Development of knowledge-based web services to promote and advance Industrial Symbiosis in Europe (**eSYMBIOSIS**)

LIFE09/ENV/GR/000300

END-OF-ACTION REPORT

ACTION 2

SERVICE ARCHITECTURE & IMPLEMENTATION

June 2013

INDEX

Revision	*Description*	*Date*
Draft v.1.0	Initial Version Document	05/06/2013

1. INTRODUCTION

1.1 MANAGEMENT FRAMEWORK AND PROCEDURES

NTUA is the overall Project Coordinator supervising the progress of all the actions in close collaboration with all the associated beneficiaries. In project Management, NTUA:

(i) has the global view on the project;

(ii) ascertains the progress;

(iii) manages the priorities during the project;

(iv) secures the flow of information between the project actions/activities as well as between the project beneficiaries as required for the implementation of the project..

The Executive Committee composed from representatives of all beneficiaries of the project with the Project Coordinator manage the progress of the project, resolve issues, enhance communication among the participants and to inspect the quality and deliverables and reports. For each Action / Activity there has been assigned a Leader amongst the beneficiaries.

The end-of-Action Reports are internal management quality reports of eSYMBIOSIS, as described in the technical Annex of the project and conform to the standard of the Life+ Programme for monitoring project progress via reports/deliverables.

The end of action report is produced in the scope of Action 7, which is responsible for the monitoring and evaluating the project's progress and performance and is running during the whole duration of the project

The general procedures of Action 7 envisage that the coordinating beneficiary (NTUA) together with all the associated beneficiaries perform their monitoring tasks assessing progress of each Action with respect to the expected results and the performance indicators.

For each Action - Activity a managing representative is responsible to prepare a short end-of-Action report and submit it to the Executive Committee assessment. The end-of-Action reports contain information on the work done within the Action under the scope of the Action objectives and the Indicators set.

1.2 END OF ACTION 2 REPORT

The present *End of Action* report covers Action 2, "Service Architecture and Implementation".

This action had a duration of 25 months (start date: 01/01/2011 and end date: 31/01/2013).

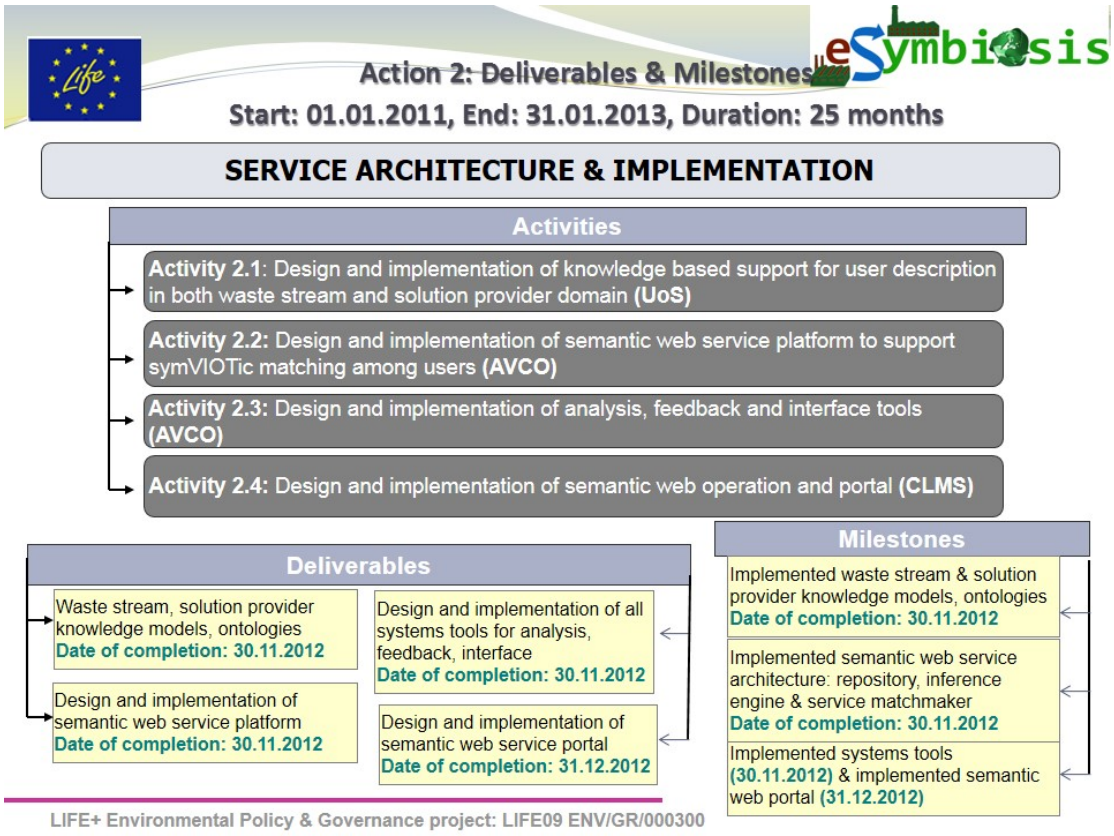

Fig. 1: *Action 2: Presentation Card – External Monitoring Visit, December 2012*

Action 2 involves four Activities: A2.1, A2.2, A2.3 and A2.4 as follows:

- ***Activity 2.1:*** Design and implementation of knowledge based support for user description in both waste stream and solution provider domain.
- ***Activity 2.2:*** Design and implementation of semantic web service platform to support symVIOTic matching among users.
- ***Activity 2.3*:** Design and implementation of analysis, feedback and interface tools.
- ***Activity 2.4***: Design and implementation of semantic web operation and portal.

