CRitical S**YST**em Engineering **A**cce**L**eration

Exploitation Plan V1
D102.040

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1   Introduction

1.1 Role of deliverable

The CRYSTAL Exploitation Plan describes the exploitation plans of the individual partners in the consortium. It takes into account the different approaches for industrial end users, tool providers and academic partners and details for each SP the main exploitable knowledge, the exploitable product(s) or measure(s), the sector(s) of application, the timetable for commercial use, possibilities for IPR protection, the CRYSTAL partner(s), owning the results.

1.2 Relationship to other CRYSTAL Documents

This document (D102.040) is the initial version of the exploitation plan. It is based on a coarse grained description of the exploitable foreground, identified by the individual partners. In the second version (D102.070 at M24) the entire plan will be based on the list of CRYSTAL Technical Items (TIs). A TI in CRYSTAL is a specific solution that helps to realize the innovations of the project. Each TI implements a precisely defined set of requirements, and is therefore ideally suited to track the exploitation opportunities of our project on a fine granularity (see Section 1.3). The list of TIs is still in a preliminary version, since the process for identifying the TIs could be only started after the M9 milestone, where the first version of the use-case definitions was available. Therefore it was decided to base this first version of the report not on the Tis, but on a coarse grained description of the Foreground. Nevertheless, the initial draft list of TIs can be found in Annex I.
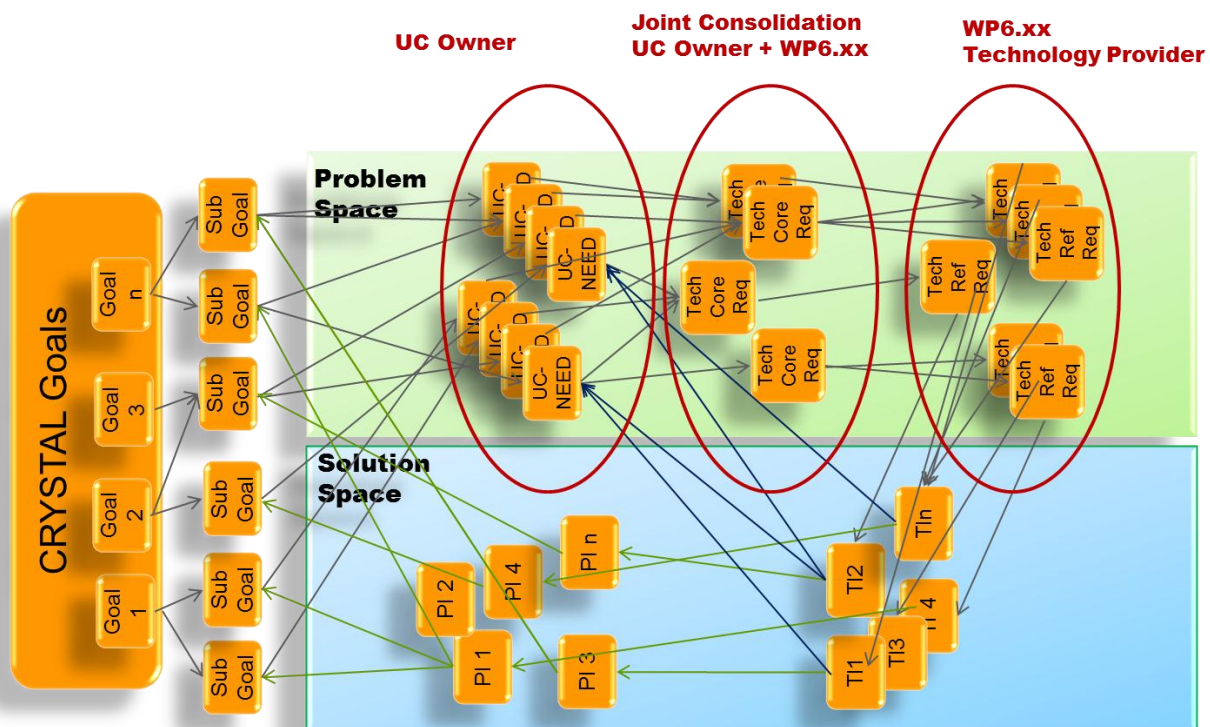
1.3 Definitions

Figure 1-1: TI Process

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The definitions in this chapter come from the CRYSTAL Technical Item Monitoring Process which is a common process to efficiently integrate and align all involved stakeholders (use-case owners, IOS, platform builder, brick providers) in our project. It ensures consistency on project level and enables monitoring of the progress towards project objectives.

1.3.1 CRYSTAL Goals and Sub Goals

The CRYSTAL goals and sub goals constitute the objectives targeted in CRYSTAL. The progress will be measured against these objectives (WP1.3). An initial set has already been defined in the Technical Annex (Part B, Table 2.1). The list of goals and sub goals can be extended during the execution of the project, if proposed by the TB.

G_01 Enhance interoperability and provide seamless ready-to-use tool chains (by 15%)	
SG_01.01	Strengthen the seamless use of model-based systems engineering techniques (in order to enhance interoperability and provide seamless ready-to-use tool chains (by 15%))
SG_01.02	Provide implemented, validated, and ready-to-use integrated tool chains
SG_01.03	Evolve interoperability specification towards a European standard and improve the RTP (in order to Enhance interoperability and provide seamless ready-to-use tool chains (by 15%))
G_02 Manage increasing embedded system complexity (by 25%)	
SG_02.01	Evolve interoperability specification towards a European standard and improve the RTP (in order to manage increasing embedded system complexity (by 25%))
SG_02.02	Strengthen the seamless use of model-based systems engineering techniques (in order to manage increasing embedded system complexity (by 25%))
SG_02.03	Improve the requirement management and development process, providing a standard - common - systematic approach featuring traceability
SG_02.04	Manage complexity increase of 25% with 10% effort reduction
SG_02.05	Improve the configuration management process in the preliminary design phases
G_03 Support cross-domain reusability, re-certification, re-qualification, and design variability	
SG_03.01	Improve and foster cross-domain reusability and variability management
SG_03.02	Improve collaboration among engineering disciplines involved in embedded system development
SG_03.03	Increase reusability of design and tools minimizing re-certification costs
SG_03.04	Reduce effort and time required for re-validation and re-certification of systems after making changes by 10-15%
SG_03.05	Transfer procedures and tools between different domains, e.g. between aeronautics and space business
G_04 Reduce development & design costs and time-to-market (10-15%)	
SG_04.01	Reduce development and development life cycle costs by 15-20% depending on application domain
SG_04.02	20% fewer design iterations
SG_04.03	Reduce the cost of integration, configuration, deployment, and maintenance of appropriate tool chains for all major actors in the supply chain involved in the project by 50%.
G_05 Reduce validation and test effort (by 15%)	

SG_05.01	Opportunity to adapt a proprietary test suite to a real multi-provider interoperable environment without manually rewriting each test
SG_05.02	Reduce time needed for system test definition by 80% (rail domain)
SG_05.03	Reduce time needed to complete test analysis by at least 40%
SG_05.04	Reduce time and effort needed for system validation by 15-20%

Table 1-1: List of goals and sub goals

1.3.2 Project Innovations (PI)

PIs will be developed by CRYSTAL in order to achieve the goals and sub goals. Below you can find a current list of PIs of CRYSTAL. This list can be extended during the project execution if required.

PI_ID	Name	Description	Sub Goal
PI_0001	Reuse of engineering artefacts	Reuse of models, configurations, parameters, requirements and other artefacts across different phases of the development process. Explicit description of variability in order to make reuse more efficient	SG_01.01
PI_0002	Enable semantic coupling of executable models across tools	Support the coupling of formerly isolated simulation models across tools and also across developers / users to create holistic simulation scenarios.	SG_01.01
PI_0003	Enable model based HiL tests	Enable the model based development of hardware in the loop testing scenarios.	SG_01.01
PI_0004	Enable semantic coupling of executable models across tools	Support the coupling of formerly isolated simulation models across tools and also across developers / users to create holistic simulation scenarios.	SG_02.02
PI_0005	Enable simulation of hardware and software	Give insight to performance of the soft- or hardware at multiple maturity levels.	SG_02.02
PI_0006	Enable cost reduction by hard- and software simulation	Pinpoint weak points in complex systems at an early design stage	SG_02.04
PI_0007	Enable simulation of design choices for performance analysing	Benchmark multiple design choices at an early stage to make better design decisions.	SG_04.01
PI_0009	Tool independent specification of test-case stimuli and test oracles	Support the tool independent description of test-case stimuli and test oracles that will be coupled with existing models to form executable test cases and automated test suites.	SG_05.01
PI_0010	Tools to benchmark of specific (sub)systems to analyse performance measure	To validate implemented subsystems based on defined interfaces and performance measure	SG_05.01
PI_0011	Provide a modeling environment where stakeholders can work seamlessly on models using appropriate viewpoints	WP609 work package will provide an Integrated Engineering Model Based Environments compliant to the ISO / IEC 42010 standard (architecture viewpoints)	SG_02.02

PI_0012	Provide a modeling environment where stakeholders can work seamlessly on models using appropriate viewpoints	WP609 work package will provide an Integrated Engineering Model Based Environments compliant to the ISO / IEC 42010 standard (architecture viewpoints)	SG_03.02
PI_0013	Refinement, transformation, and exchange of models, model elements, and basic models structures	e.g. test case generation, requirement formalization, model refinement in specialized tools, etc.	SG_01.01
PI_0014	Traceability between model elements and other artefacts (e.g. requirements, tests, etc.)	Linking single elements in a model to various other artefacts to ensure traceability throughout the development process.	SG_01.01
PI_0015	Improve model visualization	Complexity can be reduced by abstraction and appropriate visualization and representation	SG_02.04
PI_0016	Impact analysis to support change management	Identifying what is affected by changes is the first step towards reducing the effort for validation and certification - maybe not everything needs to be re-certified	SG_03.04
PI_0017	Early validation of system specification based on models	e.g. timing analysis, design optimizations based on models	SG_04.01
PI_0018	Assisted configuration of the System Engineering Environment that is tailored to a user-specific development process	Implemented by the Platform Builder	SG_04.03
PI_0019	Traceability between requirements and tests	get an overview what has already been tested, needs to be tested, and if requirements have been completely tested	SG_05.03
PI_0020	Assisted configuration of the System Engineering Environment that is tailored to a user-specific development process	Implemented by the Platform Builder, this PI implements a method to organize the System Engineering Environment. The Platform Builder specification and its implementation are the TIs.	SG_04.03
PI_0021	Definition of a standardized meta-model to describe Tool properties.	Tool Providers will have a common meta-model to define their Tools, a common interface to identify Tools, this facilitate the Tools' selection to accomplish appropriate tool-chain. Furthermore the relevant TI will facilitate the Tool-chain's deployment.	SG_04.03
PI_0022	Definition of enriched meta-model to describe Business Process taking into account SEE configuration objectives.	Use Case provider will have a meta-model to define the whole Business Process also with SEE configuration information; this will facilitate and improve the automated SEE configuration.	SG_04.03
PI_0023	Provide a general modeling design framework for the UI	WP609 work package will provide an Engineering Model Based Environments for the UI design based on Top-Down generative approach.	

Figure 1-2: List of Project Innovations

1.3.3 Technical Items (TI)

A TI in CRYSTAL is a specific solution that helps to realize the innovations of the project. Each TI implements a precisely defined set of requirements. A TI is associated to a specific Technology Brick (e.g., a specific interface for a specific tool). A Technology Readiness Level (TRL) is assigned to each TI and will be used for progress monitoring. The initial draft list of TIs can be found in Annex I.

2 Exploitation

2.1 General overview

2.1.1 General Overview „Embedded Systems"

Embedded systems are the enablers for new or improved system features and are nowadays deployed for safety-critical functionalities as well. This evolution leads to a trade-off between the rapid increase of new functionalities and the need to control costs, time and quality related to the development activities. Typical activities to be performed when developing new functionalities include planning, specification, modelling, analysis, verification, implementation and testing. These activities already require a significant amount of effort. On top of this, each activity further requires the use of its own set of tools with dedicated input and output formats, only loosely coupled to other tools. This complicates sharing of information between different tools, and developers are forced to manually transfer information between many different tools. An immediate consequence of this is a huge amount of double work leading to unnecessary costs. The risk of inconsistencies, which also compromise safety, between models in different tools is evident.

A first step towards this goal is the definition of common and standardized exchange formats. While the exchange formats constitute a backbone for better tool integration, the next step is to let the development tools work directly on a common data set. A platform that controls and protects the common information and orchestrates the connected tools according to a predefined development process, erases the borders between tools in the sense that it is neither necessary to model the system multiple times nor to explicitly import and export data. Such an approach allows significant savings of development effort and costs by reducing the amount of double work.

Two central topics of CRYSTAL are therefore (1) the further development of interoperability specification towards a standard and (2) the maturation of integrated tool chains towards industrial application. These two topics are typical examples of technologies required by all competitors, leading to competitive advantages when tailored to the domain and company specific needs. These activities are strongly supported by the size and political weight of the consortium, as well as the very good integration within the European industry and research landscape. During the project, a sustainable model will be developed that ensures the further activities on the Cooperative RTP (CRTP) and the IOS such as increasing the number of tool vendors, suppliers, SMEs in the ecosystem. The following sections provide an overview on the exploitation plans of industrial end users, tool vendors and academic partners while detailed information including CRYSTAL impact on market and competitive situation are provided in Chapter 3 Partner Exploitation.

2.1.2 Industrial Exploitation

CRYSTAL has been explicitly designed and made with easy and straight-forward exploitation in mind. The identification of necessary bricks, involvement of brick providers and their commitment to collaboratively work towards a coherent software engineering environment (on the basis of a specific use case, mirroring current industrial partner's development environment) facilitates quick integration into industrial development. According to the assessment results of CRYSTAL, the aim is to deploy the built bricks and tool chains on first industrial projects as pilot applications; to be prepared during the year following the end of CRYSTAL inside each company and with supply chain members for collaborative work items.

For the aeronautic market, innovative systems are key differentiators. Systems represent e.g. about one third of the price of an aircraft – increasing the development efficiency by mastering system engineering practises has therefore a significant impact. In aeronautics, system engineering relies on two pillars: the methods and tools supporting the system development phases and the system engineering framework in which the engineering activities are exercised. CRYSTAL addresses these two needs maturing innovative technologies up to TRL5/6 in the field of system design, validation and verification and developing the concept of RTP

based on interoperability standard that will allow to ease the setting up of engineering environment. The outcomes and innovations of CRYSTAL project (for instance, enhanced requirements and model based engineering solutions, cross-disciplinary model based methods, RTP/IOS, standards) will thus significantly reduce lead time and costs, improve process interfaces for aeronautics supply chain members and design maturity. Thus these improvements will reinforce the competitive position of the CRYSTAL consortium members and their stakeholders on their market against their worldwide competitors.

The Healthcare domain partners will benefit greatly from the CRYSTAL results because the development time will decrease drastically and the safety related quality will increase because the compliance to the safety embedded system requirements can be tracked during the whole product development lifecycle. Fast exploitation is planned by the Healthcare partners by adopting the CRYSTAL IOS/RTP and the CRYSTAL interoperable tool chain tailored to the Healthcare standards and requirements such as the IEC 62304, a standard for the development of healthcare embedded systems and IEC 60601 for development of safe healthcare embedded system. Furthermore the IEC 13485 is a standard for the development of medical devices and 21FDA820 is the US standard for development of medical devices.

