PROJECT FINAL REPORT

Grant Agreement number: 246083

Project acronym: IDEAS

Project title: Instantly Deployable Evolvable Assembly Systems

Funding Scheme: THEME [NMP-2009-3.2-2] [Adaptive control systems for responsive factories]

3.1 Publishable summary

IDEAS stands for Instantly Deployable Evolvable Assembly Systems. Its objectives are to develop EAS systems for two industrial customers, IVECO and ELECTROLUX.
The project took advantage of several developments that were done during the EUPASS (FP6...) project, such as:

- ontological descriptions of the assembly processes [9],
- equipment modules prepared for embedded control [11],
- data exchange protocols verified, [12],[13],
- basic methodological principles set [14],

IDEAS had as a main objective to implement the agent technology on commercially available control boards. This would enable distributed control at shop-floor level. What is being considered here is not the planning or logistics level but the actual operational level of the assembly system.
To this effect the ELREST company and FESTO research division set out to specify the exact requirements, based on the needs detailed by the industrial customers Electrolux and Centro Ricerche FIAT. MASMEC, Karlsruhe Institute of Technology and FESTO supported the effort by developing system modules, TEKS provided the simulation software, and UNINOVA and KTH developed the agent technology. Finally, the methodological framework upon which the whole project would base its work, was developed by University of Nottingham.
The project's first objective was to prove the validity of the approach by running a medical assembly system at the FESTO facilities (see diagram below).

The system shown in figure 1 ran the following processes:

- Glueing unit:
  Dispensing glue for assemly of small components
- Pick & Place unit
  Pick and place handling system
- Electrical testing unit

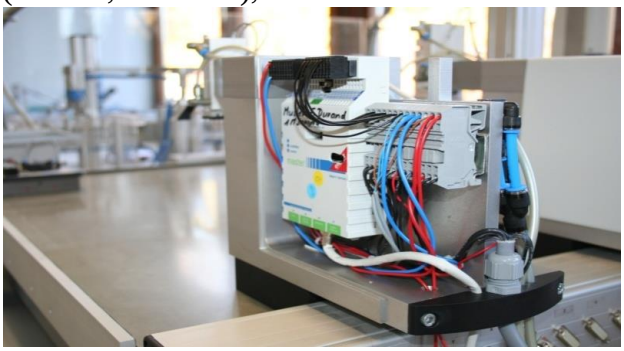
Testing unit for qualitiy/functional product test

- Stacker unit

Pneumatic/Servopneumatic handling system

Figure 1. *The FESTO MiniProd System*

This assembly system, called the MiniProd, was finally demonstrated in January 2011. It ran with a multi-agent control setup, could be re-configured on-the-fly, and the modules self-configured. This was achieved thanks to the fact that the agent software could be run on commercial control boards (Combo, ELREST), which are shown below.



As this could probably be viewed as the first time an assembly system actaully operated with a totally distributed control system, and self-configured, it was shown again for the European Commission in November 2011. The system performed flawlessly, confirming that multi-agent control can be used for truly reconfigurable assembly.

Figure 2. *Combo211 (Elrest) applied in a module*

In order to attain this success, IDEAS has relied on the following developments:

- A simple and effective mechatronic architecture
- Control boards developed for multi-agent applications
- Am elaborate and well-structured methodology
- Industrial commitment

The mechatronic architecture is, first of all, an architecture that considers the control demands from an embedded-system point of view. That is, each assembly system module is an entity with its own control, hence the "mechatronic". The difficulty was in creating an architecture out of which an effective control structure could be instantiated for any assembly system layout. As the demands on assembly are extremely diversified (see conveyor system in MiniProd-free-moving pallets!), this posed challenges. The final Mechatronic Architecture is based on four basic agents:

- ❖ Machine Resource Agent
- ❖ Coalition Leader Agent
- ❖ Transportation System Agent
- ❖ Human Machine Interface Agent

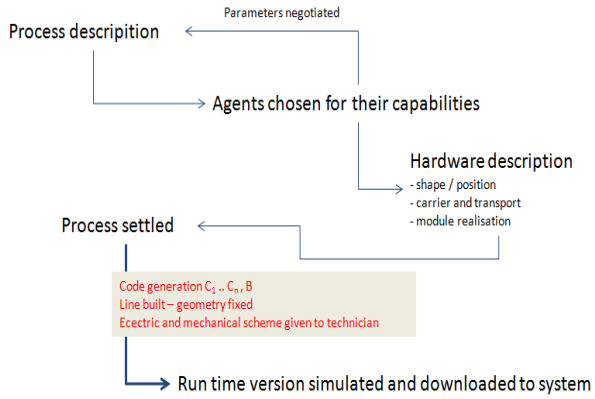
In order to implement this, the project developed several tools. The actual agent development environment, called IADE (IDEAS agent devt.env.) is based on an elaboration of JADE. The Java Agent DEvelopment framework is FIPA compliant and also provides basic development tools. The IDEAS project further developed these tools and included others to support the simulation of the agent control prior to its being downloaded into the modules. Experiments made at the simulation level and real module also indicated that the simulated module and real unit actually run the exact same code, rendering the simulation extremely accurate (1:1 relation).

The second main development has been the development of commercial control boards capable of running the multi-agent setup. The ELREST company provided the project with several alternatives, out of which the Combo211 was selected for use. This required quite some developments, amongst which:

- Combo200 series runs on WinCe6
- Implemented CrEme™, a Java Virtual Machine (NSI.com)
- Fits to the needs of the Agents and supports JADE
- Implementation of 24V I/Os, Ethernet, CAN and RS232/RS485 connections

The control boards function very well and have also been thoroughly tested at the other partners labs. The project currently intends to develop three variants of these control boards, depending on the required granularity and number of agents/module (from very small, cheap, to mid-size capable of running more than one agent).

Figure 3. *Simplified View of Development Process*



Thirdly, the project would have never succeeded if the tools that are required to engineer such solutions were not specifically designed and integrated within the IDEAS methodology. This work, led by University of Nottingham, has brough together many partners (KTH, MASMEC, KIT, TEKS, ELREST, FESTO): the synchronisation and

integration are sensitive aspects. The objectives included:

- Develop Semantic Representations for Devices and Skills
- Create Requirements and Target Specification Language
- Semantic Rules for Integration & Validation of Skills
- Develop a rapid System Configuration Environment
- Develop Visualisation and Transparency Tools

Note that this includes skill definition support, Workflow definition support, simulation tools and more. This advanced software tool, based on Automation ML, assists users in forming IDEAS systems and is schematically shown in Figure 3.

One of the most interesting outcomes of the work has been the link between simulated system and real system. Using commercial software (Visual Components) coupled to the multi-agent programs made it possible to run the exact run-time code prior to download. That means that the simulations represent exactly what will occur in reality (at control level).
All the developments, from EUPASS to IDEAS and beyond, would be quite superfluos if industry had not provided the critical mass and know-how to achieve such results. Industrial aspects are the key ingredient as the certification procedures, variation of hardware constraints, specific customer needs, market demands, etc., all play a decisive role in the effective deployment of a technology. IDEAS took this a step further as it set as an objective that one of the "missing links" had to be corrected: develop a control board for such applications. This was made possible by the industrial commitment, both at control development and requirements specification.

The project finally consolidated these results by building the two industrial systems initially planned for IVECO and ELECTROLUX. The systems were built at KTH (ELECTROLUX processes) and MASMEC (IVECO processes). The products assembled are an ECU (electronic control unit) from a commercial vehicle, and some specific washing-machine components. The figures below illustrate the schematic layouts.

