubles the expected amount defined in the proposal as an indicator of progress of this action D3 (200 copies for each brochure).

The final brochure has been designed and produced in the last stage of the project, after the construction of the field tests of Gijón and Castellbisbal, showing the main results obtained in the monitoring activities, the software developed and the main conclusions of the project. 200 copies have been printed for this final brochure, hence accomplishing the expected results for this action.

Both the initial and the final brochures have been distributed in the fairs, congresses and technical events attended by the partners of the project.

There are still remaining brochures at COMSA’s office, which are delivered to other customers and suppliers, such as FGC and other companies and Administrations.

We believe that the dissemination of the project’s objectives and results through brochures has been very positive, since they have been handled in several fairs and congresses attended by the project partners and they have been distributed to potential clients in several meeting held and to be held in the near future.

This action will be continued after the project finishes, in order to promote SFS-Rail and obtain new clients in order to use it in their new railway lines.
Deliverables | Foreseen | Actual
--- | --- | ---
D3.1 Initial brochure, presentation of the project | 01/11/2013 | 28/02/2014
D3.2 Final brochure, presentation of the project results | 02/05/2016 | 26/09/2016

Expected results
To inform about the GAIN project main goals and results to stakeholders | 01/01/2016 | 100%

Progress indicators
Number of brochures produced | 2 | 2
Number of copies distributed | 400 | 500

**Action D4: Dissemination through the Media**

Throughout the project, three press conferences have been performed, which have been reflected through the following three press notes published:

- A technology will provide a second life to the steelworks slag (EFE Verde) 05.24.14.
- Gain COMSA leads the European project for the reuse of waste steel railways (Press COMSA).
- Gain COMSA leads European Project for valorisation of steel waste in railways lines (FuturEnviro)

Each press note has been published on different media, namely:

- The first press note was published on “www.lainformacion.com” on July 2014.
- The second press was more widespread and was published in “www.elvigia.com”, “www.vialibre-ffe.com” and “www.cadenadesuministro.es” along 2015.
- The third press note has been published on “FuturEnviro” on July, 2015.

The first press note presents the activities and goals expected by the project, where the concept of reusing steel slag as aggregate is introduced, prolonging the life cycle of the material and decreasing the amount of slag waste currently going to landfill.

From the second press note the impact of the project increased. Three different media have published the note by mentioning the significance of the project and the future importance of its implementation.

The first media in publishing the second press note was “El Vigia” Group. "El Vigia" Group, born in September 1995, consists of a set of printed and on line publications, specialized in information logistics, transport and infrastructure. The company is formed by a group of information professionals and media management with a commitment to inform with rigor and quality to companies and professional specialized in logistics and foreign trade.

The second media to publish the press note has been "Cadena de Suministro", which is an online journal for the transport sector and logistics, while the third medium in which it was published was “VIALIBRE” magazine.VIA LIBRE internet edition is present on the web since 2000 (www.vialibre.org) conceived as the information portal of the railway sector in Spanish language and published daily.
Finally, the third press note placed the project into the international scene by the publication on FuturENVIRO’s website. The journal is dedicated to presenting metallurgical processes and related research aimed at improving the sustainability of metal-producing industries, with a particular emphasis on materials recovery, reuse, and recycling.

With all this, the expected indicators for this action have been accomplished, since 3 press conferences (and press notes for each conference) have taken place, and 6 articles have been published in national and local newspapers. Finally, the dissemination was successfully achieved in compliance with Article 13.1 of the Common Provisions, as required in the communication received on 13/10/2015.

The deliverable of the action has been attached in section 7.3.3 of this Final report, with more specific information on the dissemination of the LIFE Gain project through the media.

We believe that the dissemination of the project’s objectives and results through the media has been key to widespread the benefits of SFS-Rail, since the online magazines were the press releases have been distributed have an important impact on the construction and the railway sector.

This action will be continued after the project finishes, since SFS-Rail will be promoted during the following years to reach potential clients.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Foreseen</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4.1 Press activities undertakers during the project and press articles released</td>
<td>01/07/2016</td>
<td>30/09/2016</td>
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</tbody>
</table>

Expected results

<table>
<thead>
<tr>
<th>Expected results</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>To achieve an effective communication to local and regional population</td>
<td>15/01/2015</td>
<td>100%</td>
</tr>
</tbody>
</table>

Progress indicators

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press conferences organized</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Press notes delivered</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Articles published in national and local press</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

**Action D5: Dissemination of project’s results through technical publications**

The first paper presented describing the project was made in the proceedings of the Second International Conference on Railway Technology, held in Ajaccio on April 2014. The range of topics considered during the Conference included: Rolling Stock, Infrastructure, Energy and Environment, Signalling and communication, Operations and Strategies and Economics. The conference proceedings were published by Civil-Comp Press and Saxe-Coburg Publications.

The following publication was made in the proceedings of the Slag Valorisation Symposium held in Leuven (Belgium). The content of the Symposium provided a rich overview of the contemporary trends in the worldwide research and innovation strategies as regards the valorisation of ferrous and non-ferrous slag, fly ash, bottom ash and numerous other high-temperature residues.
Project dissemination in technical journals began with the article published in FuturEnviro. This magazine in just under three years since it was launched (June 2013), has become a benchmark publication for the dissemination of projects, technologies and current developments in the environment sector, with special emphasis on two sectors that are at the forefront of their publication: water management & treatment and waste management & treatment.

Once the proposed tasks of the project were developed and having obtained very positive results in the field test sections; stage focused in dissemination and publication of results began. The first article that the results begin to be presented is published in the Spanish Journal of Public Works (Revista de Obras Públicas).