A particularity for the automotive domain is the existence of already or soon-to-be-established standards for exchange of data between tools: AUTOSAR and EAST-ADL as well as the ISO26262 standard for functional safety. Many automotive companies currently put a lot of effort in adjusting their development environments and processes in order to comply with the standard. A well-integrated and consistent SE environment, as envisioned by CRYSTAL, considerably facilitates compliance with the standard due to its foreseen ability to capture data consistently and to trace the dataflow between tools.

The latter two aspects, AUTOSAR/EAST-ADL and ISO26262, provide each on its own strong drivers for fast exploitation in companies as they imply shorter time-to-market and lower development cost. When this is combined with the first aspect, CRYSTAL's close connection with real SE environments and the tight collaboration with the providers of essential bricks in those environments, the incentives and the possibilities of exploiting the results are prevailing.

Railway companies are facing the exigency of managing several projects at the same time. For this reason it is a real need to reduce the efforts currently spent in the validation and verification activities, decreasing in this way also the time-to-market and the improvement of adapting capacities to evolving needs and constraints.

A lot of efforts are currently spent to perform the following activities:

- to define the system tests and analyze the log reports;
- to manage the variations reducing the occurrence of possible errors in case of modifications in system requirements.

Therefore, is known the value added provided by:

- anticipating at the system modeling phase of some analysis to avoid possible replication errors;
- adopting the use of a common language to define the tests in order to facilitate the setup of interoperable multi-company testing environment, to speed up the assessment of a system in different countries, allowing the interactivity with systems developed by other suppliers.

2.1.3 Tool Vendor Exploitation

RTP and IOS will enable tool providers to exchange data with tools from other tool vendors in a much easier way. As the integration with other tools and exchange of data to the existing tool platforms is an essential part of tool vendor business models, this will save substantial integration costs and reduce the time to market of innovative tool-chains and features.

As with other standards and ecosystems, RTP and IOS will help to enhance functionality, improve robustness and openness of the tool solutions. It will help tool vendors on the one hand to concentrate on novel, market-relevant and emergent features, and on the other it will reduce the fear of potential buyers of doing business with new tool vendors. Both of these points will open up new growth opportunities, especially for small vendors. The success of RTP and IOS will open new business possibilities in new market segments and will enable the tool vendors to have partnerships with other players, which will increase the global foot print in various application domains. US and Asia will be explored thanks to the enhancement of the individual tool bricks and integrated tool chains. Also, becoming well-known tool-chains among all the European companies involved in the CRYSTAL project will accelerate the speed of technology pervasion in other countries.

The R&D work of the tool providers will be performed in tight cooperation with academic partners and potential tool users. This will bring the latest state-of-the-art features from research to industrial-strength solutions with a shorter time-to-market, a lower cost and higher user experience. Most probably, innovative product features that have been identified and prototyped in CRYSTAL, can be put into operation already 1-2 years after project end.

2.1.4 Academic Partner Exploitation

Academic partner exploitation covers several aspects, depending on the type of academic partner, which may be university institutes, independent contract-oriented research organizations or different types of public-private partnerships comprised by a mixture of public authorities, universities and industry.

- Education and training: results and experiences from CRYSTAL to be integrated into lectures, courses, tutorials, lab exercises, topics to be used or PhD- or Master thesis
- Industrial seminars, workshops, tutorials and post-university professionals' training
- Consultancy for industry, public authorities and governmental organizations
- Basis for future research and co-operations in European or nationally funded projects, national competence programs
- Application of results (tools developed, RTP, knowledge) applied in co-operations with industry in context of commercial projects
- Integration of results (tools) into existing tool chain offers, and of knowledge into consultancy offers (portfolios)
- Basis for spin-off companies, competence centres and the like.

A very important means of exploitation of research results is standardization, as mentioned in the reviews of the ETPs (European Technology Platforms) and by EC officers (e.g. in Support Actions like ProSE, COPRAS etc.). Particularly research organizations are very active in generic standards and derived domain standards (together with industry of course) in international standardization organizations (IEC, ISO), and even in standards created by industry-driven organizations like ETSI, OMG, RTCA, SAE etc.

3 Partner Exploitation

Based on the CRYTSAL Project Innovations, all partners were asked to provide their exploitation plans. The forms used for this survey can be found in annex I. These forms for industrial partners, technology providers and academic partners were created to collect high quality information in a harmonized way. Grouped into

- Industrial partners
- Technology providers
- Academic partners

The results of the exploitation survey can be found in this chapter. Some partners even provided detailed exploitation intentions for specific Technical Innovations or Technical items.

3.1 Industrial partners

3.1.1 AIRBUS (A-G | A-F | A-UK)

INDUSTRY PARTNER	
Organization: AIRBUS Operations GmbH, AIRBUS Operations SAS, Airbus Operations Ltd	Short Name: A-G, A-F, A-UK
Author: Odile Laurent, Dietmar Sander	
Relevant Markets of your company impacted by CRYSTAL Airbus is one of the world's leading aircraft manufacturers, and it consistently captures approximately half or more of all orders for airliners with more than 100 seats. The Airbus market size comprises 14 aircraft models, from the 100-seat single-aisle A318 jetliner to the 525-seat A380 - which is the largest civil airliner in service. Combined orders for Airbus single-aisle and wide-body jetliners totaled more than 11700 with over 7300 aircrafts delivered to customers worldwide. Innovative systems are key differentiators on the civil aeronautics market. Systems represent about one third of the price of an aircraft. It is thus crucial to make more efficient the development of systems. When mastering system engineering practices, system development becomes more efficient, so that benefice in terms of development cost and time is expected. In aeronautics, system engineering relies on two pillars: the methods and tools supporting the system development phases and the system engineering framework in which the engineering activities are exercised. CRYSTAL addresses these two needs maturing innovative technologies up to TRL5/6 in the field of system design, validation and verification and developing the concept of RTP based on interoperability standard that will allow to ease the setting up of engineering environment. The CRYSTAL engineering capabilities will strengthen Airbus expertise in the development of aircraft systems and architectures reinforcing its core business. In particular, the cabin, landing gear, flight control and environmental systems will benefit from CRYSTAL methods allowing early design maturity. The interoperability standard will reinforce the cooperation between the actors of the aeronautics supply chain facilitating the data exchanges and reducing rework on system development. The concept of RTP will create an industrial eco-system from which innovation can emerge. Innovation increasing competitiveness, CRYSTAL will contribute to the Airbus growth and time to market. Moreover, the interoperability standard will contribute to create synergy between tools vendors and to make emerge an European competitive market in Product Life Cycle management (PLM) capabilities for aircraft. The emergence of mature engineering capabilities will allow the setting up of engineering agile methods that efficiency support the deployment of concurrent engineering, key factor of success in system development within Airbus. With the arrival on the market of Asian aircraft manufacturer competitors, the maturity and efficiency of system engineering environment will bring to Airbus a major asset that will contribute to keep its leader position in aeronautics. If the assessment made by Airbus in the frame of CRYSTAL shows clear benefits, Airbus will exploit the results of CRYSTAL as technology-concepts into the development of the future single-aisle aircraft entering on the market approximately in 2025.	

Major Benefits of CRYSATAL for your position in the Market

The CRYSTAL project mainly aims at bringing to an industrial level of use the Reference Technology Platform (RTP) specified and implemented in former projects - in particular CESAR. It means to set up methods and chains of tools industrially usable in order to optimally support the development of embedded systems. Moreover, one major goal of CRYSTAL is to define an interoperability standard between tools which is accepted by all the industrial stakeholders. Such a standard would make it possible to significantly reduce the workload for the future integration of additional tools.

To achieve these goals, EADS Innovation Works Germany will work within the framework of CRYSTAL with other major industrial partners involved in systems transport and health as well as with tools providers of foreground. EADS Innovation Works Germany will focus his activities on the following fields: definition of interoperability standards; definition of the development of RTP platform; integration of design tools with analysis safety ones; implementation of the approaches of lines of products; support to the integration of functional models with physical models, in particular through the use of Modelica; improvement of the existing approaches of use of ontologies for the specification and the modeling of the requirements. The acquisition and the evaluation of the results will take place within the framework of two use-cases defined with Airbus and Airbus Defence and Space.

The CRYSTAL project will give benefits to EADS Innovation Works thanks to the foreseen results. Within the group EADS, Innovation Works mission is to understand innovative technologies and manage their development till their industrial use. To fulfill this task, EADS IW is involved both in research projects and programs of EADS divisions like the development of new aircraft and space systems. To do so, the programs of EADS divisions, to which CRYSTAL results will promise more success, are already identified prior to the choice of CRYSTAL themes to which EADS IW will work on. EADS IW will integrate the CRYSTAL results continuously in these programs through the involvement of EADS IW in TRL (Technology Readiness Level) revues, which are made by programs on a regular basis for promising technologies

Competitor descriptions (with regard to activities addressed in CRYSTAL)

Bombardier (Canada). Upcoming competitor with current development of C Series single aisle aircrafts with up to 100 passengers (first flight 2012).

Embraer (Brasil). Upcoming competitor with small program of single aisle aircrafts up to 100 passengers – e.g. Embraer 190 & 195.

Boeing (US). Major competitor of Airbus the complete own aircraft program ranging from single aisle to long-range and with half double-decker of B747-8.

Suchoi (Russia). Upcoming competitor with single aircraft program (SSJ 100) with up to 100 passengers – entry into service 2011.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description:
    - Safety tools chain based on OSLC
    - Multi-physics modelling methodology
    - Safety modelling methodology

- Business case and market: The main beneficiaries of the exploitation of the CRYSTAL results will be Airbus and the European tools providers. For Airbus, the deployment of new innovative engineering capabilities in the field of Model Based Safety Assessment, requirements formalization and simulation coupled to the use of integrated tools environment relying on the tools interoperability standard will strongly contribute to:
    - reduce the development cycle and time to market,
    - reduce the number of iteration cycles (re-work),
    - reduce the systems development cost and recurring costs,
    - share engineering methods, techniques and tools along the supplier chain,
    - ease the customization of engineering frameworks thanks to the emergence of a tools

interoperability standard,

- get a better maturity of systems far before the Entry Into Service of the aircrafts,
- master tools obsolescence based on the deployment of standard interoperability concept.

More specifically, the model-based approach developed in the frame of CRYSTAL will contribute to improve the specification and validation of requirements, the system architecture design and validation, the functional safety analysis. Moreover, the emergence of mature engineering capabilities will allow the setting up of engineering agile methods that efficiency supports the deployment of concurrent engineering, key factor of success in system development within Airbus.

- Roadmap for Exploitation

  As it is extremely risky to make evolve radically the engineering process and the tooling environment on operational programs, a progressive approach of CRYSTAL results deployment is envisaged:

  A first selection of possible methods and associated tools having reached a good level of maturity (at least TRL6), based on the CRYSTAL use case assessments, will be made,

  - The set-up of an Airbus framework based on the tools interoperability standard concepts will allow to assess the CRYSTAL interoperability principles in the Airbus information system,
  - The identification of the part of the process on which the new CRYSTAL methods and tools can be applied while preserving the best Airbus practices based on lessons learnt,
  - The identification of the systems on which the methods and tools will be able to be deployed operationally favouring the ones assessed as CRYSTAL use cases,
  - The use of the valuable methods on the next aircraft program or possibly partially on the existing programs when modifications occur,
  - The deployment of a customized engineering framework built from the CRTP assets, in-house tools and services on the next aircraft program or possibly for major evolutions on the existing programs.

  It is highlighted that the different steps of CRYSTAL results deployment within Airbus described above are subject to evolution depending on the maturity of the CRYSTAL outcomes and on possible adjustments of the Airbus business plan.

- Expected availability for use:

  2017 for the engineering framework

  2015 for the safety modelling methodology

  2017 for the multi-physics modelling methodology

External exploitations

- Description
  - Safety tools chain based on OSLC
  - Multi-physics modelling methodology
  - Safety modelling methodology
- Business Case and Market: The tools providers will also take benefit from the Airbus use of innovative engineering tools and frameworks. Indeed, the tools interoperability standard will contribute to create synergy between tools vendors and to make emerge an European competitive market in Product Life Cycle management (PLM) capabilities for aircraft. This eco-system will boost the development of major European tools providers in the field of system engineering with value creation for the European aeronautic industry.
- Roadmap for Exploitation: see above
- Expected availability for use:

  2017 for the engineering framework

  2015 for the safety modelling methodology

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2017 for the multi-physics modelling methodology

3.1.2　AVL

INDUSTRY PARTNER

Organization: AVL List GmbH	Short Name: AVL

Author: Horst Pflügl, Annemarie Hamedler, Klaus Rothbart

Relevant Markets of your company impacted by CRYSTAL
AVL LIST GmbH is the world's largest privately owned and independent company for the development of powertrain systems as well as simulation, instrumentation and test systems. AVL has about 2.500 employees in Graz and a global network of 45 representations and affiliates resulting in total 5.250 employees worldwide.
AVL´s Powertrain Engineering division activities are focused on the research, design and development of various powertrains including e-mobility trains in the view of low fuel consumption, low emission, low noise and improved driveability.
The Advanced Simulation Technologies division develops and markets the simulation tools and methods which are necessary for the powertrain development work.
The Instrumentation and Test Systems division is an established manufacturer and provider of instruments and systems for powertrain and vehicle testing including combustion diagnostic sensors, optical systems as well as complete engine, powertrain and vehicle test beds.
AVL supplies advanced development and testing solutions for conventional and hybrid vehicle components and systems like simulation platforms, development tools and system integration tools.
AVL was the coordinator and partner of the ARTEMIS Call 1 project CESAR (cost efficient methods and processes for safety relevant embedded systems) and is as well a partner of the MBAT project. Consequently, AVL will take care of and will drive the aimed technology transfer from these ARTEMIS projects to CRYSTAL in terms of applying the results and outcomes of these projects to industrial applications. With the exceptional role of being not only an industrial partner but also a technology and tool provider, AVL will contribute to the CRYSTAL project by providing even more seamlessly integrated AVL tools for industrial applications and thus will strengthen AVL partners even more in their competition. Hence, AVL will drive and communicate the establishment of industrial standards.

Major Benefits of CRYSTAL for your position in the Market
The expected results of this research project will be transferred to our products and distributed over the world, especially to our European OEM's, the supply industry as well as research centres. Internally in AVL, we will use the results in our daily development work in costumer projects. We expect an increase in accuracy, a reduction in development time and effort and significantly improved project collaboration driven by the major aims of the CRYSTAL project such as integrated industrial tool chains and the establishment of a widely accepted interoperability standard. In addition, this interoperability standard will have a positive impact on AVL as a tool provider. Integration of AVL tools will be more straightforward and will thus open new market prospects and opportunities to AVL.

Competitor descriptions (with regard to activities addressed in CRYSTAL)
FEV Motorentechnik GmbH is one of the largest independent suppliers of engineering services, constructing powertrains for cars, trucks, ships and locomotives. Furthermore, FEV is producing test beds for testing powertrains and vehicles concerning fuel consumption, durability, acoustics and emissions. FEV employs in total approximately 1.800 persons.
Ricardo Ltd. is providing technical and strategic consulting to the automotive, transport and energy industries. Ricardo employs approximately 1.500 persons.