Figure 4. *The ECU Assembly System(MASMEC)*

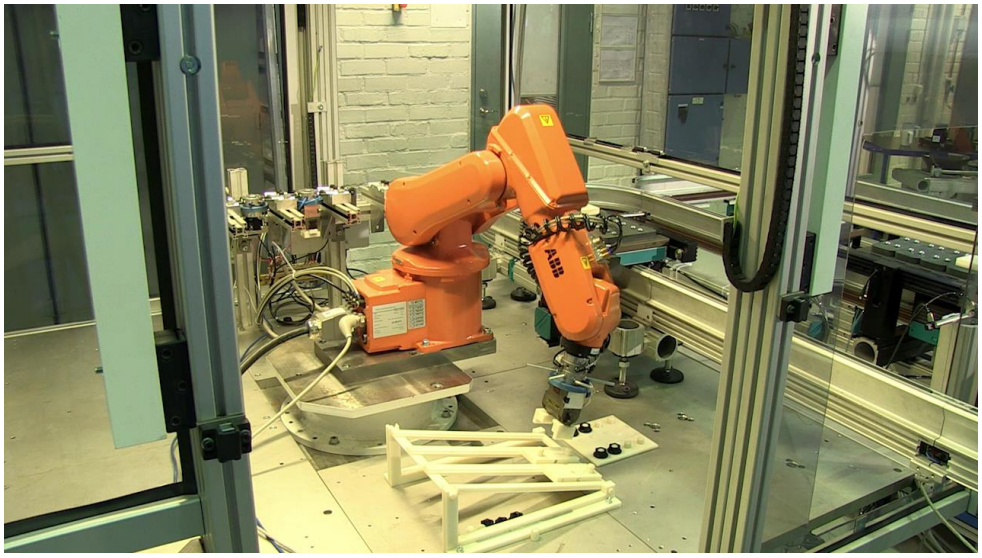


Figure 5. *The Washing Machine Components Assembly System* (KTH)

Both solutions were thoroughly validated, demonstrated and Life-Cycle Analyses performed. Finally, a new Business Model was developed in support of the more strategic decisions that will be encountered.
Videos are available and have been disseminated.
The project also received the Emerald Literati Award for Outstanding Paper 2013.

3.2 Core of the report for the period: Project objectives, work progress and achievements, project management

3.2.1 Project objectives for the period

The project had no precise recommendations to account for (from Mid-Term).

The IDEAS project had three main objectives for its final period:

1. Comply with deliverables list
2. Build demonstrator 1 at MASMEC
3. Build demonstrator 2 at KTH

Beyond these direct objectives the project also intended to act upon the Exploitation aspects.

The project built and demonstrated the two assembly systems as required, the short details of which are given in the previous section. This was achieved albeit a revision of the budget and partner responsibilities: see Mid Term review for 1st Amendment details. The final period did incur in an extra Amendment as well. The easons for the second Amendment were:

1) small defaulting of partners CRF and Electrolux, which they highlighted themselves, and proposed solutions for. The Project Management Board (PMB) convened and resolved this quickly.
2) the project requested a minor extension in order to finalize the two systems. The assembly systems were to be of industrial level, an objective which required extensive testing and finalisations.

In terms of deliverables there were some delays reported by the PMB but all deliverables were finally accounted for. The main reasons behind the delays were due to synchronisation issues between workpackages that had not been foreseen during proposal writing, and due to the minor re-scheduking of responsibilities during the second amendment.

The Final Review took place without any issues being raised and the project was deemed as very successful.

3.2.2 Work progress and achievements during the period

WP1
WP1 terminated at Mid-Term and was therefore not active during second period. The results, however, continued to be updated: the glossary and terminology documents were considered dynamic throughout the project.

WP2
WP2s main objectives for the second period all focussed on the finalistation of the supporting tools for the mechatronic system design. This included the following software tools:

- Finalisation of low-level libraries
- IADE (IDEAS Agent Devt. Env.) software support & integration
- WorkFlow Management Tool
- IDEAS Configuration Tool
- IDEAS Visualisation Tool
- Integration of tools into a single user interface: MASCOT (Muti Agent System Configuration Tool).

Since the software tools are fundamental for the development of an IDEAS system, the Pre-Demonstrator shown in Esslingen on November 2011 was fundamental for the capture of the software issues. In fact the system shown in Esslingen had a rather unusual transportation setup as the pallets flowed freely on a suspended table. This total freedom of movement required adjustments to the software as most assembly systems have a fixed conveyor-based transportation system. The analysis also revealed issues with the slow communication and other minor limitations.

WP2 basically had an enormous workload up to the two final demonstrators. Software development is a crucial workpackage and the project held a very steady set of objectives and deadlines in order to maintain the schedule.

All software packages were finalised by March 2013. This work was conducted on the actual demonstrators (KTH, MASMEC). However, as the project goal was to develop industrial systems, the WP2 partners agreed to attempt to integrate all the tools within one single user platform (MASCOT), and also to refine the tools for required stability and robustness.
The final demonstration in July 2013 clearly illustrated the validity of the tools.

WP3
The main objectives of WP3 in the final period were focussed on optimising the performance of the novel controllers developed by ELREST, and the finalisation of the core software code to run on these devices (IADE). For the controllers in particular:

- Since IDEAS evolvable production modules are intelligent mechatronic agents that require computational power, we need control boards that are able to be attached to each module and able to support agent execution and communication between modules
- Support of **non-real-time (first)** and optional real-time-bus-systems (future)
- Development of small mechatronic agent controllers which will be implemented into the mechatronic modules (piston, electric axis, …)
- Powerful controllers to support a multiagent environment
- Implementation of the real-time-system and the JAVA virtual machine and the JADE environement

In terms of controllers the project had already developed the Combo200 but required even smaller controllers and, possibly with faster execution times. LINUX applications were envisaged and tested. In the end the project delivered two new controllers:

Effectuator 1:

- CPU solution 1 for IDEAS effectuator (MC = 3€, @ 10.000 p.a.)
  • Cortex-M3 32-bit 120 MHz
  • Interfaces CAN or non RT Ethernet.
  • Eclipse development environment or KEIL
  • 1 MB Flash, 0,5 MB internal RAM
  • CoDeSys V3 programmable
  • CAN or RT Ethernet
  • 16 digital inputs /outputs 24V
  • 8 analog inputs /outputs

Effectuator 2:

- CPU alternative for effectuator (MC = ca. 22€)
  • Altera FPGA 32-bit 80 MHz
  • Interfaces CAN, non RT and RT Ethernet (EtherCAT).
  • without OS
- • Eclipse development environment
  • 1 MB Flash, 16 MB SD-RAM
  • CoDeSys V3 programmable
  • CAN or RT Ethernet
  • 16 digital inputs /outputs 24V
  • 8 analog inputs /outputs

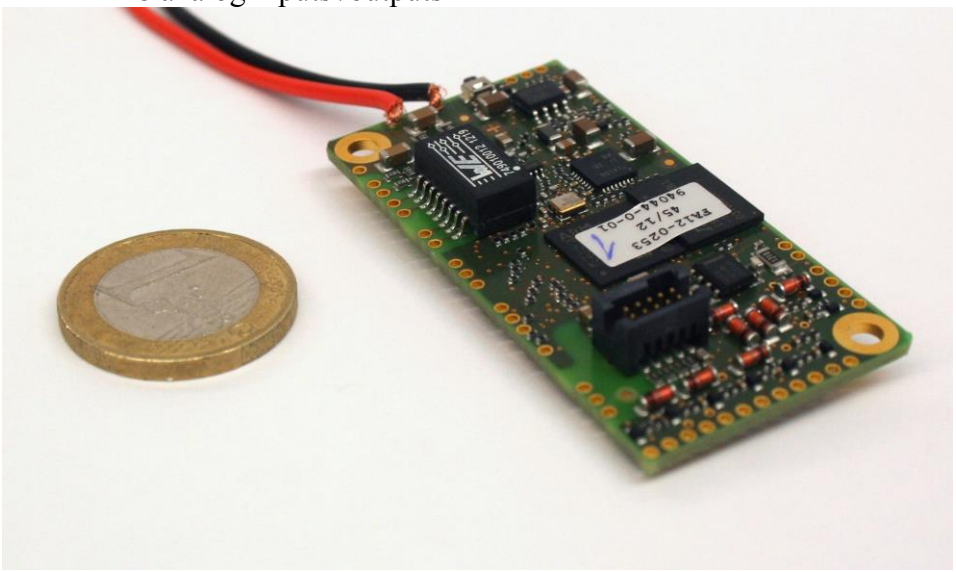


Figure 6 – The “Executor”

As shown above, the final devices were termed Executors after the final developments.
The first prototype was demonstrated ahead of schedule in December 2012 at the FESTO Workshop. All the devices were finalised on time and were applied to the two final demonstrators. In fact WP3 also developed testing platforms and other hardware support tools.