Action 2 of eSymbiosis has the following targets:

- Produce the Waste stream and solution provider knowledge models, ontologies needed for the service operation in Action 3; Target: minimum 5 different waste streams and 10 different technologies;

- Implement the inference engine and the service matchmaker;
- Design and Implement the system tools;
- Implement the semantic web service and the web portal. Target: minimum one service implemented;

As indicators for the performance of Action 2 were selected the:

- Timely waste stream and processing technology ontologies design and implementation;
- Design and implementation of inference engine and service matchmaker;
- Design and implementation of all systems tools for monitoring;
- Design and implementation of semantic web service model, service repository and web portal.

According to the Management / Monitoring Procedures Framework of eSymbiosis as previously described, the following responsibilities scheme applied:

(1) **Activity A2.1 :** Beneficiary UoS was responsible for Activity 2.1 The original assumption was that datasets available from beneficiary L2E gathered from the UK experience were sufficiently representative for the knowledge models to operate universally across different countries. However, RSE and NTUA assisted significantly, to increment the Ontologies knowledge models with regional information for the Industries, the technologies and the processes used.

(2) **Activity A2.2:** beneficiary AVCO was responsible to lead the design and the implementation of the semantic web service platform components. Further it collaborated with CLMS to integrate the intelligent components to the eSymbiosis Platform, with UoS for the models design, and with PIC so that the business needs are correctly addressed by the designed functionality.

(3) **Activity A2.3:** beneficiary AVCO was responsible for leading the implementation of the platform support tools, such as analysis, feedback and interface tools. For the same task, there was cooperation with CLMS as regards the platform components design and development, PIC for the business perspectives of the implementation (shareholding), and UoS for the binding to the Ontology Models.

(4) **Activity A2.4:** Beneficiary CLMS was leading this activity, involving the design and implementation of a semantically enriched web portal. During this activity there was high interaction with AVCO, to integrate the intelligent components developed within the portal, and with PIC as regards the UI delivered functionality and design.

The Activities at level 2 were during the project Progress broken down to a third level of analysis, to better monitor the detailed tasks within each one of them. The next three cards are taken from the external monitoring visit in December 2012 show the project Work Breakdown Schedule, the Task involvements per beneficiary, and the corresponding deliverables.

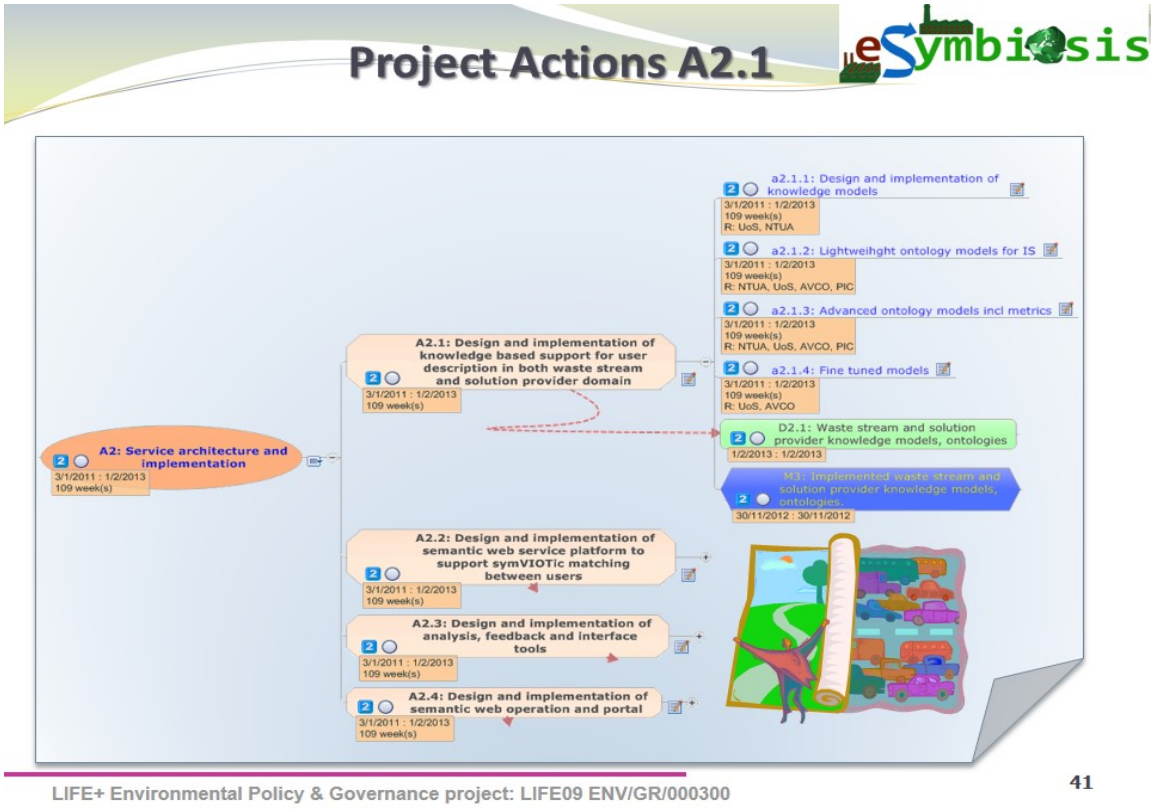

Fig. 2: *Activities 2.1 Presentation Card – External Monitoring Visit, December 2012*

Activity A2.1.1 Involved the design and the implementation of waste stream and solution provider knowledge models to support description of user semantic services.