As in 2014, the corresponding presentation of the project was done at the International Congress on Railway Technology held in Cagliari on April 2016. The publication made in the proceedings, aimed to continue the publication started in this type of congress in 2014 and has had a very positive impact. Publication of the results has reflected the commitment and reliability of GAIN LIFE+ project participants.

The next article (“New recycled aggregates with enhanced performance for railways track bed and form layers”) was accepted by the Journal of Sustainable Metallurgy and published at the end of 2016. The journal is dedicated to presenting metallurgical processes and related research aimed at improving the sustainability of metal-producing industries, with a particular emphasis on materials recovery, reuse, and recycling.

Finally, there is currently an article under review and waiting to be published in the International Journal of Railway Technology.

In total, by now 8 publications have been made in articles and specialised magazines, number that exceeds the 5 publications targeted as indicator of this action.

The dissemination of the project’s objectives and results through specialized technical publications has been key to widespread the benefits of SFS-Rail, since these magazines have an important impact on the construction and railway sectors, especially given its high environmental value.

The deliverable of the action and the different publications has been attached in section 7.3.3 of this Final report.

This action will be continued after the project finishes, since new publications on SFS-Rail are expected during next years.
Deliverables

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Foreseen</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5.1 Report on the different technical articles</td>
<td>01/07/2016</td>
<td>30/09/2016</td>
</tr>
<tr>
<td></td>
<td>published in specialized press</td>
<td></td>
</tr>
</tbody>
</table>

Expected results

<table>
<thead>
<tr>
<th>Expected results</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication of 5 articles in specialized technical</td>
<td>01/07/2016</td>
<td>100%</td>
</tr>
<tr>
<td>publication</td>
<td></td>
<td></td>
</tr>
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</table>

Progress indicators

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of articles published in specialized technical</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>publications</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Action D6: Presentation of project’s results in scientific and technical events

The first presentation of the project in a fair was in poster format in BcnRail 2013, where the project proposal was exposed. The poster proposal consisted in the use of black slag as raw material to produce a new recycled aggregate, the SFS-RAIL, to be used in the sub-ballast and sub-grade rail track foundation layers.

The second exhibition of the work was done in the "VIII Engineering International Conference for High Speed Railways" which gathered national and international experts in high speed lines from a civil engineering point of view. Experts from countries like the United States, France, Germany, Brazil, Sweden, India, Japan and Saudi Arabia, participated in the meeting.

The first presentation of the project at European level out of Spain was in the “Second International Conference on Railway Technology” in Corsica, France. In this presentation, the importance of the use of slag as sub-ballast and the raison d’être of the project was exposed which aroused great interest from the congress attendees.

The following LIFE Gain presentation in a congress was made in the Slag Valorisation Symposium held in Leuven, Belgium, in 2015. The content of the Symposium provided a rich overview of the contemporary trends in the worldwide research and innovation strategies as regards the valorisation of ferrous and non-ferrous slag, fly ash, bottom ash and numerous other high-temperature residues.

Once the project tasks were developed and having achieved very positive results in the field test sections, the following dissemination stage began, focused in dissemination and publication of the results obtained.

The first presentation of this stage was made in October 2015 at the “8th European Slag Conference” that took place in Linz, Austria. The organizer, EUROSLAG, is the European association of organizations and companies concerned with all aspects of manufacturing and utilization of ferrous slag products. The association deals with promotion of slag as a product, enables exchange of information and research as well as facilitates the interaction with governing bodies.

Following the success of the previous conference on railway technology, held in Corsica, the project was presented in the “Third International Conference on Railway Technology” held in April 2016 in Cagliari. A number of special sessions was organised at this Conference. The range of topics considered included: rolling stock, infrastructure, energy and environment, signalling and

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communication, operations and strategies and economics. The LIFE GAIN+ project was presented in the category of Geotechnical Aspects in Rail-Track Performance.

One of the most important events in innovation involving the transport area is the Transport Research Arena. The LIFE+ GAIN project was presented in the 6th edition held in Warsaw, where the slogan of the last call was “Moving Forward: Innovative Solutions for Tomorrow’s Mobility”.

The project was also exposed in the “15th International Conference on Railways Engineering Design and Operation” which took place in Madrid and was organised by the Wessex Institute of Technology, UK.

Due the importance of the LIFE+ GAIN project results in terms of Capacity, Carbon emissions, Cost and Customer satisfaction (the 4Cs). COMSA also presented the LIFE Gain project in the International Conference on Intelligent Rail Transportation held in the UK at the Edgbaston Campus of the University of Birmingham from 23-25th August, was the last done in 2016.

The project was also presented in the BCNRail 2015 in Barcelona in November 2015, and in RIELES, in Buenos Aires (Argentina) in August 2015. In total, the project partners have attended to 11 international fairs and congresses, as much as the number targeted as indicator for this action.

We believe that the dissemination of the project’s objectives and results in fairs and congresses has been very positive, since they have raised much interest among the audience in all the public events attended by the project members.

The deliverable of the action and the different posters and presentations have been attached in section 7.3.3 of this Final report.

This action will be continued after the project finishes, since SFS-Rail can be further presented in fairs and congresses to be attended by the project partners in the following years.