In terms of code development, the Ideas Agent Development Environment (IADE) represented the heart of the project. All multi-agent system performance issues would be the result of how well IADE ran. As explained earlier, the Pre-Demonstrator ran with a different tranbsportation layout and also denoted very slow execution times (related to the exchange of information).

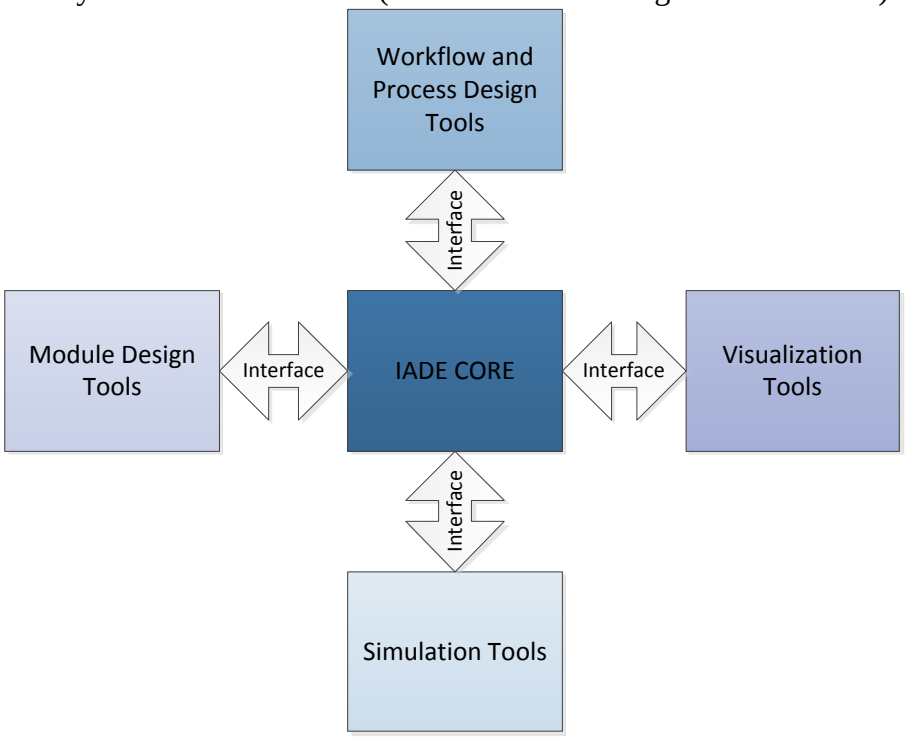


Figure 7- IADE as the "operating system" of the IDEAS project

The final IADE system solved all the issues and the demonstrators performed flawlessly. In fact the IADE software was actually applied to two other systems at UNINOVA as well. Therefore, including the Pre-Demonstrator, the IADE software actually ran on 5 separate systems, clearly proving its generic nature and performance.

WP4

This workpackage was deeply involved with the final demonstrators and included some of the main IDEAS objectives:

- To define the requirements for the *agentification* of modules and mechatronic devices constituting a production enviroment;
- To define a meta modelling language to describe both modules and mechatronic devices;
- To implement the Multi Agent embedded software;
- Study of adaptive algorithms capable to optimize the behaviour of the process.
- Determination of scalability properties, implemented as capability to achieve more complex behaviours starting from basic working models.
- Increasing of diagnostic capabily of the agents.

Needless to say, WP4 has been extensively linked with WP2 and WP3. In fact the developments of the two other Wps are integrated and embedded within WP4. This has included the realization and integration of tools (AUTOMATION ML), workflow tool (by UNOTT) and agents architecture (by UNINOVA) in order to make possible the re-configuration of modules clusters without software reprogramming.
In essence the synchronisation of work is best shown below:

- **Supporting to WP1**
  - Visualization tool requirements;
  - Implementation of the Resource and Transport Agent configurator;
  - Implementation of the Mechatronic Agent Library;
  - Setup procedures for the Masmec cell used in the academic final demonstrator;
  - **Supporting to WP2**
  - Definition of the OMAC agent state machine for pre demonstrator;
  - Integration of MASCOT tool with UNINOVA tool (integration workshop);
  - Industrial requirements for MASCOT;
- **Supporting to WP3**
  - Tests on COMBO devices;
  - Hardware definition for final demonstrator.
- **Supporting to WP5**
  - Implementation of OMAC requirements for the pre-demonstrator.
  - **Supporting to WP6**
  - Industrial demonstrator design.
  - **Supporting to WP7**
  - WP4 contribution to the IDEAS newsletter.

The development details are also reported in the "publishable summary" and are fairly extensive. WP4 also tested AutomationML, COLLADA and other commercial support software in order to attain a solution which is as close to an industrial "standard" as possible. In collaboration with WP3 and WP5 this was achieved and the MASCOT tools is a clear proof.

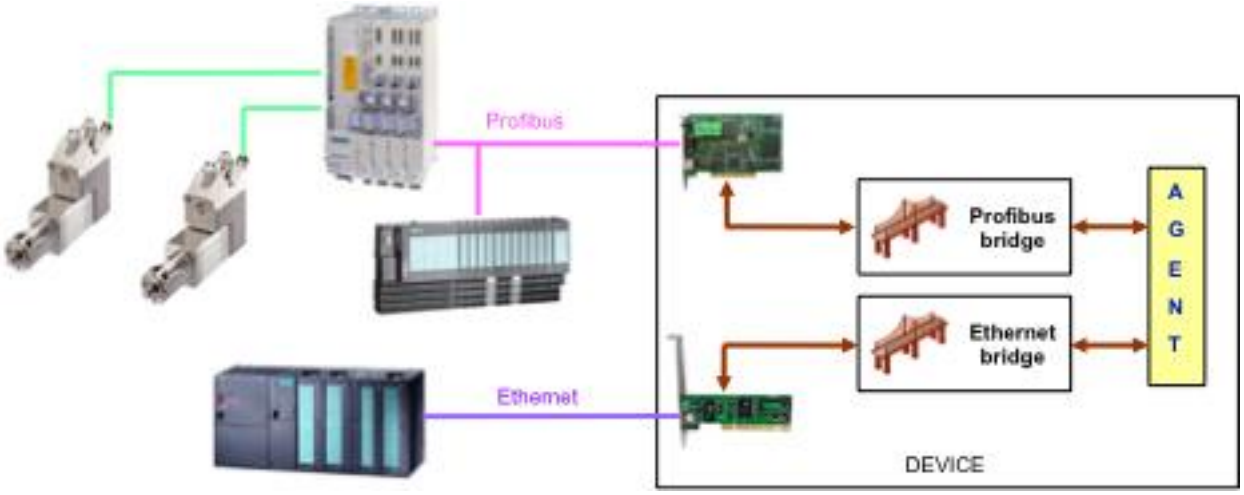


Figure 8- Connecting Legacy Equipment

The final objective of WP4 was to develop and integarte all the modules required by the IVECO industrial demonstrator. The system was successfully demonstrated in July 2013.