Datasets available from the Region of Viotia and the beneficiary PIC gathered from the UK experience were introduced to the knowledge models in Ontologies. Both waste stream and solution provider ontologies were designed and implemented using existing, primarily open source editors, such as Protégé and OntoEdit.

Activity A2.1.2 Initially, a light weight ontology was designed to capture knowledge in the domain of waste stream and solution provider technologies concerning industrial symbiosis in particular type and composition to reflect classification provided in Activity 1.2 (a preliminary ontology design for plastic product waste) During the first stage of Activity 2.1, relevant concepts and terms needed for

ontologies were identified manually from datasets available from beneficiaries L2E and NTUA.

Activity A2.1.3 At the second stage, descriptive attributes, properties and restrictions on properties were added to reflect metrics defined in Activity 1.3, in particular geographical availability of waste and byproducts, environmental and economic properties and restrictions of processing technologies. In the second stage of Activity 2.1, a range of properties were classified in order to enable ontology expansion within and after the lifetime of the project. This work was designed and implemented as models by UoS. NTUA assisted in providing cleansed data from an RSE database representing all regional Industries of Viotia.

Activity A2.1.4 Knowledge models for waste streams and respective technologies were introduced as well as Annotations of the information resources (with waste streams, standardising the process for generic use in the area of Industrial Symbiosis) .This work was designed and implemented as models by UoS. NTUA assisted in providing cleansed data from an RSE database representing all regional Industries of Viotia.

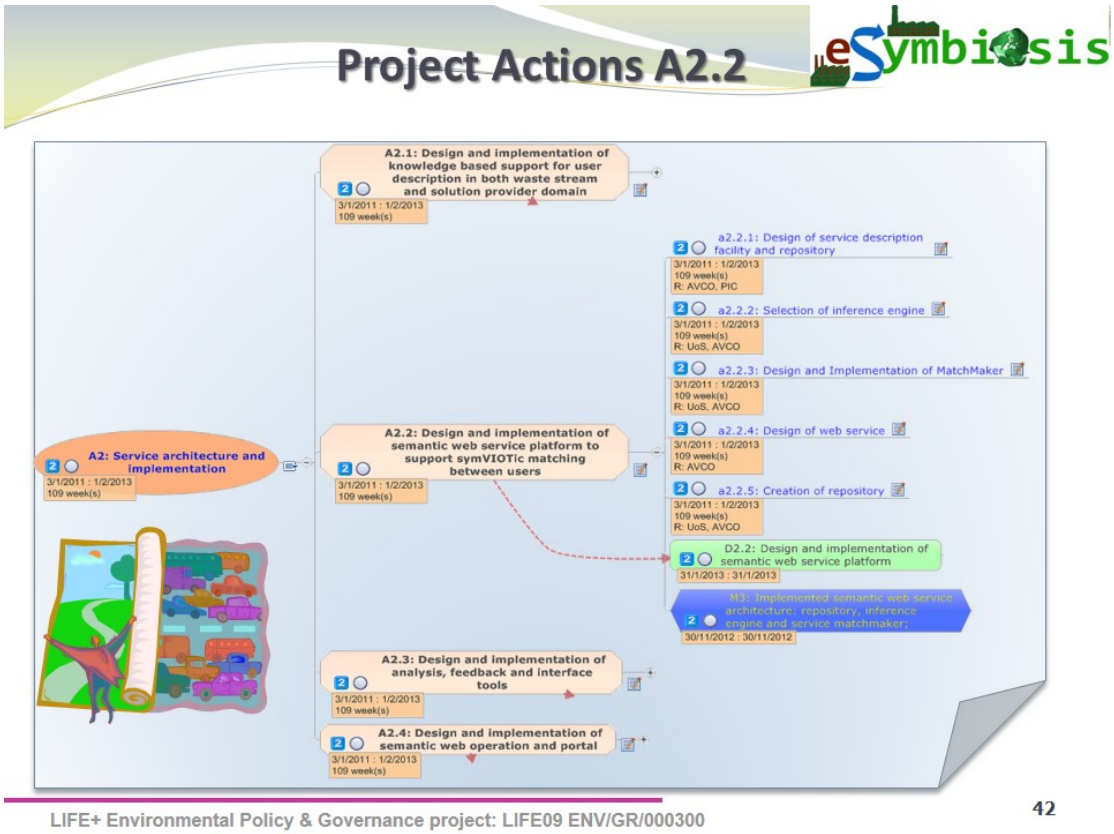

Fig. 3: *Activities 2.2 Presentation Card – External Monitoring Visit, December 2012*

Activity A2.2.1 Involved the Design and implementation of service description facility and concomitant repository to store all user's descriptions; This task was implemented by AVCO and UoS in collaboration.

Activity A2.2.2 Involved the task to select an appropriate inference engine from a set of already available ones. The project took the decision to finally implement a dedicated Inference engine as none of the existing was deemed as appropriate for the project goals, in terms of flexibility and performance. The Ontologies were used to impement the processing waste stream and solution provider knowledge models. This work was implemented by AVCO, with the scientific support by UoS and the requirements and domain specific issues by PIC.

Activity A2.2.3 Involved the task to select an appropriate service matchmaker from a set of already available ones. The project decided for the same reasons as in Activity A2.2.2 to implement its own matchmaker facility. The matchmaker supports the matching services in the repository. This work was implemented by AVCO, with the scientific support by UoS and the requirements and domain specific issues by PIC.