Planned Exploitation of CRYSTAL

Internal / external exploitations

Expected Exploitable Result

- Description: Open Development Platform
- Business Case and Market:
    - A faster reaction to time to market is necessary due to the increasing complexity of the connected powertrain.
    - Support of powertrain development process by using the Open Development Platform which brings openness for the integration of customer applications and consistent use of data, test methodologies, models and results. The ODP supports and integrates standards e.g. FMI, ASAM ODS.
    - Since the customers deal with the high complexity they need consistent data, results, methodologies, models and the link between them as well as tool support throughout the whole development process.
    - The results of CRYSTAL will be used to deal with these challenges.
- Roadmap for Exploitation:
    - New products and product enhancements integrated in the ODP.
    - The results will be used in the Open Development Platform which is used through the whole powertrain development process. Customer applications can be integrated in an early development phase to reduce time to market and to deal with the increasing complexity of powertrain.
- Expected availability for use: release to the market 2 years after project end

3.1.3 AVL-R

INDUSTRY PARTNER	
Organization: AVL Software and Functions GmbH	**Short Name: AVL-R**

Author: Jörg Settelmeier

Relevant Markets of your company impacted by CRYSTAL

AVL Software and Functions GmbH (Regensburg, Germany) is a newly founded 100% subsidiary company of AVL List GmbH (Graz, Austria). Main objective of AVL Software and Functions is the development of software and functions within the Powertrain area (i.e. engine management, hybrid control, electrical vehicle control, …). AVL Software and Functions is working on both, Diesel and Gasoline combustion engines, but also on electric vehicles. One major part of interest of AVL Software and Functions are lying in the development of safety monitoring concepts (including architectural aspects) for new vehicle platforms. Another one is the enhanced interface between vehicle-energy management function and grid via wireless communication.

AVL´s Powertrain Engineering division activities are focused on the research, design and development of various powertrains including e-mobility trains in the view of low fuel consumption, low emission, low noise and improved driveability.

Major Benefits of CRYSTAL for your position in the Market

The expected results of this research project will be transferred to our products and distributed over the world, especially to our European OEM's, the supply industry as well as research centres. Internally in AVL, we will use the results in our daily Embedded Software Systems development work in costumer projects. We expect an increase in accuracy, a reduction in development time and effort and significantly improved project collaboration driven by the major aims of the CRYSTAL project such as integrated industrial tool chains and the establishment of a widely accepted interoperability standard. Moreover, the AVL-R as independent engineering partner, can increase their activities in Development process consulting or at the evaluation of Development tools for the customers.

Competitor descriptions (with regard to activities addressed in CRYSTAL)

FEV Motorentechnik GmbH is one of the largest independent suppliers of engineering services, constructing powertrains for cars, trucks, ships and locomotives. Furthermore, FEV is producing test beds for testing powertrains and vehicles concerning fuel consumption, durability, acoustics and emissions. FEV employs in total approximately 1.800 persons.

IAV GmbH: (German: Ingenieurgesellschaft Auto und Verkehr) is, with over 4000 employee, one of the leading engineering providers to the automotive industry. They provide production-ready automotive solutions in all fields of powertrain, electronics and vehicle development.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description: Common AVL Simulation Model Data Backbone to enable simulation and plant models exchange. This activity will improve the quality of the Control system models of AVL-R by using engine simulation tool from AVL (AST) offline in desktop applications and online in MiL, SiL and HiL environments.

- Business Case and Market:

  1) Enable an efficient data exchange between AVL (IST/AST) and AVL-R

     ... via especially defined interfaces

  2) Better collaboration of AVL-R and AVL via an efficient exchange

     ... via the direct link between the related departments

  3) Reproducible development steps

     ... via using version management

- Roadmap for Exploitation: Implementation of the Simulation Model Data Backbone and the Exchange-possibilities as Standard Tool Set within the Organization.

- Expected availability for use: During 2017

Expected Exploitable Result

- Description: Integrated Tool Environment for embedded controls development: AVL-R is using different tools for the various development steps throughout the V-Cycle. These tools are currently bundled via a so called Integrated Tool Environment which also supports some kind of guidance for the developer through the development process (requirement management, architecture, model development, tests and code generation). Via using IOS to link the separate tools, the data exchange is done in a more structured way and the Integrated Tool Environment can more easy adapt at changed tools.

- Business Case and Market:

  1) The Integrated Tool Environment will be more stable in Architecture/GUI and more clear in the interface definition. This leads to a better maintenance (e.g. related tools change on definition or related tools will be exchanged) due Lifetime.

  2) The development by itself is working in a stable environment, and will be more efficient.

     -> Increase the efficiency of AVL-R development process and tool environment

- Roadmap for Exploitation: Push tool suppliers to use the upcoming interoperability standard. Apply IOS within internal tool environment

- Expected availability for use: During 2016

Expected Exploitable Result

- Description: Improvement of the Development via „Efficient Variant Handling within V-Cycle: AVL-R

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provides software solutions for various domains (e.g. automotive, shipping, trucks, etc.). The solutions for the different domains can be very different, but within one domain there is often a huge potential for reuse. Currently, there is no explicit and systematic variant handling at AVL-R. SW variants are stored in PTC Integrity, without mechanisms to search for or select a specific variant. Furthermore, there is no detailed definition of variant handling and usage throughout the development process. This activity will improve the handling or reuse of the different variant during the development process.

- Business Case and Market:

    1) Lead to a more efficient development by using existing solutions

    2) Improve the overview over given solutions in a structured and organized way

    3) allows the support of Sales, Development

    4) Possibility of efficient resource and expertise share over different locations

- Roadmap for Exploitation: The found results will be implemented in the Tool environment of AVL-R to give the developer a better overview about the existing solutions. The implemented result will support the developer in his daily work.

- Expected availability for use: During 2017

3.1.4 ALS

INDUSTRY PARTNER	
Organization: ALSTOM Transport France SA	**Short Name: ALS**
Author: Pascal Poisson	

Relevant Markets of your company impacted by CRYSTAL

In the field of rail transport, Alstom is the sole multi-specialist globally number one in term of orders. Alstom Transport supplies rolling stock, transport infrastructure and signaling, maintenance equipment and global rail systems.

From very first TGV delivered in 1978 to the AGV, the fourth generation of very high speed trains, Alstom has acquired a world leading position in this market sector. The technological advance of Alstom allowed acquiring the world rail speed record at 574.8 Kmh on April 3rd, 2007.

The company is number 2 worldwide in Urban transport: one out of four metro systems, and one out of three tramways in the world have rolled out of Alstom's manufacturing lines.

ATIS (Alstom Transport Information Solutions) supplies rail operators with automatic control systems that allow them to operate trains in complete safety, with the desired availability and expected performance.

The products / systems offering is made of :

- Control centers to manage traffic, routes, trains, crews, resources,…
- Automatic Train Control to operate train movements in complete safety
- Interlocking systems to protect routes
- Passengers information to provide real time information
- Integrated security management systems to handle security on board and in stations.

ATIS French sites develop mainly control centers and automatic train control systems for Urban markets

Next to rail domain innovations, system engineering performance is more and more a key market differentiator. It impacts cost and turnaround time of projects.

Breakthroughs in methods and tools supporting the system development phases and in system engineering framework for systems development are needed and expected from CRYSTAL project results.

So it is expected that the CRYSTAL project will help to mature related innovative technologies up to a TRL

level 6-7 (pre-industrial)

Reaching this maturity level is the success factor that will enable short deployment cycles. This is why a RTP integrating stable tools is of upmost importance. Having innovative concepts is not sufficient if they are not enough specified and implemented to run a representative rail use case.

If the demonstrator implementing the Alstom Rail use case in the frame of CRYSTAL shows clear benefits, Alstom will exploit the results of CRYSTAL as technology-concepts into the development of the whole products and systems offering from ATIS. Then a deployment in other divisions should logically follows. The market introduction of related new products and systems should occur in the 2020ies.

Major Benefits of CRYSATAL for your position in the Market

It is expected that the CRYSTAL project defines the mechanisms and delivers an implementation of a design framework in its Reference Technology Platform (RTP). This framework should help to structure tools interactions through a widely adopted standard as a support of the Engineering process in use within Alstom. The prime focus of the use case concerns the integration of the safety analysis process in the design process. It is expected that the concurrency of the activities as well as the fact that system and software actors in the one hand and the safety engineers in the other hand will share project knowledge through extra design views such as dysfunctional and non-functional ones.

It must be mentioned that next to the focus set in Crystal project, Alstom Transport in engaged in other national or European programs that together should complement the definition and the validation of the next generation of Alstom Design Platform. This resulting platform has to provide efficiency gains throughout the design cycle allowing a more efficient share of knowledge among large design teams and providing means to perform continuous validation of functional and non-functional requirements, thus shortening significantly rework phases.

Competitor descriptions (with regard to activities addressed in CRYSTAL)
- Siemens (Germany & France)) which has recently acquired Invensys Rail, taking then a leading position in the Signaling market.
- Thales Rail (France) : which owns roughly the same market share than Alstom in the signaling market.
- Ansaldo ASTS (Italy & France), which is an important player especially in Mainline market.
- Various actors, among them upcoming Chinese ones

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result
- Description:
    - Safety tools chain based on OSLC
    - Design tools integration
    - Support of Alstom design process
- Business case and market:
    - The main beneficiaries of the exploitation of the CRYSTAL results will be Alstom Transport TIS and the tools providers. Business case relies on reduction of development cost through the following gains:
        o Reduce design lead time thanks to an efficient concurrency between actors
        o Compensate extra effort devoted to simulation by savings introduced through tools interaction
        o reduce the number of iteration cycles (re-work), thanks to continuous verification
        o reduce the systems deployment cost at customer sites

    The targeted market is first the products and the systems of the Signaling division prior to a larger dissemination.

- Roadmap for Exploitation

  Internally the expected benefits of CRYSTAL project are monitored by the Alstom's R&D project cycle, including validation milestones. At the end of the cycle a first demonstrator has to illustrate the potential of the technology and its maturity. From this stage on, a deployment plan is built, targeting first an industrial demonstrator, then a gradual dissemination according to projects pace and typology.

- Expected availability for use:

  2017 for the Engineering framework to start the industrial demonstrator (first industrial use attempt)

3.1.5 EADS-CAS – (new Airbus Defence and Space)

INDUSTRY PARTNER

Organization: Airbus Defence and Space	Short Name: EADS-CAS

Author: Uwe Kühne

Relevant Markets of your company impacted by CRYSTAL

Airbus Defence and Space is an Airbus Group (legally EADS) company and is a worldwide leader in global security solutions and systems, providing Lead Systems Integration and value-added products and services to customers around the globe: air systems (aircraft and unmanned aerial systems), land, naval and joint systems, intelligence and surveillance, cyber security, secure communications, test systems, services and support solutions. Nearly all Airbus Defence and Space products in the above mention sectors are based on safety critical embedded systems. CRYSTAL and especially the envisaged CRYSTAL RTP with its interoperability specification will help Airbus Defence and Space to improve its market position especially compared to US and Asian competitors.

Major Benefits of CRYSTAL for your position in the Market

The concept of a Reference Technology Platform (RTP), based on an industrial interoperability standard will improve dramatically the product development lifecycle (especially civil certification according to RTCA DO-178B & DO-178C) inside Airbus Defence and Space. Firstly, for Airbus Defence and Space as a major player inside the European domain of safety and/or security relevant systems.. Within that industry sector it is necessary to create industry consortia on a national or European level to develop common industrial standards.. This also means that several large industries and SME have to collaborate under a massive time and cost pressure and have to harmonize their specific development tools and processes. A RTP based on industrial standards will reduce the efforts for collaboration dramatically and will be the enabler for better security and/or safety solutions for Europe.

Secondly, even inside Airbus Defence and Space the RTP concept will lead to cost savings and improvements of the development process. Airbus Defence and Space serves to very different markets inside the security domain, like flying platforms, large scale integration projects, equipment development. A common reference platform like the RTP will help to decrease the complexity of the overall product development tools and processes.

Competitor descriptions (with regard to activities addressed in CRYSTAL)

Diehl BGT Defence (Germany). Avionic (e.g. cockpit and display systems) and defence systems (e.g. electronic warfare, missile warner, self-protection).

Datamat (Italy). Active in defence and space. Command & Control, Mission Planning, Simulation & training.

Honeywell (US). Radar, Integrated avionics & information systems, mission management systems, command & control, tactical data management, advanced situational awareness.

Indra (Spain). Electronics Equipment. avionics systems & equipment, high knowledge of avionics & optronics.

Raytheon (US). Electro-optic / infrared sensors, airborne and ground-fixed radar, high-energy lasers).

Rockwell Collins (US). Datalinks & Networking, displays, flight displays, head-up guidance systems,

integrated avionics, surveillance systems.

Saab (Sweden). Military Mission Management systems, cockpit displays, data recording systems, digital map systems, integrated avionics systems, mission computers, tactical reconaissance, command & control, airborne surveillance, simulation & training.

Sagem (France). avionics (cockpit displays), aircraft data recording systems, optronics, mission planning systems for helicopters, surveillance systems.

Thales (France). airborne systems, airborne radars, ground surveillance radar, optronics mission systems, avionics systems, avionics computers, leading market position in electronics.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result
- Description: Support of Avionics Product Family
- Business Case and Market: Product Line Mgmt. for Airbus-DS Sferion Product Family
- Roadmap for Exploitation: Know-How transfer; Use Case taken from the Application Area; Pilot Project; Support for development of new variants of products
- Expected availability for use: In a 5-years term

Expected Exploitable Result
- Description: Support of Radar Product Family
- Business Case and Market: Product Line Mgmt. for Airbus -DS Radar Product Family (Spexter, . . .)
- Roadmap for Exploitation: Know-How transfer; Pilot Project; Support for development of new variants of products
- Expected availability for use: In a 5-years term

Expected Exploitable Result
- Description: Standard Toolset (for Electronics)
- Business Case and Market: Organization wide (Airbus - Defence and Space - Electronics)
- Roadmap for Exploitation: Implementation of EADS-Cas RTP as Standard Tool Set within the Organization
- Expected availability for use: In a 3-years term

Expected Exploitable Result
- Description: Company Guidelines
- Business Case and Market: Organization wide (Airbus - Defence and Space - Electronics)
- Roadmap for Exploitation: Adaption of Guidelines to improve efficiency by utilizing the EADS-Cas RTP (see above)
- Expected availability for use: In a 3-years term

3.1.6 DAIMLER

INDUSTRY PARTNER

Organization: DAIMLER AG	**Short Name: DAIMLER**
Author: Daniel Hopp	

Relevant Markets of your company impacted by CRYSTAL

Daimler AG is one of the world's most successful automotive companies. With its divisions Mercedes-Benz Cars, Daimler Trucks, Mercedes-Benz Vans, Daimler Buses and Daimler Financial Services, the Daimler Group is one of the biggest producers of premium cars and the world's biggest manufacturer of commercial vehicles with a global reach. Daimler Financial Services provides financing, leasing, fleet management, insurance and innovative mobility services.

In the year 2011, Daimler generated revenue of €106.5 billion. The individual divisions contributed to this total as follows: Mercedes-Benz Cars 52%, Daimler Trucks 25%, Mercedes-Benz Vans 8%, Daimler Buses 4% and Daimler Financial Services 11%. At the end of 2011, Daimler employed a total workforce of more than 271,000 people worldwide.