WP5

The main tasks of WP5 were accomplished in period 1 as the Pre-Demonstrator was the primary objective of this workpackage. The tasks remaining for the second period included the following:

- Definition of components (final demonstrators)
    - Academic demonstrator at KTH
    - Industrial demonstrator at Masmec
- Realisation and system integration: Collaborative work between partners
- Testing
- Development of testing scenarios for the demonstrators

As such the work was supportive of the final demonstration tasks and initiated with a full analysis of the pre-demonstrator.

All the hardware developments (controller boards) were tested and analysed under WP5. Issues regarding IADE code details in relation to transportation alternatives (with/without conveyors, etc.), embedding of devices within modules, and supporting the development of the "virtual station" were all conducted within WP5.

These tests and developments were demonstrated at the SPS/IPC/DRIVES 2011 fair in Nürnberg. The system brought to the industrial show is given below, along with its technical details. Note that this work also included some collaboration with 3S as the project was investigating new ways to represent the development aspects for the user.

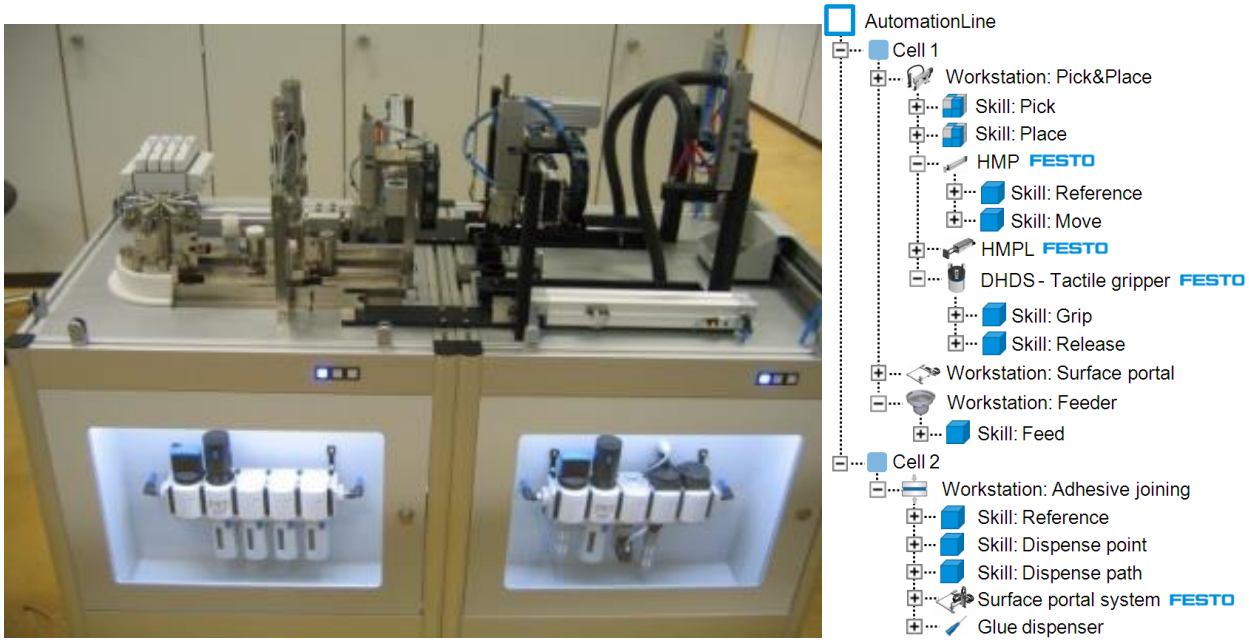


Figure 9: the WP5 Demonstrator at the SPS/Drives Fair

WP6

WP6 had two main objectives:

1) Develop and demonstrate two assembly systems,
2) Carry out Life-Cycle Analyses.

Both objectives came under Project Management Board attention at the outset of Period 2 as CRF and ELUX approached the PMB with issues of reduced involvement. The PMB resolved the issue very quickly and, together with the close support of the Project Officer, a new man-month distribution was attained. CRF maintained the leadership of WP6 and total control of the deliverables; however, the deliverable D6.5 was removed and integrated within D6.4, Life Cycle Analyses. Details given in following section.

WP6 developed the two test cases as a first step. An Electronic Control Unit (ECU) was chosen as the product to be assembled within the MASMEC demonstrator, whilst selected washing machine processes were chosen for the KTH demonstrator (attachment of "feet" onto washing machine base). The MASMEC system was therefore designed to assemble two variants of the ECU, whilst the KTH system assembled three variants of the "feet" assemblies (processes were maintained generic).

The two system demonstrations also led to videos, designed and developed by WP7. The systems can be seen below.