Activity A2.2.4 Involved the Design and the Implementation of the eSymbiosis Portal, the web facility which supports Industrial Symbiosis activities and practices. This work was done by CLMS with the guidance of PIC. CLMS and AVCO collaborated in integrating the Intelligent with the User oriented transactional platform components.

Activity A2.2.5 Implementing the Portal and the user services, and the repository created by the project. This work was done by CLMS with the guidance of PIC. CLMS and AVCO.

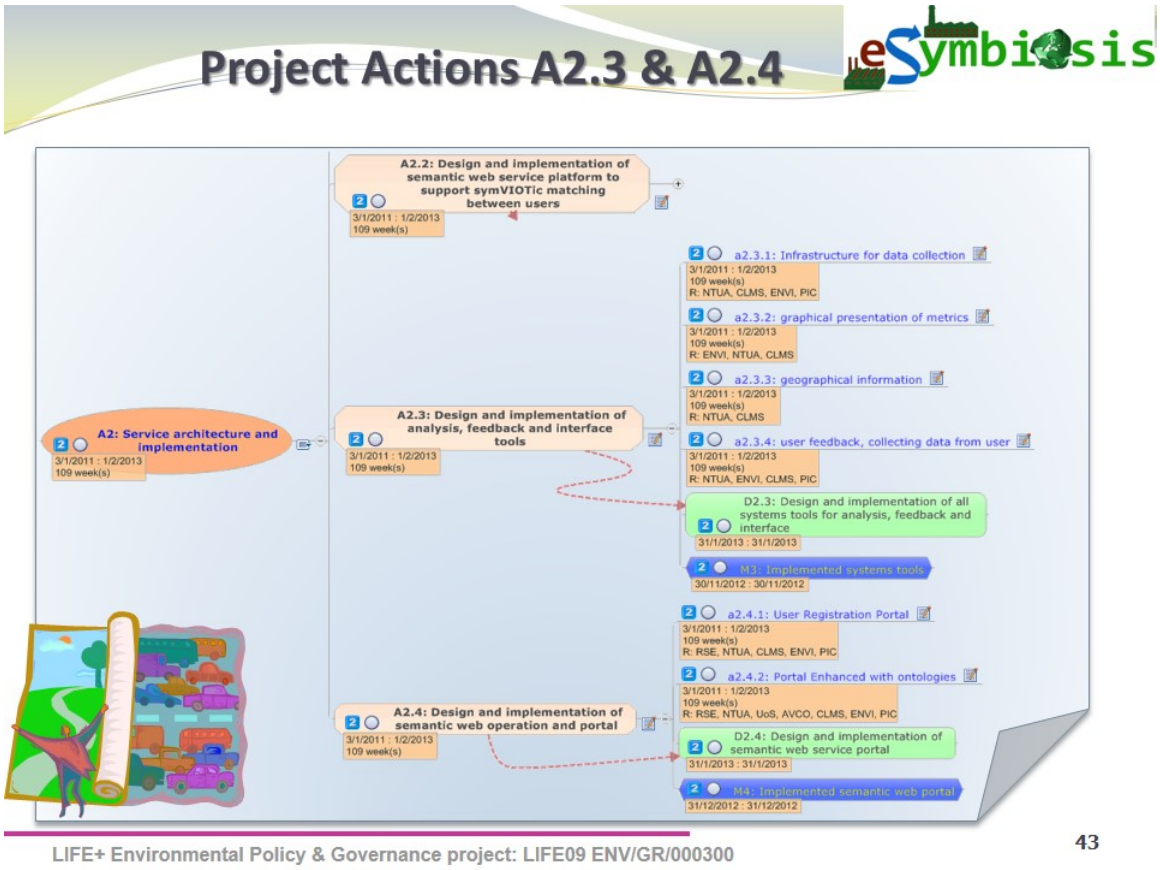

Fig. 4: *Activities 2.3 and 2.4 Presentation Card – External Monitoring Visit, December 2012*

A2.3.1 The work here designed and Implemented the infrastructure for data collection (user and Interest registration) by the users. The work was implemented by AVCO who was the technical Leader and CLMS, with the guidance of UoS.and PIC.

A2.3.2 During this task a number of tools providing visual presentations to the users was constructed. The work was implemented by AVCO who was the technical Leader and CLMS, with the guidance of UoS.and PIC.

A2.3.3 During this task the GIS subsystem of eSymbiosis was constructed, supporting user information presentation and searching. This task was Implemented mainly by CLMS with the help of NTUA as regards the presentation components, the GIS ontologies have been implemented via collaboration between PIC and UoS.

A2.3.4 During this task user feedback / dialogues and tools were designed. This was mainly implemented in collaboration between AVCO and CLMS, with the guidance of PIC.

A2.4.1 During this task the eSymbiosis portal was designed and implemented, performed mainly by CLMS.

A2.4.2 During this task the eSymbiosis portal and the user interactions were enhanced with Ontologies, performed by CLMS with the collaboration of AVCO and the support of UoS.