2011s revenue (in millions of EUR) in Daimler markets:

	2011	**2010**
Revenue	**106,540**	**97,761**
Western Europe	39,387	38,478
thereof Germany	19,753	19,281
NAFTA	26,026	23,582
thereof United States	22,222	20,216
Asia	22,643	19,659
thereof China	11,093	9,094
Other markets	18,484	16,042

2011s major markets of Mercedes-Benz Cars in units (group sales):

	2011	**2010**
1. Germany	290,700	292,900
2. United States	250,400	220,500
3. China	223,100	160,000
4. United Kingdom	85,000	81,900
5. Italy	73,600	76,900
6. France	50,100	52,900
7. Japan	32,500	31,200
8. Canada	30,400	29,700
9. Russia	29,800	20,300
10. Spain	24,000	30,300
11. South Africa	22,700	22,600
12. Belgium	22,100	21,500

Major Benefits of CRYSTAL for your position in the Market

Daimler will benefit from CRYSTAL in such way, that one major result will be a proven applicable interoperability standard coming along with methodology and tools which have already implemented this standard. Thus, a significantly positive effect on
- engineering efficiency
- development cost
- interdisciplinary interoperability
- engineering quality
is expected within the directly following years after finalization of CRYSTAL.

Establishing an industry standard for interoperability in product lifecycles will also enable exchange of engineering artefacts with other companies and support processes conformous to ISO26262, which is of high importance for Daimler.

Since CRYSTAL will be an industry driven project, one advantage with big impact is the involvement and integration of already existing technology and methodology, this will substantially reduce the amount of time to bring project results into industry application.

Competitor descriptions (with regard to activities addressed in CRYSTAL)

Exemplaric list of competitors in comparable product range and markets (alphabetical order):

BMW (Germany)	– The BMW Group is manufacturer of premium automobiles and motorcycles worldwide
Fiat (Italy)	– Fiat is an international auto group that designs, produces and sells vehicles for the mass market
Ford (US)	– Ford Motor Company, a global automotive industry leader based in USA, manufactures or distributes automobiles across six continents
Honda (Japan)	– From automobiles to finance, Honda has a wide array of products and services to accommodate customer's needs
Renault (France)	– The Renault group designs, manufactures and markets vehicles under three brands: Renault, Dacia and Renault Samsung Motors. Strategic cooperation partner to Daimler AG
Toyota (Japan)	– Toyota Motor Corporation is a Japan-based company mainly engaged in the automobile business and financial business
Volvo(Sweden)	– The Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment, drive systems for marine and industrial applications and aerospace components.
Volkswagen (Germany)	– The Volkswagen Group with its headquarters in Wolfsburg is one of the world's leading automobile manufacturers and the largest carmaker in Europe

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result
- Description: Tool support for interoperable variant management
- Business Case and Market: Daimler and suppliers (research and in-house use)
- Roadmap for Exploitation: Research papers, doctoral thesis, pilot project and company roll-out
- Expected availability for use: 2015 ff.

3.1.7 EADS-IW (F-G-UK)

INDUSTRY PARTNER

| **Organization: EADS Deutschland GmbH - EADS Innovation Works** | **Short Name: EADS-IW** |

Author: Andreas Mitschke, Anne Monceaux

Relevant Markets of your company impacted by CRYSTAL
The EADS Innovation Works is the research & technology production facility of EADS. With sites in France, Germany, China, India, Russia, Spain, Singapore, UK and a workforce of more than 700, it provides world-class capabilities in aeronautics, defence and space research topics. Consistent with the EADS research & technology strategy and covering the skills and technology fields that are of critical importance to the EADS group of companies, the EADS Innovation Works is organized in seven trans-national Technical Capability Centres: Composites Technologies - Metallic Technologies & Surface Engineering - Structures Engineering, Production & Aeromechanics - Sensors, Electronics and Systems Integration – Engineering, Physics, IT, Security Services & Simulation – Energy & Propulsion - Innovative Concepts & Scenarios. The EADS Innovation Works is an operational and strategic entity for the creation of added value by technology innovation. It fosters technological excellence and business orientation through the sharing of competences and means between the various partners of EADS and it develops and maintain partnerships with world-famous schools, universities and research centres.

Research activities are conducted in the fields of Composites and Metallic Aerostructures, Systems, Avionics, Equipment & Sub-systems, Flight Mechanics, through Structural Dynamics, Integration, Design & Validation to the field of Structures & Production as well as Systems & Information technologies. The EADS

Innovation Works maintains well-established links with leading universities and high-tech engineering schools by employing final-year students, post-graduate interns, doctoral candidates, and by contracting specific research projects. Reinforcing cooperation with academic labs through deeper and more targeted relationships is fully in line with the company's technology strategy.

The German part of the EADS Innovation Works in Ottobrunn near Munich and Hamburg employs a permanent staff of 220 people, 70 % of which are senior scientists. It is legally an organizational unit within EADS Deutschland GmbH, the German subsidiary of EADS N.V.

CRYSTAL will impact EADS Innovation Works Germany activities around the System Engineering domain and more precisely on the researches carried out on model-based systems engineering. This impact will concerns the development of concepts, methods and tools currently investigated on the domain presented hereunder.

Major Benefits of CRYSTAL for your position in the Market
The CRYSTAL project mainly aims at bringing to an industrial level of use the Reference Technology Platform (RTP) specified and implemented in former projects - in particular CESAR. It means to set up methods and chains of tools industrially usable in order to optimally support the development of embedded systems. Moreover, one major goal of CRYSTAL is to define an interoperability standard between tools which is accepted by all the industrial stakeholders. Such a standard would make it possible to significantly reduce the workload for the future integration of additional tools.
To achieve these goals, EADS Innovation Works Germany will work within the framework of CRYSTAL with other major industrial partners involved in systems transport and health as well as with tools providers of foreground. EADS Innovation Works Germany will focus his activities on the following fields: definition of interoperability standards; definition of the development of RTP platform; integration of design tools with analysis safety ones; implementation of the approaches of lines of products; support to the integration of functional models with physical models, in particular through the use of Modelica; improvement of the existing approaches of use of ontologies for the specification and the modeling of the requirements. The acquisition and the evaluation of the results will take place within the framework of two use-cases defined with Airbus and Airbus Defence and Space.
The CRYSTAL project will give benefits to EADS Innovation Works thanks to the foreseen results. Within the group EADS, Innovation Works mission is to understand innovative technologies and manage their development till their industrial use. To fulfill this task, EADS IW is involved both in research projects and programs of EADS divisions like the development of new aircraft and space systems. To do so, the programs of EADS divisions, to which CRYSTAL results will promise more success, are already identified prior to the choice of CRYSTAL themes to which EADS IW will work on. EADS IW will integrate the CRYSTAL results continuously in these programs through the involvement of EADS IW in TRL (Technology Readiness Level) revues, which are made by programs on a regular basis for promising technologies

Competitor description
Boeing Research & Technology – Engineering, Operations and Technology | Phantom Works: business decision making, modelling& simulation, design optimization.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result
- Description: Interoperability Specification

- Business Case and Market: EADS Systems Engineering Steering Group (SESG); EADS Strategic Standardization Committee (SSC)

- Roadmap for Exploitation: Implementation of IOS concepts into Aerospace Public Use Case Demonstrator (major milestone Q3 2014); Presentation to SESG and SSC until Q2 2014; Definition of EADS internal roadmap regarding IOS until Q4 2014; Extended prototypes and vendor buy-in until Q4 2015;

- Expected availability for use: Beginning of 2016 (i.e. end of CRYSTAL project)

Expected Exploitable Result
- Description: Ontology
- Business Case and Market: EADS Systems Engineering Steering Group (SESG); EADS Strategic Standardization Committee (SSC)
- Roadmap for Exploitation: Ontology aware IOS concepts; implemented at least as prototype into Aerospace Public Use Case Demonstrator; presentation to SESG and SSC and dissemination; extended prototypes by the end of the project
- Expected availability for use: Beginning of 2016 (i.e. end of CRYSTAL project)

3.1.8 GMV

INDUSTRY PARTNER

Organization: GMV, S.A.	**Short Name: GMV**

Author: Maria Carmen del Carmen Lomba Sorrendegui

Relevant Markets of your company impacted by CRYSTAL

GMV is a privately owned technological enterprise group with an international presence. Founded in 1984, GMV mainly operates in nine large sectors for both public and private organizations: Aeronautics, Space, Defence, Health, Security, Transportation, Telecommunications and Information Technologies.

GMV develops critical systems projects for the Aeronautics, Space and Security domains. CRYSTAL innovative results will be exploited by setting up a technological framework solution to support GMV future developments.

Major Benefits of CRYSTAL for your position in the Market

GMV is contributing to the use case demonstrator concerning "Aerospace domain". The scope of GMV's work is to evaluate the suitability and effectiveness of the processes, methods and tools developed in the frame of CRYSTAL for avionics software development. The CRYSTAL framework (tools, methods and techniques) will contribute to optimize the real-time performance for both digital signal and image processing in the field of object detection.

High quality solutions for massive computation algorithms will increase GMV competitiveness. Moreover, GMV wants to be in a better position to participate in the development of technology for critical systems, particularly in the context of HW/SW systems. CRYSTAL innovative results will be exploited by setting up a complete technological framework solution (platform, methodology and tools) to support GMV future developments in the field of Instrument Data Processing and distributed component-based technologies in HW/SW systems. CRYSTAL will have a major impact on the competitiveness for Data Processing projects and to a large extent to any embedded system having similar constraints.

GMV's exploitation actions also include identification of innovative results which could be exploited with possible support from the National Bodies supporting ITEA/ARTEMIS/FP7 as an appropriate market mechanism.

Competitor description

ESG (Germany): Design, development and integration of tailor-made, highly complex, technical avionics systems including customer-specific support during the entire lifecycle.

Critical Software (Portugal): Avionics software architecture, system testing and related regulations for the aeronautics civil and military industry.

Indra (Spain). Defence Electronics Equipment. Develop integrated vectronic and electro-optic systems for land, sea and aerial platforms.

GTD (Spain): Development of functional packages (definition of requirements, design, implementation and tests; Independent integration, validation and verification of packages developed by GTD, teams or third parties.

ATOS (France): End-to-end delivery along the value chain of embedded system design.
LogicaCMG (UK): Business consulting, systems integration and IT and business process outsourcing across diverse markets including telecoms, financial services, energy and utilities, industry, distribution and transport and the public sector.
ELSAG-Datamat (Italy): On board software, ground segments, simulation and training systems.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result

- Description: CRYSTAL framework (tools, methods and techniques)
- Business Case and Market: Aerospace
- Roadmap for Exploitation: enhance good practice and improve our position to participate in the development of technology for critical systems, particularly in the context of HW/SW systems
- Expected availability for use: At the end of the project

3.1.9 ORB

INDUSTRY PARTNER

Organization: Orbital Aerospace	**Short Name: ORB**

Author: Joaquin Lopez, Carlos Zubieta

Relevant Markets of your company impacted by CRYSTAL
Orbital Aerospace is a Spanish multinational that specialises in avionics systems engineering, testing, critical software and hardware, and offers products specifically tailored to clients' needs. With a broad multidisciplinary capacity, the company provides a range of high quality, real and immediate solutions to sectors with strong demand in highly critical environments. It thus offers innovative and cutting-edge technology, which is perfectly adaptable and scalable to any industrial interface.
The company has a consolidated experience in the aerospace industry, particularly in aeronautics, and its products have been developed taking into account the potential to reduce maintenance costs, by integrating critical SW and tested and optimised processes which will pose the next challenge for the European and international industry. Orbital Aerospace has thus established itself as a leading international partner for the design, development, integration, validation, and verification of aeronautical applications and products, in accordance with strict standards (DO-178B, DO-254, ABD-0100, ABD-200, ARO4754, A-661, etc.).
Our proposed work is the development of a tool, called AUGE- AUtomatic Generation tEst, which from the initial requirements will automatically generate test cases, models, and certification evidences of embedded, critical SW and systems.

Major Benefits of CRYSTAL for your position in the Market
Every software developed for critical systems (avionics, space, rail, military, etc.) need a very complex and expensive verification process. In fact the 50% of the cost project can be due to verification. Our tool set development proposed, AUGE, will reduce the cost of verification in 50% so, this tool, exportable to any sector, would reduce time and development costs estimated in 25% in the whole project.

Competitor description
AUGE is the alternative to the intensive and expensive effort needed to perform verification and validation tests. Not all the requirements can be translated directly into test patterns but the target is 50-75%.
With these perspectives, Orbital will become in a competitive actor leader in the embedded business. Actual customers belong to aeronautical, rail, space and renewable energy sectors and there is no doubt of the competitive improvement with this solution.
One of the not implicit goals of Orbital inside CRYSTAL project is to bring the experience in the aeronautical

and space sector to other fields with similar requirements as rail, automotive, energy, etc.

CRYSTAL project will impact in the creation of a new way to look into the Verification and Validation market. Benefits are clear in cost and technology aspects. We think that CRYSTAL project will increase the Orbital share market in this field about 100%. As the tool is a scalable and flexible solution and cost reduction is in a level project, any company in the embedded arena could be a potential beneficiary of this technology.

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result

- Description: Automatic Test Generation Tool

- Business Case and Market: The tool provides automatic low-level SW test generation from Requirement Baselines using IOS/OSLC interfaces. Devoted to Defense & Aerospace companies developing critical embedded systems.

- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.

- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result

- Description: IOS/OSLC expertise

- Business Case and Market: Consultancy IOS/OSLC support for Defense & Aerospace companies.

- Roadmap for Exploitation: Consultancy services to optimize engineering methods and SW certification processes.

- Expected availability for use: End of the project.

Expected Exploitable Result

- Description:

- Business Case and Market:

- Roadmap for Exploitation:

- Expected availability for use:

3.1.10 ASTS

INDUSTRY PARTNER

Organization: Ansaldo STS S.p.A.	**Short Name: ASTS**

Author: Luigi Velardi, Gianpaolo Massaroli

Relevant Markets of your company impacted by CRYSTAL

Ansaldo STS is a technology company of Finmeccanica group, and is the Italian leader in the sector of conventional and high speed railway lines and urban rail transport systems as designer and supplier of traffic management, signaling and automation systems, and related services. It acts as general contractor, system integrator and turnkey provider of major projects all over the world.

The increased demand for railway operations and control system both with the need of guaranteeing European leadership in the transportation strongly depend on producing technology-based high quality products at reduced costs.

European Railway system is a fertile domain in which many innovative projects are currently under development. The development of ERTMS (European Rail Traffic Management System) is one of the most important innovation in rail domain. It should be able to replace all the incompatible national European

solutions, already developed in the past, with a single train control system. It could be considered as the best performing train control system in terms of safety, reliability, traffic capacity as well as maintenance costs. Because of system's high complexity and heterogeneity, the required validation and testing effort to implement ERTMS solutions must not be underestimated: while safe transportation system and innovative embedded systems seem to be an inseparable binomial, the increasing complexity of the latter often becomes an insurmountable obstacle. Since the product quality is one of the key attributes for the European System Companies, a very high price is often paid to keep a performing market position.

Moreover, the rail business in general is rattled by high competition and low profit margins. Improvements in the development process for such systems resulting in higher productivity, better product quality, and improved time-to-market will be therefore highly desirable. The CRYSTAL project meets exactly these critical areas in the development process.