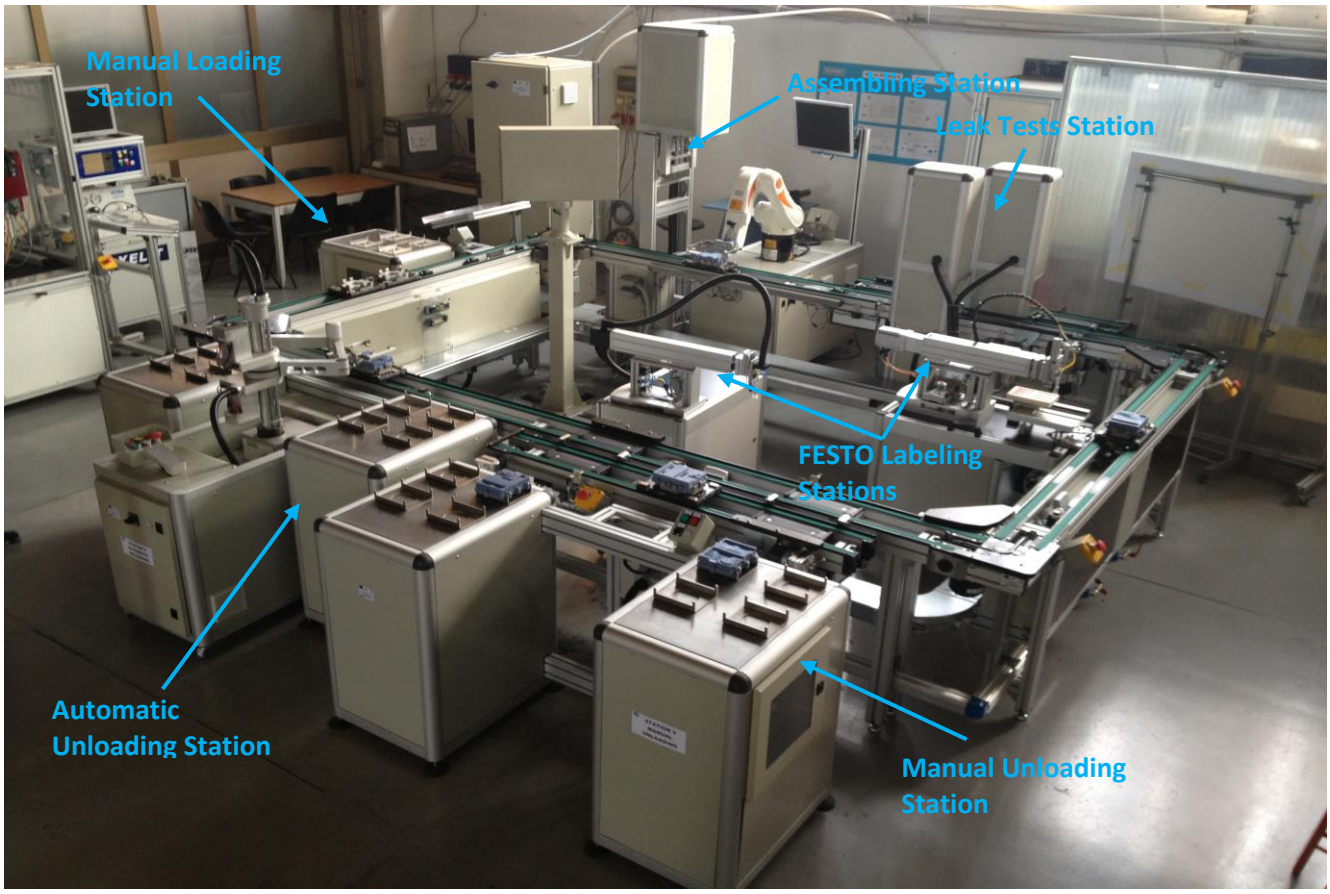


Figure 10- The MASMEC/IVECO assembly cell

Figure 11- The UNINOVA, FESTO and ELUX/KTH assembly cells

The Life-Cycle analysis work was subdivided into several sets, as given by:
Goal and Scope Definition, where the main objectives of the study are identified and highlighted, as well as the Functional Unit (which is the only reference for all the quantities taken into account in the environmental balance), the system geographical an time-related boundaries, the energy mix and all the assumptions and limitations of the study; a Flow Chart of the main phases of the product system is also built up;
Life Cycle Inventory Analysis, LCI, where the energy and material flow (inputs of raw materials and fuels and the outputs of solid, liquid and gaseous wastes) is built up and assessed; in this phase the data collection on the potential consumptions and emissions for each step of the product system's life cycle (primary data) is also included. If the primary data are not sufficient, they are integrated with information extracted from literature data, or databases, or previous studies on the same topics (secondary data);
Life Cycle Impact Assessment, LCIA, where the Inventory data collected in the previous phase are evaluated, processed and classified into Environmental Impact Categories as recognized by the main International Organizations (such as UNEP and SETAC;
Life Cycle Interpretation and Improvement, which represents the final phase of a LCA study, having the objective the analysis of the results obtained, the identification of possible critical steps in the life cycle of the case-study under consideration and, if need be, the definition of some suggestions for possible alternatives (in the materials, technologies, or through the use recycled or recyclable materials, and so on…) in order to reduce the corresponding product system's environmental impacts.
The final stages of data collection followed known methodologies and used commercial software, as indicated below.

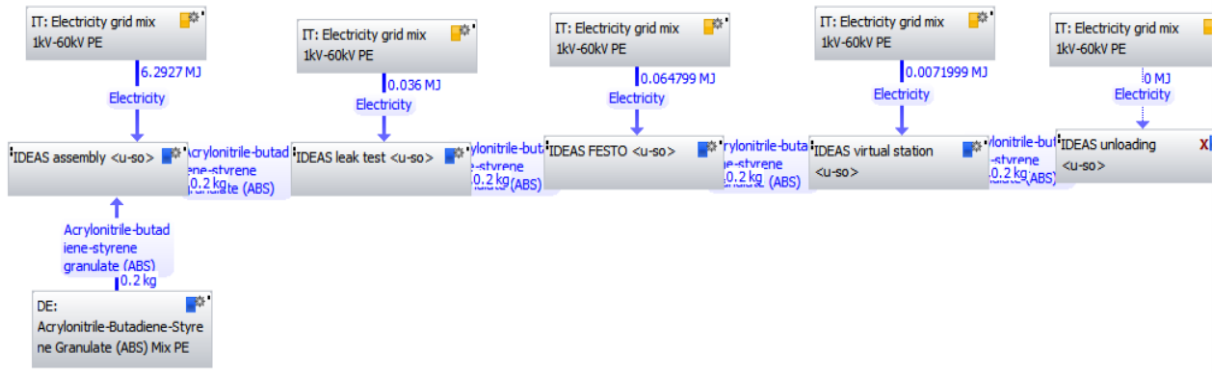


Figure 12 - The plan developed using GABI software, illustrating the electrical and ABS inputs into the model and the flow of ABS through the IDEAS demonstrator.
The analyses also concluded that some comparative studies would also be required to give a more stable prediction of impacts, but that on the whole and with a limited amount of time the results could be deemed reasonable.

Beyond WP6 and part of an academic effort within IDEAS, a Business Model also resulted from the WP6 efforts. The Business Model is fully detailed in Dr.Maffei's thesis. The model used the IDEAS demonstrators as validation examples for a business model developed for highly reconfigurable systems. It includes a complete mathematical analysis and step-by-step methodology for solution evaluations (see example below).

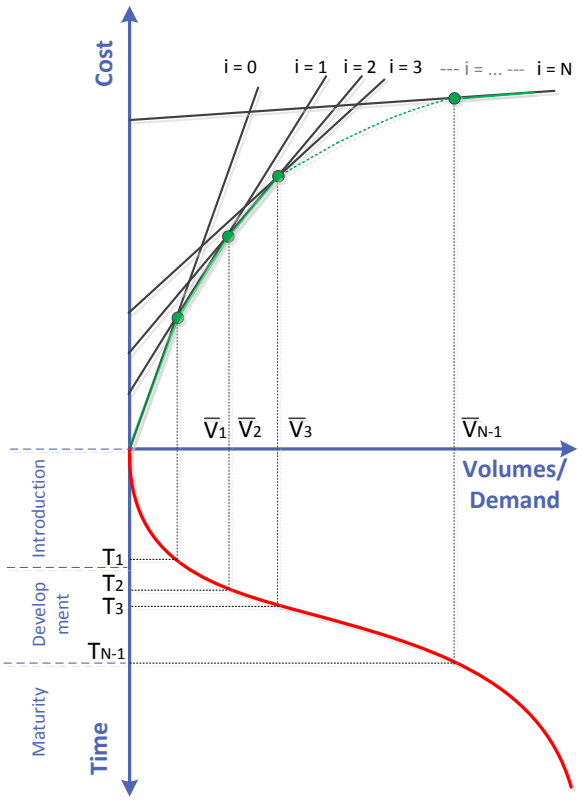


Figure 23- Graphical calculation of the economically optimal instants T_i of deployment for the $(i+1)^{th}$ automatic station

WP7

The Dissemination workpackage was extremely active in the second period covering conferences, publications, fairs, workshops, and even developing videos for broad dissemination. The list of events is given as:

JOURNALS:

- M. Onori; D. Semere; B. Lindberg Evolvable systems: an approach to self-x production.*International journal of Computer Integrated Manufacturing*, Taylor & Francis, 2010
- D. Semere; M. Onori; A. Maffei; R. Adamietz Evolvable assembly systems: coping with variations through evolvability. *Journal of Assembly Automation*, Emerald Press, Vol. 28, No. 2, 2008
- Mauro Onori; José Barata Oliveira Outlook report on the future of European assembly automation.*Assembly Automation*, 2010, Vol. 30 Iss: 1, pp.7 – 31
- M. Onori Holistic precision and the global economy. *Viewpoint, Journal of Assembly Automation*, 2011, Vol. 31 Iss: 4
- A. Maffei; M. Onori Evolvable production systems: environment for new business models. *Journal on Key Engineering Materials*, Trans Tech Publications (2011) Vols. 467 - 469, pp. 1592 - 1597, Switzerland
- M.Onori, C.Hanisch, N.Lohse, J.Barata; "The IDEAS Project: Plug & Produce at Shop-Floor Level"; International Journal of Assembly Automation; Vol.32, No.2, 2012; Emerald Press, UK
- H.Akillioglu, J.Ferreira, M.Onori; "Demand Responsive Planning:workload control implementation"; International Journal of Assembly Automation; Vol.33, No.3, 2013; Emerald Press, UK