2. ACTION ASSESSMENT AND EVALUATION

2.1 PROGRESS ACHIEVED

Action 2 started on time on Jannuary 2011. The progress achieved in this task is considerable, regarding its original goals and targets. As regards its progress profile, there was a slower pace in the start, as the original proposal assumption that the data for the ontologies would be retrieved by the UK, did not seem to suffice in order to support the local conditions in Viotia. Furthermore, there was not sufficient information in the data to construct the ontologies models. A curve point was September 2011 where the project gained access in a large data set for the local industries, in the form of a Database, owned by Region of Sterea Ellada. There was significant effort put to cleanse the data set, and extract the information in an appropriate form for the ontologies. In addition to it, using the knowledge of workflows and information related to the IS business domain based on UK Industrial Symbiosis best practices, all Design activities for all Platform components have progressed and concluded successfully, involving the conceptual design of the web service platform, and the design of the architecture

Now, the ontologies content is sound and rich enough to support real user scenarios for Action 3 and 4 which will build the eSymbiosis Industrial networks. Furthermore, significant achievements have been sustained in the areas of constructing the matchmaker and the user registration intelligent components.

The user oriented portal design received and integrated significant feedback by the Consulting Experts (PIC) in the consortium through verification and assessment activities for the Portal design. The eSYMBIOSIS portal is now in a status that can be demonstrated and engage the Regional Industry Interest. A very nice feature of the ontologies as implemented in eSymbiosis is that they are used to automatically generate user searches and dialogues, in English and Greek, transparently from the user. Of all these the biggest achievement is that during this action the initial targets for Technologies and Processes supported have been surpassed by far, transforming a ‘case based’ for mainly aiming for demonstration purposes implementation scenario to a system ready to hold real user transactions.

The project has applied for a modification since the start of this year, the reasons are mainly to give the project better chances to set up and progress in the Human

Oriented Actions and Activities (e.g. Industrial Networking, Capacity Building, Dissemination, Exploitation), not the technology ones. Reasons for the prolongation wrt. the initial plan are based in the changing Financial Environment and mainly in Greece due to the dramatic changes in the Economy, which in turn has a large impact in the processes and the operations of Businesses and Organisations. As regards Action 2, the applied extension of Action 2 was to introduce an additional three (3) months duration. To this end, we consider the task has achieve to conclude in Time, the outputs (i.e. the platform) are timely ready to support the actions of Dissemination and Capacity Building.

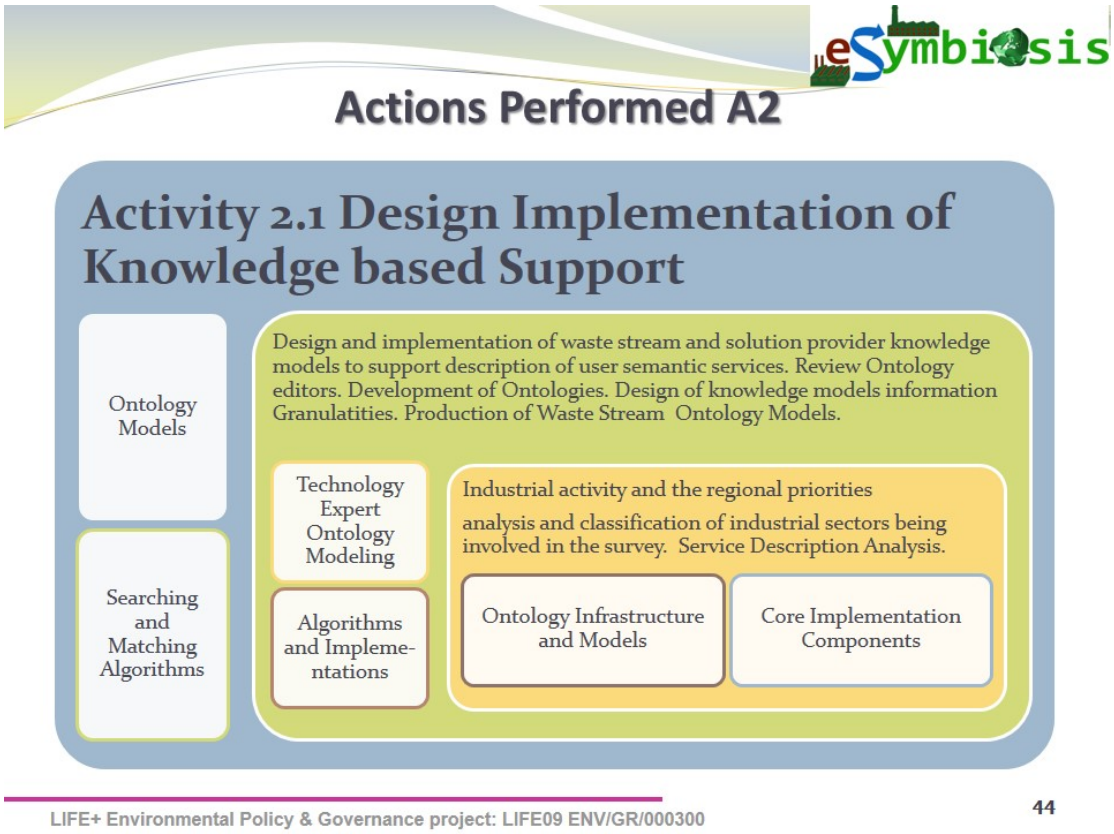

Fig. 5: *Activity 2.1 Presentation Card – External Monitoring Visit, December 2012*

Activity 2.1 for the Design and implementation of knowledge models, involving lightweight and advanced Ontology Models. In this Action Ontology concepts have been created (in both Greek and English) and enhancements to peripheral concepts. All the concepts available at present have been annotated in Greek with the main ontology developed in English. The ontology involves i) meta-ontology (the main classification level), ii) high level of domain ontology (high level classification of resources and technologies, as well as users), iii) most of resource classification

based on EWC classification from literature, iv) Technology classification and v) all the properties. The ontology is used for enabling creation of web pages dynamically. Furthermore, an external ontology has been imported for the capture of geographical information.