Major Benefits of CRYSTAL for your position in the Market

The expected results of CRYSTAL will affect the entire V&V process in all the customer projects in progress, starting from key customer projects.

We expect a reduction of Validation costs, especially the costs related to modifications and reworks on already validated versions of our products. In addition, adopting the ERTMS interoperable testing language under definition by UNISIG consortium allows us to speed up the interoperable testing in all the projects in which ASTS is involved together with other big European suppliers.

Competitor description

Siemens is the biggest railway industry supplier...

Alstom is an important railway industry supplier in Europe and all across the world. Alstom and ASTS together provided the technological infrastructure to realize all the ERTMS lines in Italy.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description: Exploiting CRYSTAL Technical Innovations (Tools and Methodologies) in Test Definition activities

- Business Case and Market: Improvement in ASTS Testing Process which should easily reduce time and costs needed for the V&V activities.

- Roadmap for Exploitation: Having the opportunity to use a new methodology thanks to which the model becomes a sort of "natural step" in test definition process (so that, once the model is defined, the test cases can be semi-automatically generated from it), would imply a significant reduction of time and costs during the validation phase.

- Expected availability for use: End of the project

Expected Exploitable Result

- Description: Exploiting CRYSTAL Technical Innovations (Tools and Methodologies) in Test Definition activities

- Business Case and Market: Improvement in ASTS Testing Process which should easily reduce time and costs needed for the V&V activities.

- Roadmap for Exploitation: The traceability of the model, both on system requirements and on generated tests, could support the engineers in the analysis of the impact of modifications in system requirements during the whole life cycle of the system, reducing time needed to identify the impacted tests and to modify them after changes in requirements.

- Expected availability for use: End of the project

Expected Exploitable Result

- Description: Exploiting CRYSTAL Technical Innovations (Tools and Methodologies) in Test Executions activities
- Business Case and Market: Improvement in ASTS Testing Process which should easily reduce time and costs needed for the V&V activities.
- Roadmap for Exploitation: Through the conversion into a data standard format it will be possible to solve the interoperability problems due to different proprietary data formats (coming from heterogeneous providers) that hinder the test execution.
- Expected availability for use: End of the project

Expected Exploitable Result
- Description: Exploiting CRYSTAL Technical Innovations (Tools and Methodologies) in Test Report Analysis activities
- Business Case and Market: Improvement in ASTS Testing Process which should easily reduce time and costs needed for the V&V activities.
- Roadmap for Exploitation: The automatic traceability between requirements and tests would simplify the maintenance of entire test suite and the analysis of the results, speeding up the identification of requirements or parts of the system not rightly implemented.
- Expected availability for use: End of the project

Expected Exploitable Result
- Description: Exploiting CRYSTAL Technical Innovations (Tools and Methodologies) in Test Report document Drawing up activities
- Business Case and Market: Improvement in ASTS Testing Process which should easily reduce time and costs needed for the V&V activities.
- Roadmap for Exploitation: Through the automatic generation of the report of the testing campaign it will be possible to reduce significantly the effort currently spent in manually analyzing that report.
- Expected availability for use: End of the project

3.1.11 AVL-S

INDUSTRY PARTNER

Organization: AVL Schrick GmbH	**Short Name: AVL-S**

Author: Bert Kehrens

Relevant Markets of your company impacted by CRYSTAL
For four decades AVL SCHRICK has been producing and developing combustion engines and high-performance components for renowned automotive manufacturers worldwide.
Our company is continuously evolving and creating ideas for emerging technologies in changing international markets. We provide solutions to improve the performance, power and life cycle of the modern engine, without compromising on comfort whilst importantly reducing emissions and CO2.
As a member of the AVL Group with headquarters in Graz, Austria, we are part of a worldwide competence network
AVL´s Powertrain Engineering division activities are focused on the research, design and development of various powertrains including e-mobility trains in the view of low fuel consumption, low emission, low noise and improved driveability.
With the exceptional role of being not only an industrial partner but also a technology and tool provider, AVL will contribute to the CRYSTAL project by providing even more seamlessly integrated AVL tools for industrial applications and thus will strengthen AVL partners even more in their competition. Hence, AVL will drive and communicate the establishment of industrial standards.

Major Benefits of CRYSTAL for your position in the Market

The expected results of this research project will be transferred to our products and distributed over the world, especially to our European OEM's, the supply industry as well as research centres. Internally in AVL, we will use the results in our daily development work in costumer projects. We expect an increase in accuracy, a reduction in development time and effort and significantly improved project collaboration driven by the major aims of the CRYSTAL project such as integrated industrial tool chains and the establishment of a widely accepted interoperability standard. In addition, this interoperability standard will have a positive impact on AVL as a tool provider. Integration of AVL tools will be more straightforward and will thus open new market prospects and opportunities to AVL.

Competitor description

FEV Motorentechnik GmbH is one of the largest independent suppliers of engineering services, constructing powertrains for cars, trucks, ships and locomotives. Furthermore, FEV is producing test beds for testing powertrains and vehicles concerning fuel consumption, durability, acoustics and emissions. FEV employs in total approximately 1.800 persons.

Ricardo Ltd. is providing technical and strategic consulting to the automotive, transport and energy industries. Ricardo employs approximately 1.500 persons.

Planned Exploitation of CRYSTAL

Internal / external exploitation

Expected Exploitable Result

- Description: We will use the results in our daily development work in costumer projects. We expect an increase in accuracy, a reduction in development time and effort and significantly improved project collaboration

- Business Case and Market: The interoperability standard will have a positive impact on AVL Schrick as an Engineering Service provider. Integration of AVL tools to our customers' tool chain will be more straightforward and will thus open new market prospects and opportunities to AVL by being more competitive than our non EU competitors

- Roadmap for Exploitation: Exploiting the results from the Project will be driven be building experience coming from applying the new processes and improved tools to real life development projects. Using a real-life project will enable us to generate re-usable examples of efficient and integrated powertrain development that as a 1st priority will greatly support our acquisition activities and strengthen our image. These example that are generated will also be used on conferences, customer workshops, expositions demonstrating how an efficient and interoperable tool chain shall be used in our day to day business as a Powertrain System Developer.

- Expected availability for use: during the cause the project the final desired result will slowly increase in maturity. Due to the support of tool venders within our Use Case we expect some parts of interoperable tool chain to be available at a late stage of the project already. Expecting an industrialisation of the IOS and a broad support of tool vendors within the industry we could foresee a steady increase in interoperability and growing improvement of our position in the market in respect to Powertrain Development.

3.1.12 CRF

INDUSTRY PARTNER	
Organization: Centro Ricerche Fiat S.C.p.A	**Short Name: CRF**
Author: Alberto Melzi	

Relevant Markets of your company impacted by CRYSTAL

Centro Ricerche Fiat, since its foundation in 1978, has the mission to develop and transfer innovative products, processes and methodologies in order to improve the competitiveness of the products of the Fiat Group. CRF conducts collaborative research initiatives at the national and international levels in partnership with all the key public and private stakeholders concerned with Sustainable Mobility, targeting specifically the industrial exploitation of research.

In the context of CRF mission the CRYSTAL platform is a way to improve the development cycle of the typical systems "on the shelf" (innovative products ready for implementation in new vehicle concepts), reducing costs and time to market, in particular for the point of view of the functional safety.

The market share is potentially every new component or system of components for the innovative development of the vehicles.

Major Benefits of CRYSTAL for your position in the Market

The benefits from the overall integration of the development process within the RTP, in particularly linked to the safety aspects through the assessed compliance with the ISO 26262 standard, is related to the consequent alignment of the design to the expected evolution of the automotive market constraints and customer requirements, that in the next future will be well focused on the safety and quality regulations more and more linked to the technical standards in evolution on this matter.

Competitor description

There are not specific competitors for CRF market other than other car makers outside Europe that are looking to the same market constraints, as functional safety and quality design, for which ISO 26262 in particular will constitute a target for the new products development.

Planned Exploitation of CRYSTAL

exploitations

Expected Exploitable Result

- Description: Framework for managing-mapping Functional safety information/data versus modeling data (e.g. simulink)
- Business Case and Market: Development of systems on the shelf for using or re-using them in different applications. Time and cost reductions of functional safety conformity assessment.
- Roadmap for Exploitation: Enhance good practice by spreading results internally and by the customers.
- Expected availability for use: By 2018.

3.1.13 IFX-UK

INDUSTRY PARTNER

Organization: Infineon Technologies UK	Short Name: IFX-UK

Author: Helen Finch, Serrie Chapman

Relevant Markets of your company impacted by CRYSTAL

Infineon Technologies focuses on the three central challenges facing modern society: Energy Efficiency, Mobility and Security and offers semiconductors and system solutions for automotive and industrial electronics and chip card and security applications. Infineon holds Top Positions in all its target markets, it is currently #2 worldwide in Automotive, #1 in Power and #1 in Chipcard. It is a world leader in environmental sustainability through both its working practices as well as its product line.

The tool platform developed in CRYSTAL will be applied primarily within Infineon's automotive segment, although power and chipcard applications will also be kept in focus.

The results of CRYSTAL will be used to support the next generation of design, verification, implementation

and integration of Infineon's TriCore microcontroller devices. These are leading edge components in the field of automotive safety, particularly targeting powertrain applications. Support for innovations in TriCore safety features will contribute to better fault tolerance (improved safety and availability), shorter development times and lower costs, hence increasing the marketability of these products. Currently TriCore devices are present in more than one third of all new cars worldwide and it is expected that the improved and integrated design methodologies will contribute to a further increase in this market share.

Infineon AG was a partner of the ARTEMIS Call 1 project CESAR (cost efficient methods and processes for Safety Relevant embedded systems). The work done within CESAR has already extended from pilot projects to all Infineon business lines and is deemed mandatory for all automotive Safety products which need to comply with the new ISO26262 Safety Standard. Infineon UK will use the tools and methods resulting from CRYSTAL to further improve its development processes for the TriCore family of microcontroller devices and associated systems.

TriCore devices, as with all safety-related automotive products within the Infineon range, are ISO26262 accredited; Infineon has been working with the draft standard for over three years and is now well placed to meet the challenges of the full standard which was released in November 2011.

In addition to providing a natural follow-on from CESAR development work, CRYSTAL activities will also be complementary to the VeTeSS ARTEMIS project which started in May 2012 and is being led by Infineon UK. VeTeSS is concerned with verification and test to support functional safety standards, principally the automotive ISO26262 standard for automotive electronic systems.

Major Benefits of CRYSTAL for your position in the Market

CRYSTAL will follow on from the Cesar project work, which implemented full requirements traceability into Automotive for a platform of 8 AURIX, Tricore™ microcontroller based, products for the powertrain market, as well as multiple projects on other Business lines (chipcard which has security standards, power, industrial/multi-market and others). Whilst implementing the CESAR solution it became clear that improvements in the requirements gathering and writing phase are needed. Infineon's contribution to CRYSTAL would be to investigate formal or semi-formal notations to replace the current non-formal requirements and to investigate also common standards for transfer of requirements with our customers using the ReqIF or a specified flavor of it. We will also investigate improvements to the cross domain issues in order to cut out under and over-engineering between the various pre and post silicon validation/verification groups in order to save money and bring our time to market down significantly, with early lifecycle modelling possibly from the formal requirements. The expected benefit of this research project to IFX-UK would be to reduce time to market as follows :

•   Ensuring that the product requirements are formal and that we have a clearly recognised standard for the notations.

•   Better interfacing with our customers to ensure we are in agreement and understand all parties concerned

•   Early lifecycle modelling to improve testbench and design automation & reduce risk based on the formalised requirements

•   Defining set UML requirement standards for the automotive industry within Europe should make us a more viable choice for our customers and we will also have the advantage of having the tooling and documentation in place before any such standard becomes available.

•   The over-engineering/under-engineering within the cross domains we are aware is a very big and timely cost within our workflow. To ensure visibility between the domains to highlight these issues would be a great cost and time benefit to improve our time to market.

Competitor description

Renesas: Japanese competitor, current world leader, formed by Hitachi and Mitsubishi. Employs 42000 (although was set to shed 15% earlier this year).

STMicro: Italian French competitor, formed by SGS microelectronica and Thompson semiconductors. Currently #3 in world automotive. Employs 53,300 (end 2010).

Freescale: American company based in Austin Texas. Motorola spin-off. Currently #4 in world Automotive. Employs 18,500.

NXP: Dutch competitor – formally Phillips fbased in Eindhoven. Currently #5 in world automotive. Employs 24,000.

Planned Exploitation of CRYSTAL

Internal / External Exploitations

Expected Exploitable Result
- Description: Requirement Quality Boilerplate (semi-formal)
- Business Case and Market: Tier1 customers and Infineon Design and verification/test engineers
- Roadmap for Exploitation: Quality Requirements to enable us to drive a requirements driven verification, automation and interoperability is not possible without a good quality set of requirements (also part of ISO26262 standard for ASIL C and D)
- Expected availability for use: M36

Expected Exploitable Result
- Description: Tailored Product Requirement Documents
- Business Case and Market: Tier1 customers and Infineon Application engineers and product line management
- Roadmap for Exploitation: Correct product with improved customer interface and earlier conflict and impact analysis. Through ensuring that the internal requirements are matched to the external ones and thus tailoring the Product Requirement Document per customer
- Expected availability for use: M24

Expected Exploitable Result
- Description: DaD (Data Analyser Dashboard)
- Business Case and Market: Tier1 customers and Infineon
- Roadmap for Exploitation: Improved time to market through more automated project and requirement management, no ISO required as this will directly integrate with asureSign through API
- Expected availability for use: M24

Expected Exploitable Result
- Description: asureSign extensions
- Business Case and Market: Infineon management, design and verification/test engineers
- Roadmap for Exploitation: Improved reuse of Requirements and Tests. Support of IFX ARQE XML standard schema
- Expected availability for use: M12 - M18 rollout

Expected Exploitable Result
- Description: asureSign extensions
- Business Case and Market: Tier1 customers, product line management, design and verification/test engineers
- Roadmap for Exploitation: Improved time to market through better variant management allowing us to more easily identify over engineering especially across the test/verification/firmware/software domains. Support of IFX ARQE XML standard schema
- Expected availability for use: M12 - M18 rollout

3.1.14 ITK-E

INDUSTRY PARTNER

Organization: ITK Engineering	Short Name: ITKE

Author: Matthias Gemmar, Daniel Christlein, Aleksander Lodwich

Relevant Markets of your company impacted by CRYSTAL

ITK Engineering is an established expert in the development of software in all of the major target markets and application fields of CRYSTAL. Our focus is on providing engineering services to major OEMs and small and large TIER1s in the automotive industry, but our services also extend to customers in the aerospace industry, the health care sector and others with need of control systems and embedded software, like robotics. The technological advances to be implemented by CRYSTAL should generate a profound and fundamental impact in all aspects of embedded systems engineering and thus affect all of these markets. Since the market is so large and varied, estimates of the total market potential are exceedingly difficult. We would therefore like to focus on a few select fields of application. For example, expenses for R&D at Volkswagen AG reached 6.257 million € in 2010. It is estimated that the share of development costs of embedded software has reached approx. 30% today, and it is expected to rise even further (due to the increasing number of ECUs in the average vehicle, the considerable length and costs of the development and testing cycle and the high demands regarding the qualifications of the R&D personnel). Based on the market share of VW of 21,9%, we thus estimate the total costs of R&D in embedded software in the German automotive industry at 8.571 million € p.a. Development costs for a single automobile platform typically exceed 1.000 million € (for example, the R&D costs for the Audi A8 are estimated at 1.500 million €). While R&D costs are primarily generated at the OEMs, development tasks are increasingly outsourced to external providers of engineering services. With an annual turnover of approx. 40 million €, ITK Engineering is among the major such independent providers in Germany and thus in an excellent position to leverage the results of CRYSTAL in the German automotive industry as well as other sectors.