CONFERENCES:

- L. Ribeiro; J. Barata; J. Ferreira An agent-based interaction-oriented shop floor to support emergent diagnosis. *8th IEEE International Conference on Industrial Informatics (INDIN)*, 13-16 July 2010, Osaka, Japan

- L. Ribeiro; J. Barata; J. Ferreira The Meaningfulness of Consensus and Context in Diagnosing Evolvable Production Systems. *Doceis2010*, Portugal
- Luis Ribeiro; José Barata; Gonçalo Cândido; Mauro Onori Evolvable Production Systems: An Integrated View on Recent Developments. *DET2010*
- N. Siltala; A. Hofmann; R. Tuokko; G. Bretthauer Emplacement and blue print – An approach to handle and describe modules for evolvable assembly systems. *Proceedings of DET2009 6th International Conference on Digital Enterprise Technolgy*, 14-16 December 2009, Hong Kong
- L. Ribeiro; J. Barata; J. Ferreira An agent-based interaction-oriented shop floor to support emergent diagnosis. *Proceedings of 8th International Conference on Industrial Informatics (INDIN)*, July 2010, Osaka, Japan
- H. Akillioglu; P. Neves; M. Onori Evolvable Assembly Systems: mechatronic architecture implications and future research. *3rd CIRP Conference on Assembly Technologies and Systems (CATS'10),* June 2010, Trondheim, Norway
- A. Hofmann A comprehensive micro-assembly process oriented methodology supporting the realisation of evolvable micro production systems. *Proceedings of DET2009 6th International Conference on Digital Enterprise Technology*, 14th-16th December, Hong Kong
- M. Onori; J. Barata Evolvable production systems: new applications in mechatronic equipment.*Transactions on Industrial Electronics, IEEE Journal*, 2010, IES Society
- A. Maffei; M. Onori Evolvable produktion system: Business perspective. *IEEE International Conference on Materials, Mechatronics and Automation (ICMMA)*, 2011, Melbourne, Australia
- A. Maffei Evolvable production system: A new business environment. *International Symposium on Assembly and Manufacturing (ISAM)*, 2011, Tampere, Finland
- M. Onori; P. Neves; H. Akillioglu; A. Hofmann Dealing with the unpredictable: An evolvable assembly cell. *Intenational Symposium on Assembly and Manufacturing (ISAM)*, 2011, Tampere, Finland
- H. Akillioglu; M. Onori Evolvable production systems and impacts on production planning.*International Symposium on Assembly and Manufacturing (ISAM)*, 2011, Tempere, Finland
- A. Maffei; H. Akillioglu; P. Neves; J. Ferreira; M. Onori Emerging behaviour as a driver for the sustainability of a modular, "skill-centric" produktion system. *Africon'2011*, Zambia
- M. Onori; P. Neves; A. Maffei; H. Akillioglu; N. Siltala Dealing with the unpredictable. An evolvable robotic cell. *4th International Conference on Changeable, Agile and Reconfigurable Systems (CARV)*, 2011, 2nd - 5th October, Montreal, Canada
- M. Onori; H. Akillioglu; A. Hofmann An evolvable robotic cell. *37th Annual Conference of the IEEE Industrial Electronics Society (IECON)*, 2011, Melbourne, Australia
- P. Neves; J. Ferreira; M. Onori; J. Barata Context and implications of learning in evolvable production systems. *37th Industrial Electronics Conference (IECON)*, 2011, Melbourne, Australia
- A. Maffei; A. Hofmann From flexibility to true evolvability: An introduction to the basic requirements. *International Symposium on Industrial Electronics (ISIE)*, July 2010, Bari, Italy
- A. Maffei Evolvable production systems: A new business environment. *International Symposium on Assembly and Manufacturing (ISAM)*, May 2011, Tampere, Finland
- H. Akillioglu; M. Onori Evolvable production systems and impacts on production planning.*International Symposium on Assembly and Manufacturing (ISAM)*, May 2011, Tampere, Finland
- A. Hofmann; G. Bretthauer; N. Siltala; T. Tuokko Evolvable micro production systems: Specific needs and differences to macro. *International Symposium on Assembly and Manufacturing (ISAM)*, May 2011, Tampere, Finland
- L. Ribeiro; G. Candido; J. Barata; S. Schuetz IT support of mechatronic networks: Abrief survey.*International Symposium on Industrial Electronics (ISIE)*, June 2011, Gdansk, Poland
- L. Ribeiro; J. Barata; M. Onori; C. Hanisch; J. Hoos; R. Rosa Self-organization in automation - the IDEAS pre-demonstrator. *37th Annual Conference on IEEE Industrial Electronics Society (IECON)*, Nov. 2011, Melbourne, Australia
- L. Ribeiro, R. Rosa; A. Cavalcante; J. Barata IADE - IDEAS Agent development environment: Lessons learned and research directions. *CIRP Conference on Assembly Technologies And Systems (CATS)*, 2012, Ann Arbor, USA

- H. Akillioglu; A. Maffei; P. Neves; J. Ferreira Operational charakterization of evolvable production systems. *CIRP Conference on Assembly Technologies and Systems*, 2012, Michigan, USA
- M. Onori; J. Barata; F. Durand Evolvable assembly systems: Entering the second generation. *CIRP Conference on Assembly Technologies and Systems*, 2012, Michigan, USA
- P. Ferreira; N. Lohse Configuration model for evolvable assembly systems. *CIRP Conference on Assembly Technologies and Systems*, 2012, Michigan, USA
- M. S. Sayed; N. Lohse Distributed bayesian diagnosis for modular assembly systems - a case study. *CIRP Conference on Assembly Technologies and Systems*, 2012, Michigan, USA
- P. Ferreira; N. Lohse; M. Razgon; P. Larizza; G. Triggiani Skill based configuration methodology for evolvable mechatronic systems. *38th Annual Conference on IEEE Industrial Electronics Society (IECON)*, Oct. 2012, Montreal, QC
- NewTech 2013 Advanced Manufacturing Engineering and Technologies, Stockholm, Sweden. Call for papers see **newtech2013.com**
- 2013 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2013), Manchester, UK. Call for papers see **www.smc2013.org**
- 2013 IEEE The 11th International Conference on Practical Applications of Agents and Multi-Agent Systems (PAAMS 13), Salamanca, Spain. Call for papers see **www.paams.net**
- 2013 IEEE The 8th International Symposium on Applied Computational Intelligence and Informatics (SACI 2013), Timisoara, Romania. Call for papers see **conf.uni-obuda.hu/saci2013**
- 2013 IEEE International Conference on Industrial Technology (ICIT 2013), Cape Town, South Africa. Call for papers see **www.icit2013.org**
- 2012 The 4th CIRP Conference on Assembly Technologies and Systems (CATS 2012), Ann Arbor, MI, USA. Call for papers see **cirp.me.engin.umich.edu**
- 2012 The 6th International Precision Assembly Seminar (IPAS 2012), Chamonix, France. Call for papers see **www.ipas2012.org**
- 2012 The 10th International Conference on Practical Applications of Agents and Multiangent Systems (PAAMS 2012), Salamanca, Spain. Call for papers see **www.paams.net**
- 2012 The 9th World Congress on Intelligent Control and Automation (WCICA 2012), Beijing, China. Call for papers see **wcica12.amss.ac.cn**
- 2012 The 38th Annual Conference of the IEEE Industrial Electronics Society (IECON 2012), Montreal, Canada. Call for papers see **iecon2012.org**
- 2012 The 45th CIRP Conference on Manufacturing Systems (ICMS 2012), Athens, Greece. Call for papers see **http://www.lms.mech.upatras.gr/ICMS2012/**
- 2012 IEEE International Conference on Intelligent Engineering Systems (INES 2012), Lisboa, Portugal. Call for papers see **http://www.ines-conf.org/ines-conf/2012.html**

EFFRA Roadmap:
The IDEAS consortium could deliver a contribution for the EFFRA Roadmap "Factories of the Future 2020" in the field of adaptive and smart manufacturing systems (version: 7 March 2013).