<table>
<thead>
<tr>
<th>Deliverables</th>
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<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6.1 Report on the fair and congresses attended</td>
<td>01/07/2016</td>
<td>30/09/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected results</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>To disseminate the project’s objectives and its results in the scientific, academic and governmental field through the participation in technical and scientific events</td>
<td>01/07/2016</td>
<td>100%</td>
</tr>
<tr>
<td>To share the know-how and experience with the expert audience attending to these congresses and fair, which will add value to the project</td>
<td>01/07/2016</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th>Foreseen</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fairs and congresses related to the railway sector where the project’s results have been presented</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

**Action D7: Elaboration of Layman’s report**

The Layman’s report has been elaborated during the last trimester of the project, from July 2016 to September 2016, once the results of the project were obtained and the conclusions were drawn. The Layman’s report has been attached in section 7.3.1 of this Final report.
This action will not be continued after the project end.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Foreseen</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7.1 Layman’s report</td>
<td>30/05/2016</td>
<td>30/09/2016</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected results</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaboration of Layman’s report in both paper and electronic format</td>
<td>30/05/2016</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of copies of the Layman’s report distributed</td>
<td>500</td>
<td>50 in paper + Available through website</td>
</tr>
</tbody>
</table>

**Action E1: Project Management**

This action has been described in section 4 of this Final report. However, the table for its evaluation is summarised below.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected results</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful development of the project in terms of quality, time and budget</td>
<td>30/09/2016</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress indicators</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of meetings of the Steering Committee</td>
<td>6</td>
<td>100%</td>
</tr>
</tbody>
</table>

5.3. Evaluation of Project Implementation

Methodology applied and results achieved

The methodology applied within the project has been successful and the results of the actions carried out have been satisfactory. The work conducted in the project has followed all the milestones and deliverables set in the proposal. By the Inception Report, which was submitted on 31/03/2014, all the deliverables and milestones listed in the proposal were achieved. From there on, the general progress of the project has been satisfactory and according to the schedule. By 01/05/2015, moment of the Mid-term report, the 100% of the actions that were to be completed were finalised. Only action B3 (design of the first field implementation) was delayed, thus affecting action B4 (Construction of the field tests), action C4 (Monitoring of the field tests) action B5 (Development of the software) and action B6 (SFS-Rail track solutions catalogue), which depended on the results of the field tests monitoring. Despite this, the project ended on time, on 30/09/2016, with all the actions of the project fully completed.
The major difficulty encountered was finding a proper location for the field tests within the ADIF’s network, given the need of finding a railway stretch with subballast and subgrade layers, enough track possession and adequate characteristics for the construction of the field tests and the performance of the monitoring activities. The construction of the field tests suffered a delay as a consequence of the delay in the design of the field tests, though the construction of the field tests in Gijón was done on time and without setbacks, as a demo site of the SFS-Rail.

On the other hand, the rest of actions have progressed smoothly. The LCA results show that the SFS-Rail is a better product for the environment than conventional aggregates used for the subballast and subgrade layers of railway lines. The plant adaptation has been done satisfactorily, without major drawbacks, and the Quality Control Plan for the SFS-Rail has been properly defined.

Furthermore, some actions have suffered an improvement of the cost-efficiency and are worthy to be commented. On one hand, the website, which was initially conceived to be designed by an external company, has finally been designed and implemented by the Communication Department of COMSA. On the other hand, the socio-economic analysis of project impact was thought to be subcontracted to a university or external company with experience in this field; however, it is currently being carried out by COMSA’s personnel.

In the following table, a summary of the objectives, the achieved results and the evaluation of each action is presented.