Major Benefits of CRYSTAL for your position in the Market

The technology bricks generated and tested by CRYSTAL will directly benefit ITK in its core activities. Development processes will be facilitated by the availability of standardized, modular software components, interfaces and tool chains. We thus expect a reduction in the length of development cycles by approx. 20% per project, and thus a corresponding increase in turnover.

This is particularly important given the increasing complexity of embedded software systems, especially in the automotive sector, which is unfortunately not matched by an equivalent increase in the availability of sufficiently skilled engineers. CRYSTAL will greatly increase the productivity of highly qualified R&D personnel, allowing them to keep pace with the accelerating complexity of the development cycle. Without efforts like CRYSTAL, there is a very real danger of modern embedded systems reaching a level of complexity that is not manageable by established R&D processes and methodologies any more, which would severely hamper further technological advances in this field.

Furthermore, due to our participation in CRYSTAL, we will gain unique competencies in the application of CRYSTAL-specific methodologies and technology bricks in the development process. ITK will thus become a prime industrial partner for major OEMs and those small and large TIER1s deciding to adopt the technologies introduced by CRYSTAL, particularly partners collaborating in the project. This will provide us with a unique advantage on the market, allowing us to increase our market share and thus turnover even further by an additional estimated 10-20%.

Competitor description

On the markets served by ITK (primarily the German automotive industry, but increasingly overseas markets as well, particularly Japan and the United States), there are a number of competitors in the field of embedded software engineering. To our current knowledge, none of them are currently pursuing efforts on the level of CRYSTAL, although there is a general tendency in the industry towards a greater degree of standardization and modularization of software components and interfaces. We do not list the major OEMs and their internal R&D efforts as competitors.

Relevant competitors include.
•   Gigatronik GmbH is a provider of development and consulting services in electronics and IT. With a

staff of 600, it serves a number of sectors including automotive. A review of past and current subsidized projects has not turned up any efforts competing with the aims of CRYSTAL. Gigatronik was a minor partner in a project concerning the standardization of data exchange in the context of a "digital factory", but the scope of this project is not comparable to CRYSTAL.

• Bosch Engineering GmbH is a 100% subsidiary of Robert Bosch GmbH with ~1400 employees. Its R&D activities extend to a relatively broad range of applications, including power train development, and also include solutions for the networking of electrical and electronic systems. AUTOSAR services and the development of functions and software for control-unit communication plus comfort electronics are also part of the portfolio. A review of subsidized R&D projects has not turned up any efforts relevant to the goals of CRYSTAL.

Planned Exploitation of CRYSTAL

exploitations

Expected Exploitable Result
- Description: Integrated development environments
- Business Case and Market: Establishing a standardised format for integrated exchange of data between development tools addresses one of the main bottlenecks in our current environment for developing (electrical/electronic) functions for heavy vehicles. With an integrated development environment, the tasks of different roles in the development process are more integrated: data produced by a predecessor role in one tool can be straight-forwardly used by a successor role in another tool without the need to either duplicate the data with an import mechanism, or manual recreate the data.
- Roadmap for Exploitation:

  1) Involve engineers and experts at Volvo, representing the identified roles, both in the use case definition, in the solution creation, and in the evaluation and verification.

  2) Push tool suppliers to use the upcoming interoperability standard.
- Expected availability for use: At prototype level during the project duration. Continual integration into the commercial development environment. Use the standard in in-house development and in supplier contracting by 2018.

Expected Exploitable Result
- Description: Customisable development environments
- Business Case and Market: When all development tools comply with an interoperability standard, the possibility emerges to freely customise the development environment based on COTS tools to a specific project to a low cost as it fits that project best.
- Roadmap for Exploitation: Push tool suppliers to use the upcoming interoperability standard. Spread the standard in available forums.
- Expected availability for use: 2020

3.1.15 PHILIPS

INDUSTRY PARTNER

Organization: Philips Medical Systems Nederland B.V.	**Short Name: PHILIPS**

Author: Rob Ekkel, Birgit Faber

Relevant Markets of your company impacted by CRYSTAL

Philips Healthcare (PH):

Royal Philips Electronics is a main electronics company focusing on healthcare and well-being. In healthcare, Philips' innovation revolves around improving the quality and efficiency of healthcare through a

focus on care cycles. Central to care cycle thinking is a patient-centric approach that optimizes healthcare delivery for all the major diseases. In the Philips Healthcare (PH) sector , over 12% of systems sales are invested in R&D. Philips combines its expertise in medical technology with clinical know-how of its customers to produce innovative solutions that meet not just the needs of individual patients, but which also enable healthcare professionals to work faster, more easily and more cost-effectively.

While PH has a large global organization, in the Netherlands more than 3000 people work at PH, of which 1000 in R&D. At PH in Best the Business Unit Interventional X-Ray (participating in CRYSTAL) is responsible for marketing, service, development and manufacturing of interventional X-ray systems used in the area of cardiac or vascular medical diagnosis and intervention (e.g. "dotter" treatment, orthopedic surgery). Its customers are hospitals and university medical centers. Research and innovation of the BU focus on software, (digital) electronics and mechatronics. Sales of PH's total sector amounted to €8.9B in 2011. Philips is globally number one in medical diagnostic imaging and patient monitoring. More information on PH can be found at www.medical.philips.com.

Imaging systems market
Global spending on medical imaging equipment exceeded $21 billion in 2010   and is expect to grow to $26.6 billion by 2016   (at a CAGR of 4.2%), driven by an aging population and technological advancements in the field. Topping the imaging trends is the fusion of nuclear imaging with different modalities, such as PET/CT, SPECT/CT, and MRI/PET, according to the report. Portable diagnostic equipment is also face higher demand, according to analysts. In 2010, X-ray constituted the largest share of market with around 34%, followed by ultrasound at 21%, CT scan with 19.5%, MRI with 18.5%, and nuclear medicine with 7%. The United States has a dominant share in the global market with around 37%, followed by Europe with 27%, and Asia with 27% as well.

Major Benefits of CRYSTAL for your position in the Market
The major benefits of the CRYSTAL project for Philips Healthcare are:
- Reduction in development time by model driven development supported by the use of the Reference Tool Platform for Healthcare resulting in a faster time to market.
- Secure development of new generations X-ray systems ensuring safety for patients and doctors according to international standards 21FDA820 and ISO13485 and ISO14971
- A large internal exploitation of the CRYSTAL results is foreseen within Philips Healthcare Best until 2015. Currently Philips Healthcare employs approximately 500 Software engineers.

Competitor description
There are three main players in the X-ray imaging systems market: Philips Healthcare, Siemens and GE. Together, Philips, Siemens and GE have a vast majority share of the X-ray imaging market. The remainder of the market is filled by other players like Toshiba, Hitachi, and Hologic.
Siemens
Siemens Healthcare employs over 51,000 employees worldwide and has a revenue of € 12.5 billion. Siemens Imaging & Therapy Systems cover a broad spectrum of image-based diagnostics and therapy. Their main product line in this field is the Artis Zee family for imaging in radiology and cardiology.
GE
GE Healthcare is a $17 billion unit of General Electric Company (NYSE: GE). Worldwide, GE Healthcare employs more than 46,000 people. GE Healthcare provides products for the interventional X-ray market such as the Innova® interventional X-ray systems and OEC mobile C-arms for surgical applications.

Planned Exploitation of CRYSTAL

Internal / External exploitations
Expected Exploitable Result
- Description: Measuring system engineering performance
- Business Case and Market: R&D managers: the measuring results will give the R&D managers good insight in the benefits of using interoperable model-driven development tooling: tracking the compliance to the safety embedded system requirements and standards during the whole product development lifecycle.

- Roadmap for Exploitation: At M12, M24 & M36, Philips & TU/e plan to create report outs that will show the effectiveness of the current system engineering process versus the improved engineering process. Adoption of Crystal results by R&D. This will result in faster time to market.
- Expected availability for use: M12, M24 & M36 (see Dissemination Plan)

3.1.16 BARCO

INDUSTRY PARTNER

Organization: Barco N.V.	Short Name: BARCO

Author: Tom Kimpe, Dominique Segers

Relevant Markets of your company impacted by CRYSTAL

Barco, a global technology company, designs and develops visualization solutions for a variety of selected professional markets: medical imaging, media & entertainment, infrastructure & utilities, traffic & transportation, defence & security, education & training and corporate AV. In these markets Barco offers user-friendly imaging products that optimize productivity and business efficiency. Its innovative hard- and software solutions integrate all aspects of the imaging chain, from image acquisition and processing to image distribution, management, and visualization. Barco has its own facilities for Sales & Marketing, Customer Support, R&D and Manufacturing in Europe, America and Asia-Pacific. The company (NYSE, Euronext Brussels: BAR) is active in more than 90 countries and employs 3,600 staff worldwide. In 2011 Barco posted sales of 1 billion euro.

The Healthcare Division (HC) of Barco develops and markets a wide products portfolio of high-precision medical display systems to bring accuracy and efficiency to a broad range of healthcare disciplines, including radiology, mammography, surgery and clinical review imaging.

For the CRYSTAL project, there are two market segments that are of particular importance.

The diagnostic display market is the market segment where Barco Healthcare has reached a very strong position of about 50% market share globally. The total addressable market in the diagnostic display segment is +/- 185 M EUR in 2012 and it grows at a yearly rate of around 5%. The expected total addressable market for the diagnostic display segment therefore grows up to 212 M EUR by 2015 and 232 M EUR by 2018.

Clinical review displays are sold through distribution channels only. A real distributor (e.g. Ingram-Micro) sells those further through their channels like Sis (System Integrators) or SBs (System Builders), VARs (Value Added Resellers), MRs (Master Resellers) or even TDLs (Standard Traditional Resellers).

Barco also sells medical displays into the clinical review market segment. These displays are typically used by referring physicians and specialists (oncologists, surgeons, etc.) to review medical images rather than to make a diagnosis based on the images. The total addressable market for the clinical review displays is larger than the diagnostic reading market, but Barco currently only has a market share of around 6%. The total addressable market for clinical review medical displays is expected to be around 234 M EUR by 2015 and 365 M EUR by 2018.

Major Benefits of CRYSTAL for your position in the Market

The CRYSTAL project will allow Barco to fundamentally change its current display platform.

Today, Barco's medical display platform is hardware centric (based on a proprietary hardware board with FPGAs). This makes it very difficult to support an ever growing number of product variants, to cope with pressure to bring products to market quicker, to handle maintenance and bug fixes of products in the field, and finally but not to be underestimated to comply with an increasing complexity of regulatory requirements and certifications.

By means of the CRYSTAL project we will be able to make the move to a software centric display platform that will run on top of consumer of the shelf (COTS) boards. The CRYSTAL project and consortium is a perfect match for Barco's ambitions because the interoperable tools and methodology results of the CRYSTAL project will be instrumental for Barco in order to make this move towards our new platform.

The new software centric platform will have significant impact. It will allow us to quickly develop and commercialize cost-effective and easy to maintain safety critical medical display products. By means of the software nature and by incorporating the expected results of the CRYSTAL project, the platform will

moreover be very flexible such that supporting many product variants will be much easier.

Therefore, the expectation is that because of the CRYSTAL project we will be able to increase our market share in the clinical review medical display market segment from 6% today to 30% by 2018. Obviously this will also have a positive effect on employment and economic benefits for Flanders and Europe.

Competitor description

Eizo Corporation: Eizo is worldwide active company with headquarters in Japan that focuses on professional and prosumer visualization products. They are the main competitor of Barco for medical display systems.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description: New Engineering Process: Functional modeling
- Business Case and Market: R&D Tools and Data Management
- Roadmap for Exploitation: M12 Evaluation report on the improved Engineering Process
- Expected availability for use: M12

Expected Exploitable Result

- Description: Y2 iteration of the New Engineering Process
- Business Case and Market: R&D Tools and Data Management
- Roadmap for Exploitation: M24 Evaluation report on the improved Engineering Process
- Expected availability for use: M24

Expected Exploitable Result

- Description: Y3 iteration of the New Engineering Process
- Business Case and Market: This will allow Barco to keep our existing market share (50%) in the diagnostic display market, and allow us to significantly grow and gain market share in the clinical review display segment.
- Roadmap for Exploitation: The goal of the AIPP CRYSTAL project is to have a fully optimized and interoperable tool chain to develop a first software centric medical display prototype. After a first working prototype will be available, a significant amount of additional development work will be needed before the results of the project can be commercialized. Development effort will be needed on the key components and the EMC validation of the display system. Furthermore extensive validation testing, several pilot series and regulatory approvals will need to be handled as well before commercialization can start.
- Expected availability for use: 2016

3.1.17 TTTECH

INDUSTRY PARTNER	
Organization: TTTech Computertechnik AG	**Short Name: TTTECH**
Author: Andreas Eckel, Christian Reinisch	

Relevant Markets of your company impacted by CRYSTAL

TTTech Computertechnik AG is an Austrian SME and a leading supplier of technology and software products in the field of Time-Triggered Architectures (TTA), time-triggered communication systems such as the Time-Triggered Protocol (TTP®), TT-EthernetTM, FlexRay and modular safety platforms and Systems of Systems (SoS) Infrastructures. TTTech acts as an industrial partner in terms of providing on-board data

communication solutions in the transportation industry in particular the automotive-, "off-highway-, aerospace-, railway-, and industrial (i.e. wind power) domains. TTTech also acts as a tool vendor of Time-Triggered development tools designed directly at TTTech as a TTTech brand.

On the automotive market TTTech detected a strong market pull for highly integrated solutions for i.e. Driver Assistant Systems (DAS) during the very latest periods. It clearly indicates the trend from vertical integration towards horizontal platforms and SoS Infrastructures supporting the integration from different software application suppliers by the OEM. In parallel this will reduce the number of ECUs required and will reduce integration efforts, it will reduce the variety of required networks and thus wiring and finally also weight. This appears to be perfectly in line with the OEM's goals who in addition target to reduce the dependency of automotive OEMs from the "choke-hold" of Tier one suppliers capturing more and more of the added value in the final product. TTTech sees the reply to that fact in separating the function from the platform and offering to the OEM an opportunity to integrate, on their own responsibility, various functions on one platform or SoS Infrastructure. Such SoS Infrastructure requires powerful computing platforms and ECUs on the one hand, data communication middleware bricks on the other hand plus powerful configuration tools supporting the goals of the high system level development to be conducted by the OEM. Such tools need to be well embedded in the state of the art tools, modelling and methods landscape. TTTech's vision is that the OEM will thus not purchase a large number of completely integrated systems and provide simply installation of systems including hardware and software based application in the long run any more. Instead OEMs will favour a multi computer based SoS Infrastructure. OEMs will rather produce some of the applications themselves or have them produced exclusively for their own brand plus integrating several state of the art applications on such SoS Infrastructure. This will provide them the benefit of differentiation from competitors on the one hand since Tier one suppliers sell their systems to all competing OEMs and thus suppressing the differentiation opportunity. On the other hand this will also reduce their dependency from a few Tier one suppliers and will increase their added value in the final product.