FESTO Workshop:
The workshop "Assembly Systems for a Sustainable Future" did take place in the facilities of FESTO in Esslingen at 10th December 2012. The workshop intended to bring together key players from industry and research to exchange their state of the art view and discuss the next steps in system development. Some of the attendees were ELREST, KTH, UNINOVA, University of Nottingham, MASMEC, Beckhoff, Xetics, Zurich University of Applied Science, Tampere University of Technology, SAP, and Smart Software Solutions.

Industrial Technologies 2012 Fair:
Industrial Technologies 2012 offered an integrated coverage of nanoscience and nanotechnology, materials, and new production processes (NMP). The event programme highlighted the knowledge intensive products and processes driving European growth to 2020.

Figure14- hardware from FESTO; picture right: hardware from ELREST

SPS IPC Drives 2012 in Nuremberg, Germany from 27th – 29th November 2012:
Inspired by the work on the IDEAS project showcased FESTO, and ELREST together with the company 3S – Smart Software Solution some hardware components based on results from IDEAS project in their stands.

IDEAS also succeeded in receiving the "Outstanding Paper Award for 2013" for its article on the IDEAS demonstrators. The results obtained by the IDEAS consortium also obtained interviews and coverage in:

- International Innovation Journal,
- Dagens Industri, Sweden,
- Ny Teknik, Sweden.

3.2.3 Project management during the period

The Project Management Board (PMB) has convened regularly and brought the IDEAS project to a successful conclusion. The only issue that was raised during Period 2 was that of a minor change in man-months. The main changes led to a revision of Annex I and refer to the minor man-month adjustment accepted by the Project Management Board meeting (late January 2013).
All the tables with man-month allocations were updated. That is, all the singular WP man-month figures, as well as the overall table WT6. No budget aspects were affected.

The man-month re-distribution refers to an agreement between partner CRF and the Project Management Board (PMB). The Project Officer was informed and the decision taken according to Dr. Ramboer's suggestions.
In particular: CRF was unable to accomplish some final year tasks. These amounted to 18 MM work. After a serious review it was decided to re-allocate this work to KTH (5 mm), UNINOVA (5 mm), MASMEC (5 mm) and KIT (3 mm). The correct frame of funding was maintained as well as the WP being affected. Hence no budget changes were necessary.

As the work being affected was almost entirely related to the final demonstrators (some dissemination as well, 3 mm), the actual development of the main demonstrator was subject to some

delays. This led to the PMB requesting a minor extension of the project and, subsequently, Amendment no.2.
However, the request for a slight extension of the project is mainly due to technological issues. The software, tools and integration were on schedule, but two aspects needed to be addressed with greater care:

1. the very novel controller boards developed by ELREST (unique on the market and first-ever controllers for multi-agent applications) needed further testing. If the demonstrator were purely academical, this could be overlooked. As this was an industrial one, it would be most preferable to ensure full performance. The issues were minor, but as IDEAS was first in demonstrating plug & produce at shop-floor level, a certain amount of external interest was to be expected.
2. Due to the controller boards not being fully tested, the software integration had not been run on the actual system at 100%. Once the boards were fully certified, the project proceeded with these small final integration tests.

Other than the above, no other major issues were reported in Period 2. Some deliverables were set at a later stage. This was not due to defaulting partners or lack of progress but, rather, a better synchronisation of work between the many inter-related activities.

List of Meetings:

1) KTH, Stockholm, 2011/03/18
2) Telco, 2011/05/31
3) FESTO, Esslingen, 2011/11/--
4) Telco, 2011/12/13
5) MASMEC, Bari, 2012/03/20
6) KTH, Stockholm, 2012/05/--
7) MASMEC, Bari, 2012/09/24

3.3 Deliverables and milestones tables

Deliverables

The deliverables due in this reporting period, as indicated in Annex I to the Grant Agreement have to be uploaded by the responsible participants (as indicated in Annex I), and then approved and submitted by the Coordinator. Deliverables are of a nature other than periodic or final reports (ex: "prototypes", "demonstrators" or "others"). **The periodic reports and the final report have NOT to be considered as deliverables**. If the deliverables are not well explained in the periodic and/or final reports, then, a short descriptive report should be submitted, so that the Commission has a record of their existence.

If a deliverable has been cancelled or regrouped with another one, please indicate this in the column "Comments".
If a new deliverable is proposed, please indicate this in the column "Comments".

The number of persons/month for each deliverable has been defined in Annex I of the Grant Agreement and cannot be changed. In SESAM, this number is automatically transferred from NEF and is not editable. If there is a deviation from the Annex I, then this should be clearly explained in the comments column.

This table is cumulative, that is, it should always show all deliverables from the beginning of the project.

TABLE 1. DELIVERABLES										
Del. no.	**Deliverable name**	**Version**	**WP no.**	**Lead beneficiary**	***Nature***	**Dissemination level**[1]	**Delivery date from Annex I (proj month)**	**Actual / Forecast delivery date** **Dd/mm/ yyyy**	**Status** **No submitted/** **Submitted**	**Comments**

[1] **PU** = Public

PP = Restricted to other programme participants (including the Commission Services).

RE = Restricted to a group specified by the consortium (including the Commission Services).

CO = Confidential, only for members of the consortium (including the Commission Services).

Make sure that you are using the correct following label when your project has classified deliverables.

EU restricted = Classified with the mention of the classification level restricted "EU Restricted"

EU confidential = Classified with the mention of the classification level confidential " EU Confidential "

EU secret = Classified with the mention of the classification level secret "EU Secret "

Milestones

Please complete this table if milestones are specified in Annex I to the Grant Agreement. Milestones will be assessed against the specific criteria and performance indicators as defined in Annex I.

This table is cumulative, which means that it should always show all milestones from the beginning of the project.

TABLE 2. MILESTONES							
Milestone no.	**Milestone name**	**Work package no**	**Lead beneficiary**	**Delivery date from Annex I dd/mm/yyyy**	**Achieved Yes/No**	**Actual / Forecast achievement date dd/mm/yyyy**	**Comments**

3.4 Explanation of the use of the resources and financial statements

The financial statements have to be provided within the Forms C for each beneficiary (if Special Clause 10 applies to your Grant Agreement, a separate financial statement is provided for each third party as well) together with a summary financial report which consolidates the claimed Community contribution of all the beneficiaries in an aggregate form, based on the information provided in Form C (Annex VI of the Grant Agreement) by each beneficiary.

The "Explanation of use of resources" requested in the Grant Agreement for personnel costs, subcontracting, any major costs (ex: purchase of important equipment, travel costs, large consumable items) and indirect costs, have now to be done within the Forms (user guides are accessible within the Participant Portal)[2].

When applicable, certificates on financial statements shall be submitted by the concerned beneficiaries according to Article II.4.4 of the Grant Agreement.

Besides the electronic submission, Forms C as well as certificates (if applicable), have to be signed and sent in parallel by post.

[2] In the past, the explanation of use of resources requested in the Grant Agreement was done within a table in this section. The merge of this table within the Forms C was a measure of simplification aimed at avoiding duplication and/or potential discrepancies between the data provided in the table 'Explanation of use of resources' and the data provided in the Forms C.