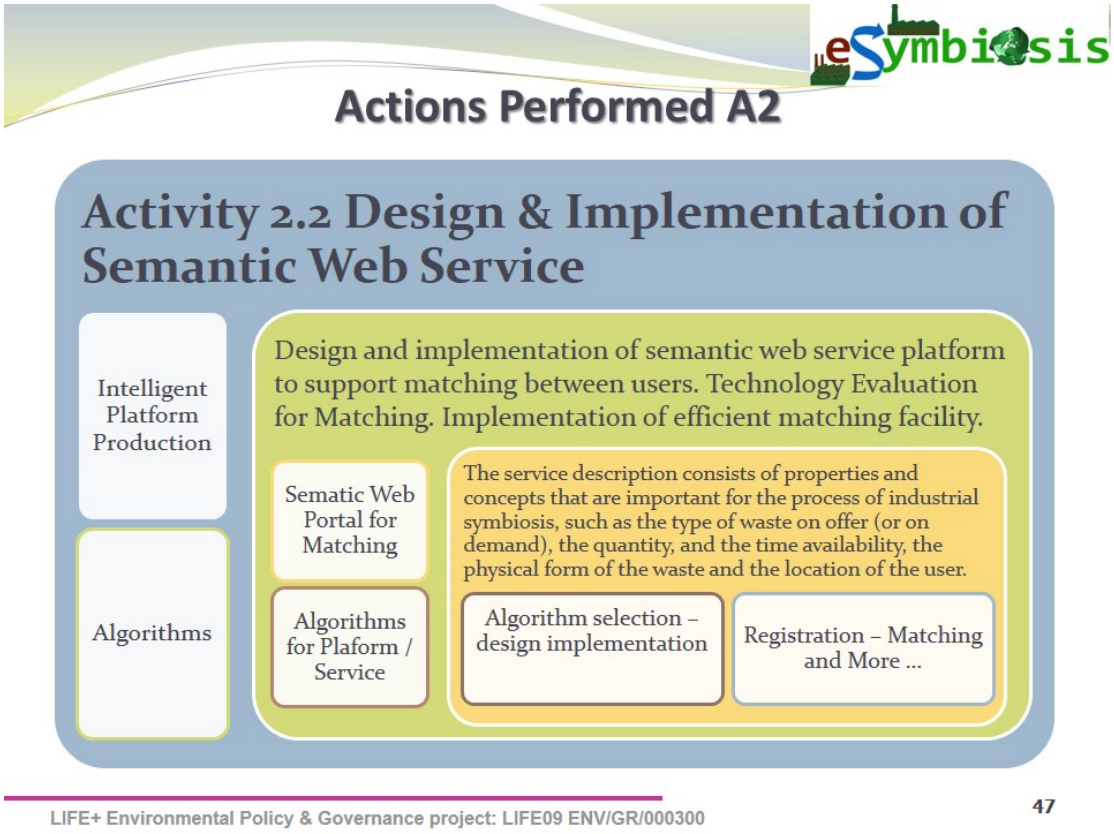

Fig. 6: *Activity 2.2 Presentation Card – External Monitoring Visit, December 2012*

Activity 2.2 for the Design of service description facility and repository and the Design and Implementation of the MatchMaker, the mathematical algorithms for the matching calculating were implemented calculating the similarity between resources and technology inputs based on the distance between concepts in domain ontology. The MatchMaker has been constructed to demonstrate the fundamental functionality of industrial symbiosis which, as intended, will be completed and tested in Viotia in Action 3. Further, all platform functionalities have been designed and their implementation has passed significant testing within the consortium.