<table>
<thead>
<tr>
<th>Action</th>
<th>Objectives</th>
<th>Outputs achieved</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Study of the state of the art regarding EU legislation</td>
<td>Detect differences in criteria and requirements between European national and Community legislation on Railway and Environmental topics</td>
<td>Research and identification of the technical standards for the subballast and the subgrade layers for some European countries</td>
<td>There were problems in finding the technical specifications in each country. Some rail administrators do not publish their standards making them inaccessible. Most countries have their regulations in their own national language making their difficult to understand. However, the research has been completed and the objectives have been achieved.</td>
</tr>
<tr>
<td>A2. Identification, study and description of EU steel making plants</td>
<td>Identification of EU steel making plants. Study of the type of installation, production rates and type of the black slag produced</td>
<td>Identification of the main EU producing plants and the different types of installations, production rates and features of the generated black slag</td>
<td>The detailed information on both the steel making plants and the black slag generated was not as accessible as expected, since the public information the companies provide in their websites is not subjected to any regulation. However, the research has been done and the objectives have been achieved.</td>
</tr>
<tr>
<td>A3. Study of the prospects of EU Railway Projects</td>
<td>Review of Community and national European rail plans. Market analysis.</td>
<td>Review of the Community and National EU rail plans. Market analysis to identify the demand forecast of SFS-Rail in the different European targeted countries</td>
<td>No difficulties in obtaining the necessary information. Gain of a general overview of the EU market as well as possible implementation constraints of SFS-Rail. It will allow the replication of the project in any other European country. The objectives have been achieved.</td>
</tr>
<tr>
<td>B1. Adaptation of an existing valorisation plant to produce</td>
<td>Define a work plan for the establishment of the production line and replication</td>
<td>The work plan for the establishment of the SFS-Rail production line and its implementation has been done. The replication guidelines to make</td>
<td>There was a 2 months delay in the completing of this first deliverable due to a work overload of ADEC GLOBAL from its daily activities. However, the</td>
</tr>
<tr>
<td>SFS-Rail guidelines</td>
<td>Implementation of the SFS-Rail stock’s management plan</td>
<td>Definition of the classification criteria in terms of granulometry, the space needed to pile up the stocks and the logistics from the plant to the storage site</td>
<td>deliverable was completed shortly after the delivery of the Inception Report. The objectives have been totally achieved</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>B2. Management of SFS-Rail stocks</td>
<td>This action has been done on time without major problems. It represents a necessary step before the following actions. The objectives have been totally achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B3. Design of the first field implementation</td>
<td>Characterization of the field tests location. Definition of the track designs. Establishment of a construction methodology.</td>
<td>Two field tests locations have been selected: El Puerto del Musel in Gijón (Asturias) consisting in three sections amounting up to 90 m and a line of ADIF network in Castellbisbal (Barcelona) consisting in three sections amounting up to 150 m.</td>
<td>This action has suffered a delay of 6 months due to the difficulties encountered in finding a suitable location for the field tests in the network of ADIF (Spanish IM). It was difficult to find a proper location, as some tracks do not have subballast and subgrade layers, or the track possessions were not granted. The field tests of Castellbisbal have been shortened because the authorised track possession does not allow a construction of a longer stretch. Finally, all the tasks of this action have been completed successfully</td>
</tr>
<tr>
<td>B4. Construction of the field tests</td>
<td>Construction of the control section and three new design sections. Quality checks.</td>
<td>The field tests have been constructed successfully and ready for the monitoring activities.</td>
<td>Both field tests have been constructed successfully. The field tests of El Puerto del Musel in Gijón have been constructed according to the schedule, while the field tests of Castellbisbal have been constructed with a delay of 5 months, on October 2015.</td>
</tr>
<tr>
<td>B5. Development of a calculation software for track design using SFS-Rail</td>
<td>Calculation software to be used as a design tool for dimensioning track layers made of SFS-Rail</td>
<td>The software has been successfully developed and all the modules work properly.</td>
<td>The six tasks initially conceived in the proposal have been reorganised, to make more sense, resulting in five tasks, the last one being split into two subtasks. The software has been calibrated with the results of the monitoring activities. All the modules of the software work properly and have been used to define the track solutions catalogue.</td>
</tr>
<tr>
<td>B6. SFS-Rail Track solutions catalogue</td>
<td>Catalogue of recommended track designs using SFS-Rail in the subballast and subgrade layers</td>
<td>The track solutions catalogue has been successfully elaborated upon the results of the calculation software and the field tests monitoring.</td>
<td>This action has been done with 5 months delay, since it could not be done until the software was finished and calibrated with the results of the field tests monitoring.</td>
</tr>
<tr>
<td>B7. Elaboration of the Life Cycle Assessment (LCA) of SFS-Rail</td>
<td>Confection of a Life Cycle Assessment (LCA) and Environmental Impact Assessment (EIA) of the tracks with SFS-Rail</td>
<td>The LCA results show that the tracks with SFS-Rail in the subballast and subgrade layers have a lower impact on the selected categories than the tracks with conventional aggregate. The EIA has been according to the Eco-Indicator 95 unifying the impact categories of the LCA to provide a unique value of the environmental impact for each solution of the track solutions catalogue.</td>
<td>The LCA has been done on schedule. Although some information was difficult to get, the LCA was done without major drawbacks. The EIA has been done at the end of the project, once the track solutions catalogue was defined.</td>
</tr>
<tr>
<td>Action Number</td>
<td>Description</td>
<td>Details</td>
<td></td>
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<tr>
<td>---------------</td>
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</tr>
<tr>
<td>B8</td>
<td>Design and implementation of the Quality Control Plan of SFS-Rail</td>
<td>Design of a specific Quality Control Plan for the production of SFS-Rail. Productivity analysis of the SFS-Rail. General and specific tests for the SFS-Rail have been defined and the productivity results report has been done after the construction of the field tests. The first task of this action was delayed from 01/10/2014 to 18/12/2014 because the responsible of ADEC GLOBAL was out for a period of time. The second task has been delivered on time. The goals have been totally achieved.</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Design of the field tests monitoring</td>
<td>Definition of the parameters to be monitored, topographic equipment and analysis methodology of the collected data. The parameters to assess the performance of the track sections made of SFS-Rail have been defined. The topography instrumentation and analysis methodology for each parameter have been established. The action has been done on schedule, even with the delay of the action B3. Methods have been defined so that the same topographic equipment is used to perform measurements of different parameters. The goals of this action have been totally achieved.</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Monitoring of the Quality Control Plan results</td>
<td>Monitoring and statistical analysis of the Quality Control Plan. The monitoring of the Quality Control Plan results has been done for the SFS-Rail production for the field tests of both field tests. The statistical analysis has also been completed. The monitoring for the production of SFS-Rail for the field tests has been done without any major difficulties.</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Socio-economic impact of the project</td>
<td>Assessment of the impact that the project’s actions will have on the local economy and population. The socio-economic impact report has been completed upon the results of the project’s implementation and surveys on site. The action started on 01/10/2014 instead of 01/07/2014 and has ended on time. It has been done by COMSA personnel, instead of being subcontracted.</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Monitoring of the field tests</td>
<td>Demonstrate that SFS-Rail is a valid alternative to natural aggregates. Comparison of the evolution of the track geometry, settlement and stiffness. The results obtained have been totally satisfactory. They have been used to The monitoring activities have lasted 12 months in each of the field test locations, according to the plan. In the case of Gijón the monitoring lasted from May 2015 to April 2016, and in Castellbisbal from October 2015 to September 2016. The results have been totally satisfactory.</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Creation and maintenance of the project’s website</td>
<td>Creation and maintenance of the project’s website. The website of the LIFE GAIN <a href="http://www.life-gain.eu">www.life-gain.eu</a> is up and running from 07/03/2014. All the contents are updated and the main dissemination documents are available for download. Indications of the European Commission on the website have been taken into account, such as the translation into Spanish and Catalan languages and the update of the sections according to the project progress. Attention has been paid to enhance the SEO of the website. The number of visitor on the website is above 13,000 by the date of this report, far beyond the expected 200 views per month considered in the proposal.</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>Notice boards informing about LIFE+ GAIN activities</td>
<td>Installation of notice boards informing about LIFE+ GAIN activities. Three notice boards have been installed: one in ADEC GLOBAL valorisation plant, one in the field tests of El Puerto del Musel in Gijón, and one in the field tests of Castellbisbal, following the instructions of the European Commission. Permits had to be asked to ADIF to install the notice board in Castellbisbal. Three notice boards have been installed instead of two, as said in the proposal.</td>
<td></td>
</tr>
<tr>
<td>D3. Dissemination through brochures</td>
<td>Elaboration of two project brochures</td>
<td>Two project brochures have been designed, as expected: one at the beginning of the project, explaining the main objectives and tasks, and one at the end of the project, showing the main results and conclusions. They have been delivered to clients and other interested audience in fairs and congresses attended by the project partners.</td>
<td>400 copies of the initial brochure have been printed and distributed in congresses, fairs technical events, which exceeds the 200 copies expected in the proposal. 200 copies have been printed of the final brochure until now.</td>
</tr>
<tr>
<td>D4. Dissemination through the media</td>
<td>Achieve an effective communication to local and regional population</td>
<td>3 press conferences and 3 press notes have been released during the project. They have been widespread in six national and international newspapers, on their online editions.</td>
<td>The expected results of this action have been achieved, i.e. 3 press notes and 3 press conferences, with dissemination in 6 newspapers.</td>
</tr>
<tr>
<td>D5. Dissemination of project’s results through technical publications</td>
<td>Publication of articles in specialised technical publications</td>
<td>8 articles have been published in specialised articles and magazines, such as FuturEnviro, Revista de Obras Públicas, Journal of Sustainable Metallurgy and proceedings of international congresses specialised in railways and slag valorisation.</td>
<td>The expected results of this action have been achieved, i.e. more than 5 publications in specialised articles and magazines.</td>
</tr>
<tr>
<td>D6. Presentation of project’s results in scientific and technical events</td>
<td>Participation in scientific and technical events</td>
<td>11 international fairs and congresses have been attended. These include congresses related to slag valorisation and railways.</td>
<td>The expected results of this action have been achieved, i.e. attendance to 11 international fairs and congresses. Feedback in all dissemination activities has been very useful and has been taken into account in the project's development.</td>
</tr>
<tr>
<td>D7. Elaboration of Layman’s Report</td>
<td>Divulgation of the objectives, actions and results of the project</td>
<td>The Layman’s report has been elaborated, addressed to the general public, summarising the objectives, actions and results of the project. It has been uploaded to the project’s website.</td>
<td>This action has been successfully executed.</td>
</tr>
<tr>
<td>E1. Project Management</td>
<td>Management of the project while assuring quality of the actions and outputs</td>
<td>The project management has been carried out smoothly, with a high level of communication between partners and a high quality standard. Meetings have been held every two months, and every six months with the Steering Committee. The consortium has addressed all the requirements by the European Commission and the External Monitoring team.</td>
<td>The project management has been carried out without major drawbacks, since both partners have had a very good communication and interaction. Communication with the External Monitoring team and the EC also been correct.</td>
</tr>
<tr>
<td>E2. After LIFE+ Communication plan</td>
<td>Lead the conservation actions to be undertaken once the project has finished</td>
<td>The document has been elaborated and uploaded to the project’s website.</td>
<td>This action has been successfully executed.</td>
</tr>
<tr>
<td>E3. External audit report</td>
<td>To audit the project after its implementation</td>
<td>The audit has been passed and the external audit report has been attached in section 8.</td>
<td>The audit has lasted one month, in contrast with the expected week that was initially expected. All the major points have been discussed and addressed. The LIFE+ GAIN partners consider that the</td>
</tr>
</tbody>
</table>
Audit has been positive and successful.