With respect to CRYSTAL TTTech is serving the automotive and off-highway markets as a supplier of SoS Infrastructures for data communication and safety relevant platforms, ECU, including middleware-bricks and tools. Currently TTTech establishes a SoS Infrastructure suitable i.e. for "Driver Assistant Systems" (DAS) using a multi-CPU based concept. In contrast to TTTech's approach today's offerings in the market include "island solutions" in the field of DAS that cover single applications such as "parking assistance", "traffic jam assistance" etc. Each of these systems is packed into one single, separated system which makes the overall functionality costly in terms of required hardware, integration and maintenance. TTTech's approach using its multi-CPU based SoS Infrastructure targets to combine all these individual equipment in one system and is oriented towards autonomous driving functionality as a final result.

Further increasing the power of such SoS Infrastructure, a new approach shall facilitate the wireless connection to the car (car2x) as well as applications for communication car to car (car2car). Finally the wireless car2x connection will also support "apps-store" functionality for the automotive market connecting the owner of the car and the car itself to the OEM. It will allow direct orders via smart phone and direct download of software and software updates to the car by the OEM as a reply to "Apps orders" via internet link coming i.e. from smart phones.

TTTech estimates this market as a double to triple digit million Euro market share opportunity for TTTech over the next decade and in case of full deployment is successful. The key enabler to be successful using and enhancing the existing technologies, tools, middleware and hardware bricks and SoS Infrastructure building blocks is the funding by ARTEMIS.

Major Benefits of CRYSTAL for your position in the Market

This powerful functionality offer resulting from the CRYSTAL project as outlined above will deploy the opportunities for TTTech significantly on the automotive market world-wide. TTTech expects that such strategies, tools and methods fully enhanced and adapted from today's status towards the functionality outlined above will drive the current SME-company towards a large enterprise in the longer term of the next 5 to 10 years. Turnover in the automotive business unit is expected to rise by a yearly ramp-up of 25% to 30 % or even more upon availability of such technology and offering. However, this is a race where TTTech is competing with large Tier one suppliers, which needs to be won. TTTech definitely sees a "once in a lifetime chance" conducting the work proposed under the funding umbrella of ARTEMIS during this short time span due to the funding provided. In case such funding would not be granted, TTTech will also conduct the work, but the required time span to completion would more than double reducing the chance to be successful in the same scale by more than half. As a small company, TTTech would not be able to spend the amount of R&D budget alone during such short period in order to achieve the same goals. In addition CRYSTAL will

have a boosting effect on the employment situation at TTTech not only during the project but even in the long run due to expected significant growth and due to the offerings enabled by the CRYSTAL results planned for TTTech. This will significantly support TTTech's position strengthening effect due to growing far beyond the critical mass to be better accepted as a series production supplier in the long run. This growth manifested in manpower, financial growth and sustainable economic wealth as well as cutting edge technology-offer is a key factor in order to survive and to assert TTTech in the strongly evolving and extremely competitive global markets.

Last not least the market situation will also improve with respect to competition since several cooperation opportunities with OEMs participating in CRSYTAL as Partners (i.e. VOLVO) will be established.

Cooperation in the area of "getting most relevant requirement information" is a key enabler when following the risky path of technology lead and development. The described TTTech strategies will significantly help to improve the TTTech relation towards OEMs.

Based on this, even cooperation chances with currently competing suppliers may materialize beyond the scope of CRYSTAL increasing the success chance in the end and potentially reducing current competitor threats.

Competitor description

Mainly TTTech sees two major, very well-known competitors in the field. These are the Robert Bosch GmbH (Approximately €30.4 billion of the €54.5 billion overall turnover are dedicated to the automotive domain in 2011. For more information pls. see http://www.bosch.com/) and Continental (automotive group turnover 2011: €30.5 billion, see http://www.conti-online.com/). Due to their huge size both are capable of funding R&D efforts much more easily than TTTech (2011 TTTech cross performance resulted in approximately € 10 million of € 29.4 million overall). This is why the ARTEMIS funding is so essential for TTTech in order to meet competition at comparable level with respect to financing such R&D efforts.

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result

- Description: Extended SoS configuration tool chains

- Business Case and Market: Existing and new customers in the automotive and off-highway domain through facilitated use and integration of the tools in the engineering environments as well as extended tool functionalities

- Roadmap for Exploitation: TTEthernet Design and Development tools will be extended to cover new/additional design or configuration options; IOS interfaces are expected to facilitate tool use in integrated engineering processes

- Expected availability for use: 3-5 yrs

Expected Exploitable Result

- Description: System of systems platform

- Business Case and Market: Existing and new customers in the automotive and off-highway domain through the offering of a new, powerful and configurable platform including tailored tools and tool chains.

- Roadmap for Exploitation: Extension of the engineering prototype towards commercial product, e.g. implementation of full functionality, extended testing

- Expected availability for use: 3-5yrs

Expected Exploitable Result

- Description: Wireless Interface for SoS platform

- Business Case and Market: Existing and new customers in the automotive and off-highway domain through extended functionality (dependable communication also in the wireless domain)

- Roadmap for Exploitation: Further evaluation and extension of the wireless option for the platform and integration of the work into commercial products in the mid-term future

- Expected availability for use: 3-5yrs

3.1.18 RGB

INDUSTRY PARTNER	
Organization: RGB Medical Devices	**Short Name: RGB**

Author: Ricardo Ruiz

Relevant Markets of RGB impacted by CRYSTAL
RGB, established in 1988, designs and manufactures a wide range of vital signs multiparameter monitoring products for Hospital and Home use. Its strength is in using latest technology in innovative concepts; e.g. in 1995, RGB developed the first CE marked Vital Signs multiparameter telemedicine monitor of its kind. RGB has delivered their products in more than 50 countries, particularly in those Spanish American speaking such as Latin America.
From initial product design through pre-market clinical tests, all our products meet applicable standards of performance, reliability and durability. Since its foundation, RGB has signed commercial OEM agreements with companies like BBRaun, Spacelabs, Palco and Kontron for world-wide distribution.

Major Benefits of CRYSTAL for your position in the Market
RGB expects to gain great experience and visibility in the use of scalable RTP and IOS concepts with the goal to reduce the time to market process of the next generation of products. In particular, within CRYSTAL, RGB will complement current developments in an innovative Use Case of Closed loop control for Blood Pressure regulation. RGB will make use of bricks in the areas of safety and security, as well as elaboration of certification documents, according to medical standards for CE marking; As a result of our participation in CRYSTAL, RGB expects to improve the product development lifecycle , obtain higher cost savings and improvements of the development process, as well as decrease the deployment complexity of the overall product development tools and processes in the particular areas described.

Competitor description
RGB has a long-term history of cooperation with companies that operate in the same market field.
Listed below are some market leaders and their range of products:
•   PHILIPS is a first player in Vital Signs Monitoring for Hospital Use, and has consistent solutions for home through Philips Consumer Lifestyle. This entity provides knowledge in products, services and service infrastructure for personal healthcare and wellbeing(-management) DRAEGUER is a German company with presence all over the world, and a leading position in OR and ICU solutions
•   CARDGUARD SCIENTIFIC SURVIVAL, LTD. It is a subsidiary of LifeWatch AG, and is a leading manufacturer and marketer of telemedicine products. Card Guard's telemedicine products provide a total solution to health care providers. Its range of wireless products includes electrocardiogram, pulse oximeter, spirometer, blood pressure monitor, glucometer and weight scale. LifeWatch is an international company that offers also a complete telemedicine service so it is a very important competitor in this market.
•   NONIN MEDICAL INC. It is a company located in USA with over 20 years of experience in the design and support of noninvasive physiological monitoring devices. They have products adequate for hospital environment but they have included recently the capability of wireless transmission of patient data, so its devices can be used also for telemedicine applications. Its range of products includes pulse oximeter, blood pressure monitor and capnometer.

•   A&D COMPANY, LTD. It is a multinational manufacturer of advanced measuring, monitoring, controlling and testing instruments. It has factories in Japan, China, Korea and Australia. One of its divisions is dedicated to manufacturing of A&D weighing and medical products that can transmit data through cable or wirelessly. Its range of products includes weight scales and blood pressure monitors.
•   CORSCIENCE GMBH. It is a small company located in Germany specialised in telemedicine products. The focus of its activities is biomedical engineering, especially the development of diagnostic and therapy devices for cardiovascular disorders. Its range of products includes electrocardiogram, pulse

oximeter and blood pressure monitor.

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result
- Description: Scheduling Requirement Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of timing requirements initially focused for the aerospace domain. With IOS/OSLC support. Devoted to aerospace companies developing critical embedded systems.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: Functional and Performance Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of functional and performance requirements fulfilment in architecture models initially expected for healthcare domain. With IOS/OSLC support.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: Interoperable Architecture Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of interoperable fulfilment requirements in architecture models. Initially expected for healthcare domain. With IOS/OSLC support.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: IOS/OSLC expertise
- Business Case and Market: Consultancy IOS/OSLC support. Intended for companies interested to use OSLC/IOS in their development process.
- Roadmap for Exploitation: Enhance good practice by spreading results through consultancy services. Listed in the services provided.
- Expected availability for use: End of the project.

Expected Exploitable Result
- Description: Methodology for EN IEEE/ISO 11073 modelling
- Business Case and Market: Methodology and consultancy for modelling interoperability aspects in healthcare devices according to EN IEEE/ISO 11073. Companies of the healthcare domain.
- Roadmap for Exploitation: Consultancy services. Listed in the offered services.
- Expected availability for use: End of the project.

Expected Exploitable Result

- Description: Simulator with HiL
- Business Case and Market: Simultator with HiL tailoring, supporting IOS/OSLC.
- Roadmap for Exploitation: Customisation support service.
- Expected availability for use: End of the project.

Expected Exploitable Result
- Description: Selling of Equipment
- Business Case and Market: Anesthetist in Operating Room and Critical Care Doctors
- Roadmap for Exploitation: Use our current distributor companies worldwide
- Expected availability for use: Once the CE mark is obtains (outside Crystal timeframe)

3.1.19 SIEMENS

INDUSTRY PARTNER

Organization: Siemens Aktiengesellschaft	**Short Name: SIEMENS**

Author: Rainer Ersch, Reiner Schmid

Relevant Markets of your company impacted by CRYSTAL

Siemens is a global powerhouse in electrical engineering and electronics. The company has 360,000 employees (as of September 30, 2011) working to develop and manufacture products, design and install complex systems and projects, and tailor a wide range of services for individual requirements.

Please describe shortly the markets of your organization which will be impacted by CRYSTAL. Figures about market size and/or your market share are of highest value!

Siemens is an integrated technology company with a clear focus on the four Sectors Energy, Healthcare, Industry and Infrastructure & Cities. These Sectors are sub-divided into 19 Divisions.

Siemens occupies outstanding positions in many markets. Our actions are driven by market dynamics and therefore also by the requirements of our customers. We want to continually outperform our competitors and, as market leader, set the standards for operating and financial performance in our industries. With a financial target system and the goal of continuous improvement relative to the market and our competitors, One Siemens is providing the framework.

Innovation is a cornerstone of Siemens' success. We closely align R&D activities with business strategy, hold key patents and have a strong position in both established and emerging technologies. Our goal is to be a trendsetter in all of our businesses. We unlock the energy and creativity of our employees, embracing the new and different. We are also ingenious and we embrace this quality in all its varied meanings – original, inventive and resourceful.

We are entrepreneurs whose innovations are successful on a global scale. We measure the success of our innovations by our customer's success. We constantly renew our portfolio to provide answers to societies' most vital challenges, enabling us to create sustainable value.

Major Benefits of CRYSTAL for your position in the Market

The development of embedded systems is getting more and more complex. Interoperability throughout the development lifecycle is one of the key objectives to beat this complexity. The results of the CRYSTAL project will be transferred to the engineering organizations to improve the software and system engineering environments to make them more efficient. Lifecycle Traceability is for many organizations a key requirement by regulatory organizations which has to be provided to get market approval for their products. Applying technologies of the CRYSTAL project will substantially improve the position in the market by improving time to market and reducing development efforts.

Planned Exploitation of CRYSTAL

Expected Exploitable Result
- Description: Established Standard for Interoperability in Engineering Environments
- Business Case and Market: Tool vendors, Tool managers, Tool user, System Integrators
- Roadmap for Exploitation: by motivating and supporting standardisation bodies to deal with interoperability in engineering environments in the form of extending existing standardisation activities or by opening new activities
- Expected availability for use: Q2/2017

Expected Exploitable Result
- Description: Deploy and enhance CRYSTAL UC SEE (e.g. AeroPUC)
- Business Case and Market: Siemens Engineering Teams to map solutions on their engineering challenges
- Roadmap for Exploitation: presentations at Siemens internal workshops and events
- Expected availability for use: Q2/2014

Expected Exploitable Result
- Description: Improvement of In-house system engineering framework for safety-critical software intensive systems by agile development
- Business Case and Market: Siemens Engineering Teams to map solutions on their engineering challenges
- Roadmap for Exploitation: presentations at Siemens internal workshops and events
- Expected availability for use: Q4/2015

Expected Exploitable Result
- Description: Exploitation of a CRYSTAL reference process for safety certification of critical systems
- Business Case and Market: Exploitation of the reference process developed at CRYSTAL within Siemens projects on technology development and assessment
- Roadmap for Exploitation: Instantiate the CRYSTAL process within Siemens (PLM- & Simulation-) tools with a Siemens use case to assess and improve the connection between tools, and company internal process(es)
- Expected availability for use: Q2/2015

3.1.20 SAGEM

INDUSTRY PARTNER

Organization: Sagem Défense Sécurité	**Short Name: SAGEM**

Author: Marc Malot

Relevant Markets of your company impacted by CRYSTAL
Sagem is a high-tech company in the Safran group. It is a world or European leader in solutions and services in optronics, avionics, electronics and critical software for the civilian and military markets. Sagem is the European No. 1 and worldwide No.3 in INSs for aeronautic, naval and land applications. It is also the worldwide No.1 in helicopter flight controls and the European No.1 in optronic and tactical UAV systems. Present across the globe via the Safran group's international network, Sagem and its subsidiaries employ 7,000 people in Asia, Europe and North America.
Sagem is composed of 3 divisions:
•   Optronics & Defense division (imagers and infrared and light-intensifying cameras, sights, periscopes, gyrostabilized pods),

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•   Avionics division (navigation, guidance and pointing systems, avionics equipment and systems – onboard information and piloting systems…)

•   Safran Electronics division (1,500 electronics and critical software specialists from the Safran group, printed circuit boards and electronic control units)

Sagem products are related to safety critical embedded systems. CRYSTAL, especially the envisaged CRYSTAL RTP with its interoperability specification and advanced engineering methods will help Sagem to improve its efficiency and then its competitive position on the market.

Major Benefits of CRYSTAL for your position in the Market

Sagem implication on CRYSTAL aims at using RTP and RE methods to improve the development process efficiency to save time and costs.

Using IOS standard and advanced requirement engineering methods is expected to provide:

-      an improved requirements capture and validation methodology by reusing knowledge and early tooled validation techniques,

-      a sharing of engineering methods, techniques and tools along the supplier chain,

-      a reduction of development cycle and time to market,

-      a reduction of systems development cost,

-      a lean and effective customization of engineering frameworks thanks to the emergence of a tools interoperability standard.