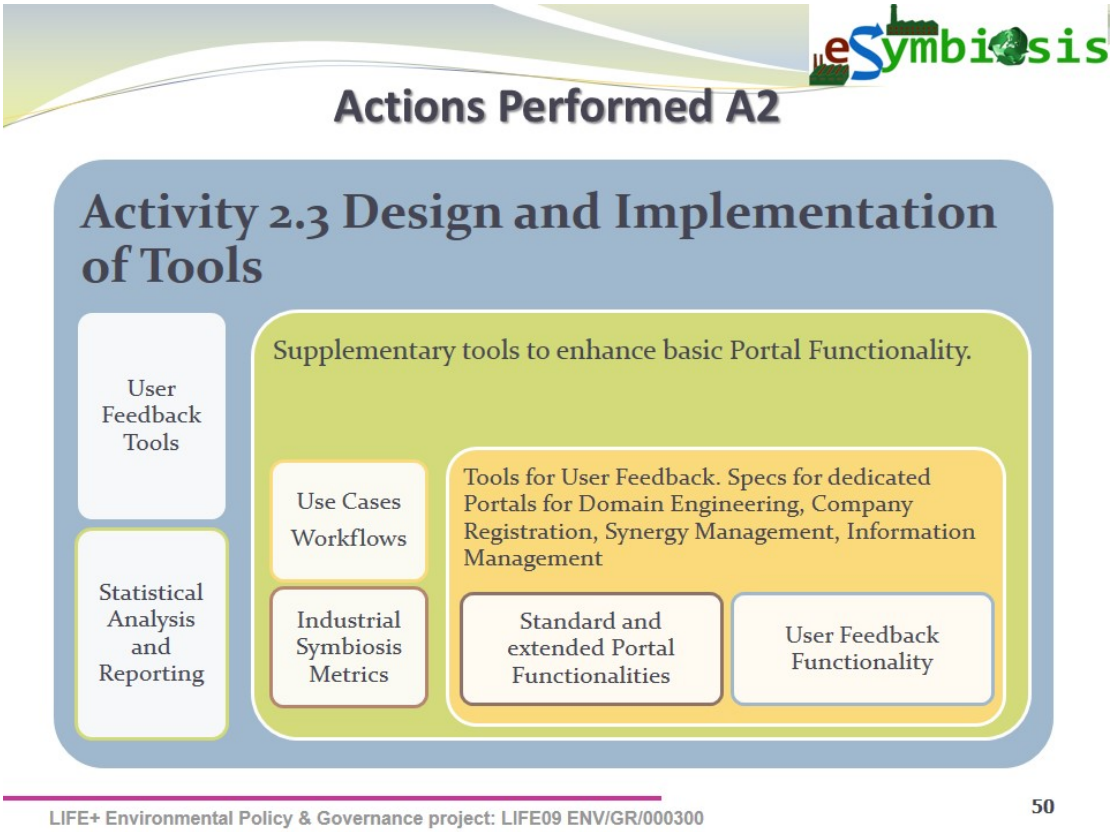

Fig. 7: *Activity 2.3 Presentation Card – External Monitoring Visit, December 2012*

Activity 2.3, for the Design and implementation of analysis, feedback and interface tools analysis on the components architecture of the platform was performed and led to the design of the platform components. Based on the partners' feedback the database schema was extended and enhanced. The Portal functionality passed over several cycles of enhancement, and now comprises of multiple information pages that present Sites, Resources information through intuitive controls (Maps, Graphs, etc.) to the user. User registration is fully supported, involving GIS information. Various types of user queries are supported, and statistics reports are generated by the system. The platform has been enriched with automated tools (wizards) to assist users.

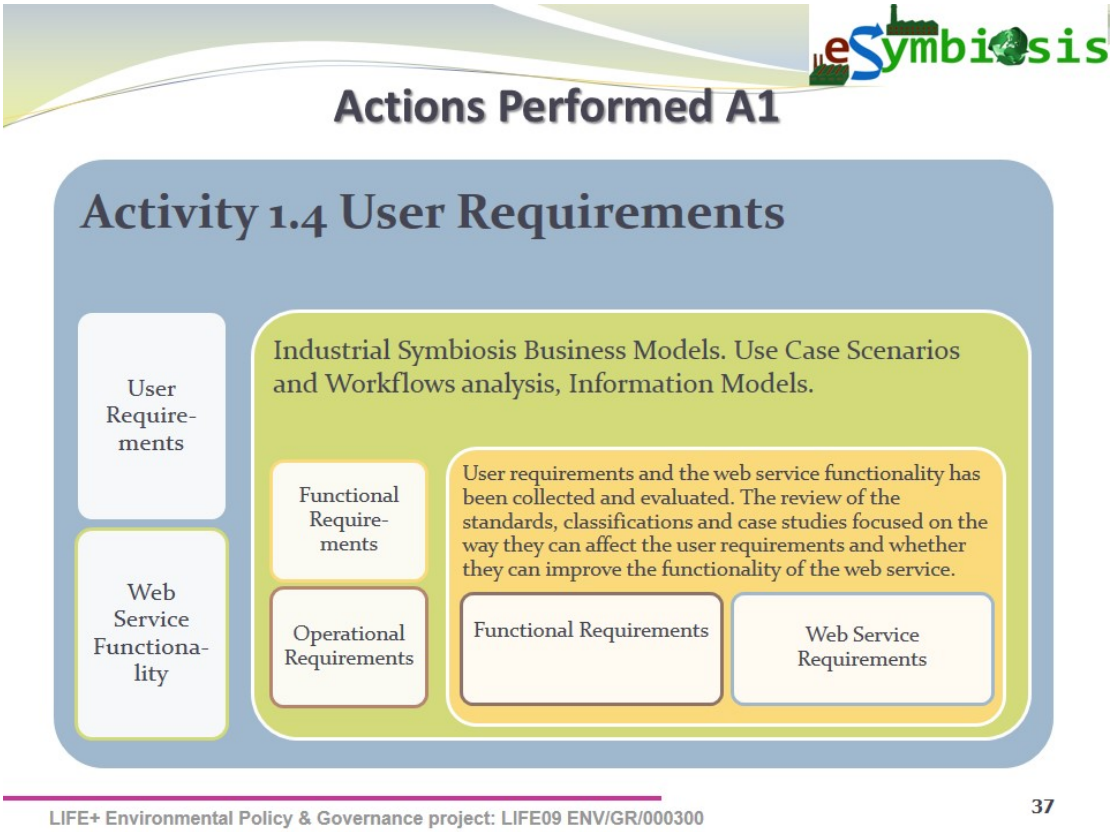

Fig. 7: *Activity 2.4 Presentation Card – External Monitoring Visit, December 2012*

Activity 2.4 for the Design and implementation of semantic web operation and portal significant work has been done for the User Registration Portal which is enhanced with the Ontologies. The ontology components have been integrated with providing advanced Knowledge Based behaviour, the portal provides a means to combining database constructs with semantic Ontology based concepts.

2.2 DEADLINES AND DELIVERABLES

The deliverables of Action 2 were performed as planned, as explained above, an additional duration of three (3) months was introduced, while an application for project extension by nine (9) months is pending. The benefit for the time extension was the enrichment of the ontologies with concepts, far beyond the original planned targets.