| E4. Networking | Sharing of experience and information regarding innovation and sustainability in infrastructures | The LIFE GAIN partners have shared their experience with other LIFE projects. Many contacts have been established during the fairs and congresses attended, even outside Europe, such as Mexico and the USA. The Port Authority of Barcelona is interested in applying SFS-Rail in future works. CELSA (steel-producing plant) has plants in Poland interested in valorise SFS. | The LIFE+ GAIN partners have followed the recommendations of the European Commission and have taken much profit of the networking activities with other LIFE projects and potential clients interested in the project. |

Visibility of the project and effectiveness of the dissemination

The LIFE Gain partners believe that the dissemination activities are very beneficial for the purposes of the LIFE+ GAIN project and the awareness of the society and the industry of the needs of a more sustainable metallurgical industry.

In this direction, and thanks to the presence of the LIFE+ GAIN partners in scientific and technical events, a wide dissemination of the project has been achieved. New contacts have risen up from the presence of ADEC GLOBAL and COMSA in congresses and fairs related to the LIFE+ GAIN project, proving the effectiveness of the dissemination activities.

The plant adaptation for the production of SFS-Rail, the Life Cycle Assessment results and a sketch of the preliminary model used for the track design calculations were immediately uploaded to the LIFE+ GAIN website in order to be visible to the stakeholders and public at large.

The information regarding the design, construction and monitoring of the field tests, which comprises the resources to be allocated, the outputs expected and achieved during the construction of the field tests and the data obtained from the field test monitoring activities have also been uploaded to the LIFE+ GAIN project’s website once the results have been obtained.

The socioeconomic impact of the project, the track solutions catalogue and the monitoring of the Quality control Plan results have also been made available at the end of the project.