The following table is required only for the funding schemes for Research for the benefit of SMEs
THE TRANSACTION
Please provide a list of the actual cost incurred by the RTD performers during the performance of the work subcontracted to them. These costs refer only to the agreed '**Transaction**'.

Name of RTD Performer	Number of person months	Personnel Costs (€)	Durable equipment	Consumables	Computing	Overhead Costs (€)	Other Costs (€)	Total by RTD performer
TOTAL								

IMPORTANT:

Form C varies with the funding scheme used. Please make sure that you use the correct form corresponding to your project (Templates for Forms C are provided in Annex VI to the Grant Agreement). An example for collaborative projects is enclosed hereafter.
A Web-based online tool for completing and submitting forms C is accessible via the Participant Portal: http://ec.europa.eu/research/participants/portal, (except for projects managed by DG MOVE and ENER).

If some beneficiaries in security research have two different rates of funding (part of the funding may reach 75%[3]) then two separate financial statements should be filled by the concerned beneficiaries and two lines should be entered for these beneficiaries in the summary financial report.

[3] Article 33.1 of the EC FP7 rules for participation - REGULATION (EC) No 1906/2006.

FP7 - Grant Agreement - Annex VI - Collaborative Project

Form C - Financial Statement (to be filled in by each beneficiary)

Project nr	**nnnnnn**	**Funding scheme**	**Collaborative Project**
Project Acronym	**xxxxxxxxxxxxxxxxxxxx**		
Period from	dd/mm/aa	Is this an adjustment to a previous statement ?	**Yes/No**
To	dd/mm/aa		

Legal Name		**Participant Identity Code**	**nn**
Organisation short Name		**Beneficiary nr**	**nn**

Funding % for RTD activities (A)		**If flat rate for indirect costs, specify %**	**%**

1- Declaration of eligible costs/lump sum/flate-rate/scale of unit (in €)

	Type of Activity				
	RTD (A)	**Demonstration (B)**	**Management (C)**	**Other (D)**	**TOTAL (A+B+C+D)**
Personnel costs					
Subcontracting					
Other direct costs					
Indirect costs					
Lump sums/flat-rate/scale of unit declared					
Total					
Maximum EC contribution					
Requested EC contribution					

2- Declaration of receipts

Did you receive any financial transfers or contributions in kind, free of charge from third parties or did the project generate any income which could be considered a receipt according to Art.II.17 of the grant agreement ? — Yes/No

If yes, please mention the amount (in €)

3- Declaration of interest yielded by the pre-financing (to *be completed only by the coordinator*)

Did the pre-financing you received generate any interest according to Art. II.19 ? — Yes/No

If yes, please mention the amount (in €)

4. Certificate on the methodology

Do you declare average personnel costs according to Art. II.14.1 ? — Yes/No

Is there a certificate on the methodology provided by an independent auditor and accepted by the Commission according to Art. II.4.4 ? — Yes/No

Name of the auditor		**Cost of the certificate (in €), if charged under this project**	

5- Certificate on the financial statements

Is there a certificate on the financial statements provided by an independent auditor attached to this financial statement according to Art.II.4.4 ? — Yes/No

Name of the auditor		**Cost of the certificate (in €)**	

6- Beneficiary's declaration on its honour

We declare on our honour that:

- the costs declared above are directly related to the resources used to attain the objectives of the project and fall within the definition of eligible costs specified in Articles II.14 and II.15 of the grant agreement, and, if relevant, Annex III and Article 7 (special clauses) of the grant agreement;

- the receipts declared above are the only financial transfers or contributions in kind, free of charge, from third parties and the only income generated by the project which could be considered as receipts according to Art. II.17 of the grant agreement;

- the interest declared above is the only interest yielded by the pre-financing which falls within the definition of Art. II.19 of the grant agreement ;

- there is full supporting documentation to justify the information hereby declared. It will be made available at the request of the Commission and in the event of an audit by the Commission and/or by the Court of Auditors and/or their authorised representatives.

Beneficiary's Stamp	**Name of the Person(s) Authorised to sign this Financial Statement**
	Date & signature

FP7 - Grant Agreement - Annex VI - Collaborative Project

Form C - Financial Statement (to be filled in by Third Party) Only applicable if special clause nr 10 is used

Project nr	**nnnnnn**	**Funding scheme**	**Collaborative Project**
Project Acronym	**xxxxxxxxxxxxxxxxxxxx**		
Period from	dd/mm/aa	Is this an adjustment to a previous statement ?	**Yes/No**
To	dd/mm/aa		
3rd party legal Name			
3rd party Organisation short Name		**Working for beneficiary nr**	**nn**
Funding % for RTD activities (A)		**If flat rate for indirect costs, specify %**	**%**

1- Declaration of eligible costs/lump sum/flate-rate/scale of unit (in €)

	Type of Activity				
	RTD (A)	**Demonstration (B)**	**Management (C)**	**Other (D)**	**TOTAL (A+B+C+D)**
Personnel costs					
Subcontracting					
Other direct costs					
Indirect costs					
Lump sums/flat-rate/scale of unit declared					
Total					
Maximum EC contribution					
Requested EC contribution					

2- Declaration of receipts

Did you receive any financial transfers or contributions in kind, free of charge from third parties or did the project generate any income which could be considered a receipt according to Art.II.17 of the grant agreement ? — Yes/No

If yes, please mention the amount (in €)

3- Declaration of interest yielded by the pre-financing (*to be completed only by the coordinator*)

Did the pre-financing you received generate any interest according to Art. II.19 ? — Yes/No

If yes, please mention the amount (in €)

4. Certificate on the methodology

Do you declare average personnel costs according to Art. II.14.1 ? — Yes/No

Is there a certificate on the methodology provided by an independent auditor and accepted by the Commission according to Art. II.4.4 ? — Yes/No

Name of the auditor		**Cost of the certificate (in €), if charged under this project**	

5- Certificate on the financial statements

Is there a certificate on the financial statements provided by an independent auditor attached to this financial statement according to Art.II.4.4 ? — Yes/No

Name of the auditor		**Cost of the certificate (in €)**	

6- Beneficiary's declaration on its honour

We declare on our honour that:

- the costs declared above are directly related to the resources used to attain the objectives of the project and fall within the definition of eligible costs specified in Articles II.14 and II.15 of the grant agreement, and, if relevant, Annex III and Article 7 (special clauses) of the grant agreement;

- the receipts declared above are the only financial transfers or contributions in kind, free of charge, from third parties and the only income generated by the project which could be considered as receipts according to Art. II.17 of the grant agreement;

- the interest declared above is the only interest yielded by the pre-financing which falls within the definition of Art. II.19 of the grant agreement ;

- there is full supporting documentation to justify the information hereby declared. It will be made available at the request of the Commission and in the event of an audit by the Commission and/or by the Court of Auditors and/or their authorised representatives.

Beneficiary's Stamp	**Name of the Person(s) Authorised to sign this Financial Statement**
	Date & signature

FP7 - Grant Agreement - Annex VI - Collaborative Project

Summary Financial Report - Collaborative Project- to be filled in by the coordinator

Project acronym	xxxxxxxxxxxxxxxxxxxxxxxx	Project nr	nnnnnn	Reporting period from	dd/mm/aa	to:	dd/mm/aa	Page	1/1

Funding scheme	CP

Beneficiary n°	If 3rd Party, linked to beneficiary	Adjustment (Yes/No)	Organisation Short Name	Type of activity								Total (A)+(B)+(C)+(D)		Receipts	Interest
				RTD (A)		Demonstration (B)		Management (C)		Other (D)					
				Total	Max EC Contribution	Total	Max EC Contribution	Total	Max EC Contribution	Total	Max EC Contribution	Total	Max EC Contribution		
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
TOTAL															

Requested EC contribution for the reporting period (in €)	