The Action Deliverables (documents) have been prepared and are ready for Internal Review. These deliverables have been attached to the Mid Term Report.

Name of the Deliverable	Status	Deadline
2.1 Waste stream and solution provider knowledge models, ontologies	Ready for Internal Review	31/11/2012
2.2 Design and implementation of semantic web service platform	Ready for Internal Review	30/11/2012
2.3 Design and implementation of all systems tools for analysis, feedback and interface	Ready for Internal Review	30/11/2012
2.4 Design and implementation of semantic web service portal	Ready for Internal Review	31/12/2012

The Milestone related to Action 2 has been matched. The functionality of the portal was demonstrated to the External Monitoring team in their visit end of December 2012.

Name of the Milestone	Status	Deadline
Implemented waste stream and solution provider knowledge models, ontologies.	Achieved	30/11/2012
Implemented semantic web service architecture: repository, inference engine and service matchmaker;	Achieved	30/11/2012
Implemented systems tools	Achieved	30/11/2012
Implemented semantic web portal	Achieved	31/12/2012

In summary, there was a delay as regards the deadlines of the original proposal, however, with the pending modification request these deadlines are extended by three months, hence, the deliverables comply with the targeted dates. By all means, all functionality was set up by end of November 2012, and delivered within the foreseen time frame, and the document deliverables writing up was in progress as it appears in and has been documented by the project's monthly reports, even when considering the original plan.

2.3 PROGRESS INDICATORS

The overall assessment of Actions is performed on the basis of evaluating the level of target figures reached. As regards Action 2, all four Activities have been completed

successfully regarding expected results and progress indicators as presented in the following tables.

Expected results for Action 2

Expected Results	Status	Comments
A verified waste stream and solution provider knowledge models, ontologies needed for the service operation in Action 3, minimum 5 different waste streams and 10 different technologies included.	Achieved	1649 different waste types and 110 different technologies in eSYMBIOSIS
Implemented inference engine and service matchmaker.	Achieved	Is available for Action 3
Design and implementation of the system tools.	Achieved	Implemented
Implemented semantic web service and web portal, minimum one service implemented at VIOT beneficiary.	Achieved	Implemented

Indicators of progress for Action 2

Indicators of Progress	Status	Comments
Timely waste stream and processing technology ontology design and implementation	Achieved	Ready for Action 3
Design and implementation of inference engine and service matchmaker	Achieved	Ready for Action 3
Design and implementation of all systems tools for monitoring	Achieved	Ready for Action 3
Design and implementation of semantic web service model, service repository and web portal	Achieved	Ready for Action 3

As shown above and discussed before in this document, the targets for the ontologies have been exceeded by far. To our experience and knowledge gained during this process, the differences by orders of magnitude in the indicators, are due mainly because the originally entered in the proposal indicators have been by far

underestimated, sufficing to be used only for demonstrations of the concept and not real use scenarios. The main achievement in constructing the intelligent eSymbiosis components is that the models are now useful for realistic business scenarios, and ready to be used with the necessary adaptation, in extended National and International applications of eSymbiosis.

2.4 OVERALL ACTION EVALUATION

Overall, Action 2 is considered to have succeeded its goals. The results of Action 2 are timely ready to be used and exploited by Actions 3 and 4.. The academic teams NTUA and UoS have ensured that the models created are sufficient for the goals of the project addressing the local implementation of IS scenarios in Viotia. The Technology Partners AVCO and CLMS with the continuous assistance and guidance of the Business Experts (PIC) have produced a Portal to host and support local business interactions for Industral Symbiosis. The outcome of this Action will further be promoted and disseminated to the Region by ENVIRECO and the Region of Sterea Ellada. (RSE).

3. RISKS, PROBLEMS ENCOUNTERED AND SOLUTIONS FOLLOWED

In Action 2 the main risk was the production of a Knowledge Model, not to be perceived as simply an academic exercise but capable to be used in Industrial applications. To achieve this, it would be necessary to have a large volume of information introduced. This has been achieved by gaining access to a large data set for Regional Industrial Information, owned by Region of Sterea Ellada, making the task feasible. The same set is not Region Specific only, as it comprises of information that can be generalized, such as the applicable technologies and the Industrial Processes.

Another risk was the technical development co-herence, as this was implemented in three mainly different sites. UoS has been creating the Intelligent Ontology Models, Avco, has been creating the Intelligent Platform Components and CLMS has been creating the Portal Functionalities.

During all the performance of Action 2 tasks, there were weekly regular teleconference meetings for the Technical Platform Developments, go co-ordinate and align development.

Furthermore, close collaboration between AVCO and UoS has allowed the optimal implementation of the Intelligent Platform components, exploiting all available knowledge captured in the models. Close collaboration has taken place between NTUA and UoS too, as regards the enrichment of the model with regional and process specific information, as NTUA had the expertise in the Industrial and Technology and UoS in the knowledge modelling Scientific and Technical state of art practices followed.

AVCO and CLMS have had very close co-operation, so to integrate the different platform parts in a unified for the user environment.

The whole user oriented functionalities were under the auspices of PIC, who has a deep knowledge of the UK best practices, and Industrial Symbiosis.

The risk of infrastructure technologies, the flexibility requested in capacity growth and the ability to provide a web based service to match data and communication loads which can be significant has been addressed by using the Cloud facilities if the Greek Research Network GRNet. The eSymbiosis Servers are hosted using modern virtualization and cloud approaches in computing.