5.4. Analysis of the long-term benefits

Environmental benefits

The main environmental benefits are summarised below:

- Black slag valorisation of 1,078 tons (potential valorisation of 280,000 tons per year).
- Reduction of the use of natural aggregates of 1,078 tons (potential valorisation of 280,000 tons per year), as foreseen in the proposal.
- Reduction of 3.42 tons of CO₂ (potential reduction of 829 tons of CO₂/year). In the proposal it was foreseen a reduction of 6.03 tons of CO₂ (potential reduction of 2,014 tons CO₂/year); however, the recalculations carried out in the LCA have led to a minor reduction.
- Reduction 197.5 Mwh (potential 65,909 Mwh/year), as foreseen in the proposal. 
All this is in line with the 7th EU Environment Action Programme objectives, since it protects, conserves and enhances the European Union’s natural capital, it helps to turn the Union into a resource-efficient, green, and competitive low-carbon economy and safeguards the Union’s citizens from environment-related pressures and risks to health and wellbeing.

Long-term benefits and sustainability

The LIFE+ GAIN project will give high visibility to an alternative solution for the railroad construction that minimises the environmental problems related to quarries exploitation and natural aggregates extraction. 
Besides, as stated in the LCA report carried out in action B7, the human toxicity and other health related issues will be improved with the use of SFS-Rail instead of natural aggregates in the subballast and subgrade layers of railway lines. 

With the SFS-Rail, important cost savings are to be achieved in the new construction and renewal of railway lines while new business opportunities are to be created related to the steel slag valorisation and applications. Regional development is expected with the creation of new specialised employment, as it has been studied in the analysis of the socio-economic impact carried out in action C3. 

The long term benefits in environmental, social and economic issues of the LIFE+ GAIN project will boost the creation of new opportunities to other projects tackling similar problems, since it will mitigate the reluctance to using recycled materials in the construction. In this line, COMSA is currently carrying out two R&D Projects related to the railway construction sector with recycled materials, namely the NEOBALLAST and HDBALLAST projects. 
Furthermore, three main actions will continue after the end of the project in order to obtain the maximum benefit of the project. 
In first place, some monitoring activities will continue further on, especially those related to the field tests (Action C4 Monitoring of the field tests). It is important that LIFE+ GAIN partners keep on monitoring the field tests in order to prove to the client that SFS-Rail performs accordingly in time and hence, it represents a durable and eco-friendly alternative to natural aggregates. 
The second action is the dissemination of the project results, so that European IMs acknowledge the use of recycled slag in track bed layers, and include them as a valid construction material in their railways norms. Provide that the most valuable information will be obtained by the end of the monitoring activities, actions related to dissemination, such as D4 (Dissemination through the Media), D5 (Dissemination through technical publications) and D6 (Dissemination through technical events) will continue after the end of the project. 
And the third action that will be carried out after the finalisation of the project will be the negotiation of commercial and cooperation agreements with steel industry, valorisation plants and construction companies in order to produce the volume of recycled aggregate demanded by the construction companies. Last but not least, the acceptance of SFS-Rail by the IMs does not mean that it will be the preferred material for subballast and subgrade layers, so LIFE+ GAIN partners must persuade other
construction companies to use SFS-Rail in their worksites based on its technical, environmental and economic benefits.

Replicability, demonstration, transferability and cooperation

The Identification, study and description of the European steel making plants located in targeted countries and the black slag produced carried out in action A2, as well as the plant adaptation and the guidelines for the replication of the production line carried out in action B1, enhance the potential for technical and commercial application and the degree of geographical dispersion of the project’s results.

The analysis of the rail plans carried out in action A3 and the study of the legislation in these countries undertaken in action A1 have enabled the identification of the target countries and stakeholders where the project results have more potential to be implemented.

Best Practice lessons

A good organization and management between the partners and the Steering Committee has proved to be an example of best practice to enhance the development of the project and the response to unexpected problems, such as the ones encountered while finding a proper field test location in ADIF’s network.

Innovation and demonstration value

Although slag aggregates have been produced in the recent years for road sub-base construction, the LIFE+ GAIN project adapts this production to the requirements of the railway legislation, such as the specific granulometry for the subballast and subgrade layers, while providing the know-how in the SFS-Rail production of the beneficiary partner ADEC GLOBAL and the expertise of COMSA in the construction and renewal of railway lines.

Moreover, the construction of the field tests in a line of ADIF’s network is of a high replicability potential and demonstration value, provided that ADIF is one of the most important Infrastructure Managers (IMs) in Europe and their cooperation with the LIFE+ GAIN project will be seen as a reliable quality mark by other European IMs.

The study of the state of the art regarding European legislation on railway infrastructure and environmental topics, the identification, study and description of the European steel making plants located in targeted countries and the black slag produced, as well as the study of the state of the art regarding the prospects of European railway projects will help to this replication.
6. COMMENTS ON THE FINANCIAL REPORT

6.1. Summary of Costs Incurred

The incurred project costs are shown in the following table:

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Budget according to the Grant Agreement</th>
<th>Costs incurred within the project duration</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Personnel</td>
<td>€ 910,800.00</td>
<td>€ 974,153.59</td>
<td>106.96%</td>
</tr>
<tr>
<td>2. Travel</td>
<td>€ 14,200.00</td>
<td>€ 5,416.31</td>
<td>38.14%</td>
</tr>
<tr>
<td>3. External assistance</td>
<td>€ 187,980.00</td>
<td>€ 101,372.69</td>
<td>53.93%</td>
</tr>
<tr>
<td>4. Durables: total non-depreciated cost</td>
<td>€ 0.00</td>
<td>€ 0.00</td>
<td></td>
</tr>
<tr>
<td>- Infrastructure</td>
<td>€ 0.00</td>
<td>€ 0.00</td>
<td></td>
</tr>
<tr>
<td>- Equipment</td>
<td>€ 0.00</td>
<td>€ 0.00</td>
<td></td>
</tr>
<tr>
<td>- Prototypes</td>
<td>€ 0.00</td>
<td>€ 0.00</td>
<td></td>
</tr>
<tr>
<td>5. Consumables</td>
<td>€ 52,500.00</td>
<td>€ 27,294.20</td>
<td>51.99%</td>
</tr>
<tr>
<td>6. Other costs</td>
<td>€ 50,900.00</td>
<td>€ 28,611.19</td>
<td>56.21%</td>
</tr>
<tr>
<td>7. Overheads</td>
<td>€ 85,146.00</td>
<td>€ 79,579.36</td>
<td>93.46%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>€ 1,301,526.00</strong></td>
<td><strong>€ 1,216,427.34</strong></td>
<td><strong>93.46%</strong></td>
</tr>
</tbody>
</table>

Following the indications of EC of their letter received on 25/11/2014, the expenses for each cost category have been monitored in order to anticipate possible substantial changes of the Grant Agreement (Art. 15.2 of the Common Provisions). The major discrepancies are shown next, per category.

As a general remark, it should be mentioned that two field tests (instead of the one foreseen in the Grant Agreement) have been constructed and monitored to demonstrate the good performance of SFS-Rail used on the railways subballast and subgrade layers. This is due to the difficulties encountered in finding a suitable location for the field tests in the network of ADIF (Spanish Infrastructure Manager), as reported in action B3. In order to avoid delays that could affect the general progress of the project, an alternative field test was designed and constructed in El Puerto del Musel (Gijón, Asturias) in the North of Spain, on April 2015. Notwithstanding, some months later, on October 2015, a field test location within ADIF network was founded suitable for the project’s requirements in Castellbisbal, near Barcelona. Therefore, finally the two field tests were constructed. As a consequence, the construction and monitoring costs of both field tests have been considered, including the costs of the field tests in El Puerto del Musel, which were not originally foreseen in the budget. This affects
actions B3, B4 and C4 in all cost categories: personnel, travel costs, external assistance, consumables and other costs.

**Comments on personnel costs**

Some actions of the project have suffered a transfer of the budget from other categories to personnel costs. Namely, these actions are:

- The analysis of the socio-economic impact (C3), which was initially foreseen to be subcontracted to a University but, at the end, it was developed by COMSA’s personnel. The reason for this change was that COMSA was able to develop it, hence allowing a more direct and easy communication and a better resource-efficiency than if this action was subcontracted.

- The monitoring of the field test sections (C4), which have been done manually and periodically by COMSA’s personnel instead of the continuous monitoring foreseen in the proposal with expensive equipment to be permanently installed on site and controlled remotely. The reason for this change was to avoid vandalism and because recent monitoring activities for other projects had proved that the expected measurements were significant only in the long term and, hence, there was no need of a continuous monitoring.

- The development of the project’s website (D1), which was initially foreseen to be subcontracted but, at the end, it was developed by COMSA’s personnel. The reason for this change was, like in the case of the socio-economic impact, that COMSA was able to develop this task, thus allowing a more direct and easy communication and a better resource-efficiency than if this action was subcontracted.

With the above budget transfers and other minor deviations on the personnel costs within the different project actions, the total personnel costs have been of 974,153.59€ instead of the foreseen 910,800.00€, which supposes an increase of **63,353.59€ (6.96%)**. This increase is below the thresholds defined in Article 15.2 of the Common provisions (30,000 € and 10%), so there is no need of amendment.

**Comments on travel costs**

Travel costs are mainly associated to dissemination in technical congresses and seminars (action D6), although some non-foreseen trips are due to project management and the construction of the field tests in Gijón.

In total, 5,416.31€ have been spent for travels, which barely supposes 40% of the budget for this category. This is due to the fact that the average cost for travel has been of less than 500€, instead of the 1,000€ per trip considered in the budget.

A total of 11 fairs and congresses have been attended by the LIFE+ GAIN partners during the project, accounting for 4,186.38€ (instead of the 13,550€ foreseen).

**Comments on external assistance**
The most important action foreseen in the budget for this category was the monitoring of the field test sections (action C4), which accounts for 125,080€ or around 66% of the external assistance costs. The remaining budget is dedicated to the external audit, the quality control laboratory tests, the notice boards and the on-site geotechnical tests.

Part of the costs for the monitoring equipment (27,162€) were transferred to personnel costs. Another part of these costs (44,392.84€) were incurred in subcontracting machinery and equipment for the construction of the field tests of Gijón and Castellbisbal (action B4), what that was not initially foreseen in the budget. These subcontracts are justified, since COMSA did not dispose of enough machinery to cope with the construction of the field tests, for different reasons. In the case of Gijón, the authorisation to start with the construction works arrived late, not allowing a proper planning of the works, while in the case of Castellbisbal, the works to be carried out were of a large-scale and a short period of time (mostly concentrated during three non-working days).

Moreover, and as explained above, the costs associated to the design and development of the project’s website (12,000€) and the socio-economic impact analysis (5,900€) were transferred from external assistance to personnel costs.

**Comments on consumables**

The costs incurred in consumables have been of 27,294.20€, roughly 52% of the budget for this category. They include materials required for the construction of the field tests and the consumables for the valorisation of the black slag.

Thus, for the construction of the field tests sections in Gijón and Castellbisbal, a total of 18,911.66€ were spent in consumables, such as sleepers, rails and natural aggregates.

The costs associated to the set of grids for screening and hammers for crushing (action B1) have a real cost of 8,382 €, slightly over the 7,500 € budgeted.

**Comments on other costs**

The expenditure on other costs has been of 28,611.19€, hence amounting up to 56.21% of the budget for this category, which relates mainly to the cost of inscription to conferences, printing of dissemination material and bank guarantee fees.

Moreover, as explained in the personnel costs section, the 15,900€ budgeted in action C4 for the construction of auxiliary elements to support the topographic station and theft-insurance contract in the field tests monitoring have been transferred from other costs to personnel costs.

Furthermore, the elaboration and printing of the project brochures and dissemination material amounted to 1,825€, which is less than the 5,000€ foreseen in the budget. In addition, 2,000€ have been spent for the dissemination of project’s results through technical publications, like Futurenviro and Revista de Obras Públicas, which is very similar to the 3,000€ that where budgeted for this action. The Layman’s report supposed a cost of 900€, less than the 2,000€ foreseen.

In addition, 4,347.51€ have been spent for the attendance to congresses and fairs to disseminate the results of the project, which is slightly more than the 4,000€ that were budgeted for such activities.
From this amount, 958.33€ have been spent by ADEC GLOBAL, who did not have budget for this action. However, we think that it was a mistake in the elaboration of the budget, because we think that both partners have to disseminate the project results, each of them in the specific congresses and fairs related to their field.

Finally, the CAIXABANK has been periodically charging to COMSA the cost of the bank guarantee. Since the beginning of the project, the accumulated bank guarantee fee charged has raised up to 8,332.41€, instead of the 21,000€ foreseen in the budget.

6.2. Accounting system

With the start of the project, the accounting system was launched. A specific accounting code has been created for the LIFE+ GAIN project (COMSA uses the order 000360000211, whilst ADEC GLOBAL uses the following one 62950000).

For COMSA, each person incurring a cost related to the LIFE GAIN project has to present such cost to the Financial Coordinator (Carlos Saborido), which has to take a decision on the eligibility of the expenditure according to the Financial Provisions of the Grant Agreement. Once the cost is accepted, the invoice and the details of these costs have to be uploaded in the in-house platform of COMSA CORPORACIÓN, where all the technical and financial information of the project is safely kept.

In what regards to ADEC GLOBAL, on a bi-monthly basis, Felix Pedroso sends to the Financial Coordinator all the information related to costs (including invoices, timesheets, etc.). Again, the Financial Coordination checks the eligibility of these costs and if approved, uploads the information to the data management system.

This process of cost approval guarantees that only actual and eligible costs are considered in the project.

Furthermore, given that the most important part of the budget is Personnel, special care has been paid to the reporting of timesheets and associated costs. Each employee is in charge of creating its own timesheets (according to LIFE+ Programme template) and to deliver it to the Financial Coordinator on the last day of the month. After the review of the Financial Coordinator, the timesheets are sent to the Project Coordination for his signature.

Invoices are stored physically and digitally in the company server. And specific folder in the server has been designed to keep the invoices, which are classified according to the Cost Category they are referring to and the year.

6.3. Partnership arrangements

Given that the project has only one associated beneficiary, it is the coordinating beneficiary who enters the information provided by ADEC GLOBAL in the financial tables. ADEC GLOBAL sends the information on a bi-monthly basis to the Financial Coordinator.
6.4. Summary of costs per action

In general, the incurred costs per action are in accordance with the grant agreement. However, some actions of the project have suffered minor modifications, as it is explained below.

Three actions have suffered a transfer of the budget from other categories to personnel costs, as it has been explained above. Namely, these actions are:

- The analysis of the socio-economic impact (C3), which was initially foreseen to be subcontracted to a University but, at the end, it was developed by COMSA’s personnel. The reason for this change was that COMSA was able to develop it, hence allowing a more direct and easy communication and a better resource-efficiency than if this action was subcontracted.

- The monitoring of the field test sections (C4), which have been done manually and periodically by COMSA’s personnel instead of the continuous monitoring foreseen in the proposal with expensive equipment to be permanently installed on site and controlled remotely. The reason for this change was to avoid vandalism and because recent monitoring activities for other projects had proved that the expected measurements were significant only in the long term and, hence, there was no need of a continuous monitoring.

- The development of the project’s website (D1), which was initially foreseen to be subcontracted to a University but, at the end, it was developed by COMSA’s personnel. The reason for this change was, like in the case of the socio-economic impact, that COMSA was able to develop this task, thus allowing a more direct and easy communication and a better resource-efficiency than if this action was subcontracted.

Other remarks worth mentioning are that personnel costs of Action A2 (Identification, study and description of the European steel making plants and the black slag produced) has increased 20% in relation to the Grant Agreement. This was due to the elaboration of a second version of the deliverable, with the addition of complementary information, especially regarding black slag. However, action A1 has had a 20% less costs with respect the budget, thus compensating the excess of action A2.

On the other hand, Action B1 (Adaptation of an existing valorisation plant to produce SFS-Rail) has less incurred costs than those allocated in the budget (17%).

A small increase of personnel costs (13%) has also take place in Action B3 (Design of the field tests), which is due to the difficulties encountered in finding a proper field location to hold the field tests. The participation of senior manager profiles, with higher hourly costs, to accelerate the selection of the field tests and minimize the delay of the action, represent one of the main causes of this small cost increment.

Action D5 has suffered an increase of almost 60% due to the subcontracting of IDEAS2VALUE as technical assistance for the publications and posters for fairs and conferences.

Finally, the costs of action E3 (External audit) have been reduced from the budgeted 13,000€ to 7,950.80€ (40% less).

The actual costs of the other actions have deviations minor to 10% with respect to their respective budget.