Competitor description

Competitors of Sagem are very variable according to the different divisions, activities and even products.

Planned Exploitation of CRYSTAL

Internal / External exploitations

Expected Exploitable Result

- Description: Available and documented enhanced Requirement Engineering Support Process on ontology and formalization allowing:

  - to share a common understanding of the terms of a project

  - to improve the validation of requirements quality.

- Business Case and Market: Sagem should first use this "requirements process" on its "Flight Control System" activities, then on avionics perimeters if significant improvement in quality of specification is measured (reduction of non-quality in development leading to reduction of cost and delays...). In case of success, this process will be deployed to the Safran group (especially Snecma...). This will impact the aeronautical market. This process, whose one of the goal is to help the stakeholders of a project understanding each other, might also be deployed among the external supply chain.

- Roadmap for Exploitation: The exploitation will be dependent on the maturity of the outcomes of CRYSTAL and on the business opportunities (new project of relevant features (size...) for supporting the deployment). The first activities should be:

  - Know-How transfer;

  - Pilot Project for benefit measures;

  - Support for deployment to a larger scope of Safran activities;

  - potential deployment on external supply chain (if confidentiality concerns have been solved)

- Expected availability for use: 1 or 2 years after the end of the project for first internal exploitation.

3.1.21 VOLVO

INDUSTRY PARTNER

Organization: Volvo Technology AB	**Short Name: VOLVO**

Author: Daniel Karlsson

Relevant Markets of your company impacted by CRYSTAL

Volvo Technology is the research company within the Volvo Group. All activities performed by the company are done with the purpose of strengthening the market position of the whole group. For that reason, the following descriptions refer to Volvo Group rather than Volvo Technology.

The Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment, drive systems for marine and industrial applications and aerospace components. The Volvo Group employs about 100,000 people world-wide and has production facilities in 19 countries and sales of products in more than 180 markets. The operations in CRYSTAL concern trucks and construction equipment, which represent the two biggest business areas of Volvo. The truck business is furthermore divided on several brands, where Volvo and Renault are the most prominent ones in Europe.

In 2011 the heavy-duty truck market in Europe 29 (EU , Norway and Switzerland) increased by 35% to 242,400 trucks compared to 2010. The situation still varied significantly within Europe. While parts of Southern Europe were struggling, other regions in Northern and Eastern Europe had recovered from the low levels of 2010. In 2012, the total market for heavy-duty trucks in Europe 29 is expected to experience a moderate decline to a level of about 220,000 trucks. In 2011, the total market for heavy-duty trucks in North America increased by 52% to 216,100 trucks compared to 142,100 in the previous year. In 2012, the total market for heavy-duty trucks in North America is expected to grow to a level of about 250,000 trucks. In 2011, the total market in Brazil increased by 2% to 111,500 heavy-duty trucks (109,800). The total Brazilian market for heavy-duty trucks is expected to record a slight decline and reach a level of about 105,000 trucks in 2012. In Japan the market for heavy-duty trucks was 24,800 vehicles in 2011 (24,500), which was an increase of 1%. Following the earthquake and the subsequent tsunami that hit Japan on March 11, 2011, there were signs of a market-recovery during the latter part of 2011 and into 2012. For 2012, the total Japanese market for heavy-duty trucks is expected to increase to about 30,000 trucks. The Indian market for heavy-duty trucks grew by 12% to 237,000 trucks in 2011 compared to 212,000 vehicles in 2010.

On these and other markets, Volvo delivered 238,000 trucks (not only heavy-duty) in 2011, out of which 95,000 in Europe. For Europe, this corresponds to a market share of 16% for the Volvo brand and 10% for Renault for heavy-duty trucks. Net sales amounted to 201bn SEK in 2011.

Measured in units sold, the total world market for heavy, compact and road machinery equipment increased by 18% in 2011, compared to 2010. After a long period of low growth, the mature markets of Europe saw rises of 31% in 2011, whereas demand in the previously sluggish North American market jumped by 37%. Asia excluding China grew by 28% and Other Markets by 14%. In China, government efforts to cool inflation dampened demand, but sales nevertheless increased by 7% in this, the world's largest construction equipment market.

In 2011, Volvo Construction Equipment had net sales amounting to 65bn SEK.

Major Benefits of CRYSTAL for your position in the Market

The major activity in CRYSTAL where Volvo is involved is in developing its own use case. The use case is based on the actual development environment used for the development of the electronic architecture. Since the majority of functionality of contemporary vehicles is based on software, Volvo has an internal goal to increase the efficiency of developing (embedded) software-based systems.

CRYSTAL's goal of establishing a standardised format for integrated exchange of data between development tools addresses one of the main bottlenecks in our current environment. Current exchange is based on files, which easily leads to consistency and versioning problems in large projects like developing a truck or a piece of construction equipment. Volvo therefore sees two major benefits for its business that cannot be underestimated:

•   Integrated development environments
•   Customisable development environments

With an integrated development environment, the tasks of different roles in the development process are more integrated: data produced by a predecessor role in one tool can be straight-forwardly used by a successor role in another tool without the need to either duplicate the data with an import mechanism, or manual recreate the data.

When all development tools comply with an interoperability standard, the possibility emerges to freely customise the development environment based on COTS tools to a specific project to a low cost as it fits that project best.

The demands on the different markets are manifold. Whereas customers demand high quality and comfort in

developed markets, the focus of emerging markets is rather on cheap and functional transport solutions. The flexibility and gained development efficiency provided by CRYSTAL's technology is expected to enable both faster reaction to market demands and needs, and also to better address the specific needs of each market. Volvo's position on the market is thereby expected to be strengthened.

Competitor description
•   Daimler is a German automotive maker with 270,000 employees. They produce both cars and trucks. Competition with Volvo is within the trucks business.
•   MAN is a German automotive maker with more than 50,000 employees. They produce heavy vehicles, such as trucks and buses, as well as diesel engines. They compete with Volvo in all these areas.
•   Scania is Swedish automotive maker with headquarters in Södertälje. They have a big market share in Sweden in trucks and buses. Competition with Volvo is within the trucks and bus business.
•   Komatsu is a Japanese manufacturer of construction and mining equipment. Competition with Volvo is within the construction equipment business.
•   Hitachi is a Japanese company that is active in a wide range business segments, amongst them transport solutions and construction equipment.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result
- Description: Integrated development environments
- Business Case and Market: Establishing a standardised format for integrated exchange of data between development tools addresses one of the main bottlenecks in our current environment for developing (electrical/electronic) functions for heavy vehicles. With an integrated development environment, the tasks of different roles in the development process are more integrated: data produced by a predecessor role in one tool can be straight-forwardly used by a successor role in another tool without the need to either duplicate the data with an import mechanism, or manual recreate the data.
- Roadmap for Exploitation:

   1) Involve engineers and experts at Volvo, representing the identified roles, both in the use case definition, in the solution creation, and in the evaluation and verification.

   2) Push tool suppliers to use the upcoming interoperability standard.

- Expected availability for use: At prototype level during the project duration. Continual integration into the commercial development environment. Use the standard in in-house development and in supplier contracting by 2018.

External exploitations
Expected Exploitable Result
- Description: Customisable development environments
- Business Case and Market: When all development tools comply with an interoperability standard, the possibility emerges to freely customise the development environment based on COTS tools to a specific project to a low cost as it fits that project best.
- Roadmap for Exploitation: Push tool suppliers to use the upcoming interoperability standard. Spread the standard in available forums.
- Expected availability for use: 2020

3.1.22 HONEYWELL

INDUSTRY PARTNER

Organization: Honeywell International, s.r.o.	Short Name: HON

Author: Jan Beran, Tomas Kratochvila

Relevant Markets of your company impacted by CRYSTAL

Honeywell is a Fortune 100 company that invents and manufactures technologies to address tough challenges linked to global macrotrends such as safety, security, and energy with approximately 132,000 employees worldwide, including more than 19,000 engineers and scientists. More than 30 000 employees are European based.

Honeywell consists of four business units, Aerospace, Automation and Control Solutions, Performance Materials and Technologies, Transportation Systems.

Honeywell Aerospace part of CRYSTAL project delivers aerospace products and services which are used globally on virtually every commercial and business aircraft operating today as well as for defence and space applications. Honeywell provides integrated avionics, engines, systems, and service solutions focusing on the technologies, that best meet customer needs to make flying safer, more reliable, more efficient, and more cost effective. Using CRYSTAL RTP, Honeywell targets high-performance navigation systems as a part of product portfolio, which supposes to be more affordable for OEMs worldwide if fundamental changes and innovation in development approach as proposed in CRYSTAL RTP are implemented.

Major Benefits of CRYSTAL for your position in the Market

Honeywell participation in CRYSTAL project is one of the key enablers in continuation with set of fundamental changes in development chain inside the company. On top of that, market for new avionics systems is opening to address growth of air traffic as well as noise and fuel consumption reduction. High-performance navigation systems are part of enabling products to respond to these market opportunities. As the affordability and OEM interest are key questions to be answered, Honeywell works intensively to improve time to market and development costs reduction by targeting modularity, portability and re-usability of particular system. As defined in proposed use case, various approaches like Cost reduction by lower-grade sensors, Preservation of performance by advanced safety analysis, Platform portability by system modularity should reduce intentions to tailor this navigation system implementation to specific aircraft where even minor system changes cause significant re-certification effort and re-application costs. On top of that, involvement and understanding of CRYSTAL RTP increases impact not only to respective avionics market but being part of such CRYSTAL helps Honeywell improve development processes and to reduce related overhead across domains also in other Honeywell business units.

Competitor description

Thales Group is a French multinational company that designs and builds electrical systems and provides services for the aerospace, defence, transportation and security markets. We compete in airborne systems, airborne radars, ground surveillance radar, optronics, EW systems, mission systems, avionics systems, avionics computers, leading market position in defence electronics.

Sagem (France) focus mainly on Aeronautics, Defence and Security. Competes in avionics (cockpit displays), aircraft data recording systems, optronics, mission planning systems for helicopters, surveillance systems.

Rockwell Collins (US). primarily providing aviation and information technology systems and services to governmental agencies and aircraft manufacturers.Datalinks& Networking, EW systems, military displays, flight displays, head-up guidance systems, integrated avionics, surveillance systems.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description: Domain ontology requirement engineering

- Business Case and Market: Using unified and restricted terminology when creating requirements will lead to less defects introduced in requirement level and enable the easier requirement formalization.

- Roadmap for Exploitation: Domain ontology will be exploited by requirement elicitation and by

> creating requirement patterns.

- Expected availability for use: 2016

External exploitations
<u>Expected Exploitable Result</u>

- Description: Formal verification tool chain
- Business Case and Market: All businesses which uses model based development can speed-up the development by using the formalized requirements and formal verification even before the system design is created. By using open integration technologies like OSLC we will enable tool interchangeability.
- Roadmap for Exploitation: Tool chain will be exploited by employing on multiple industrial projects.
- Expected availability for use: 2016

3.1.23 ALA

INDUSTRY PARTNER	
Organization: AleniaAermacchi SpA	**Short Name: ALA**

Author: Ivo Viglietti

Relevant Markets of your company impacted by CRYSTAL
AleniaAermacchi is a Large Aerospace company of Finmeccanica Group. AleniaAermacchi products range includes training aircrafts, like the M346, tactical transports, like the C27J, and participation to military joint projects like Eurofighter, the F-35 Joint Strike Fighter and the Neuron European UCAV. It also plays leading roles in commercial aircrafts with special focus on regional transports: advanced aerostructures for Airbus and Boeing, in an equal-share joint venture with EADS, it owns ATR, and withSukhoi it is developing and marketing the Superjet 100.
These products are largely based on safety critical embedded systems: the envisaged CRYSTAL RTP bricks with their interoperability specification will make systems development quicker and will raise the quality, so improving market position especially compared to raising Asian competitors.

Major benefits of CRYSTAL for your position in the market
The concepts and components of the foreseen Reference Technology Platform (RTP), based on an interoperability industry standard will improve significantly the product development lifecycle within company and with sub-contractors/partners.
A significant system development time and costs reduction has to be achieved by means of:
defining and implementing non-recurring cross project activities. They include planning and establishing a library of knowledge and practices applicable to the entire system lifecycle. In the context of CRYSTAL special emphasis will be put on preliminary design, logistic engineering and change management processes. This knowledge will represent the basis for training activities and for setting up process automation and monitoring.
By consolidating an integrated industrial "reference" tool chain we will be able to deploy a distributed and interoperable environment for enforcing the collaboration among company departments and with the sub-contractors / customers.
With respect to the past, logistic engineering aspects and cost parameters will be considered in an integrated way as part of the reference process. Reference data and process models will be defined in order to be re-used on coming projects.
The company application of CRYSTAL findings, especially practices, data model parts and integration approaches is planned to be gradual, starting in parallel with CRYSTAL activity, in order to enjoy benefits as early as possible.

Competitors description

KAI
a South Korean aerospace company, originally a JV of Samsung Aerospace, Daewoo Heavy Industries   and Hyundai Space and Aircraft Company. It is active in many sectors, including military trainers (T50); satellites and general aviation aircrafts.

EMBRAER
Embraer S.A. is a Brazilian aerospace company that was created as a government-owned corporation that produces commercial, military, and executive aircrafts and provides aeronautical services. It is the third-largest commercial aircraft manufacturer in the world.

Dassault Aviation
It is a French aircraft manufacturer of military, regional and business jets, a subsidiary of Dassault Group. Its products include the Rafale fighter aircraft and the Falcon business jet.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result

- Description: Consolidation of company's best practices based on MBSE/Harmony methodology
- Business Case and Market: These practices are in line with the plans for setting up an advanced "development process" to be employed as a reference for new products/programmes that would start early. As already pointed out in the project proposal, these new programmes include the development of a new turboprop regional aircraft.
- Roadmap for Exploitation: Validation and consolidation for methods and processes that are subject of the study. They include the MBSE itself, including logistic support aspects, the Product design configuration and change management. They can be applied starting from the product's early definition phase and would be adopted for establishing functional architectures and making trade off analysis on the basis of non-functional requirements. They will be adopted by the following departments:
  - Preliminary design
  - Avionic Systems design
  - Logistic Support

- Expected availability for use: The new processes will be adopted through an incremental approach in order to harmonize their availability with the development roadmap for the new products. This means that first applications would involve the conceptual definition phase for the new regional aircrafts development.

Expected Exploitable Result

- Description: Integration of System Engineering and PLM platforms that AleniaAermacchi is employing. They include at least IBM Rational DOORS, Rhapsody and Siemens TeamCenter
- Business Case and Market: Availability of an integrated ALM/PLM platform that interoperates through a well-established standard, such as the IOS foreseen in the context of ARTEMIS. This would also allow to easily interoperate with the tool chains deployed by the suppliers and the customers.
- Roadmap for Exploitation: Providing our industrial needs through the analysis of Use Case scenarios. The needs would allow tool providers to enhance their product's capability to interoperate according to our data-models. Our Use case includes many different scenarios that will be analysed incrementally. The higher priority scenarios will be detailed first in order to ensure a quicker reaction from tool providers.
- Expected availability for use: As per the methods, we would expect an incremental adoption of the integration techniques. The idea is starting to gain confidence with the new approach starting from early 2014. This would allow us to identify criticalities and new requirements well before the end of

the project.

Expected Exploitable Result
- Description: Reference data model to support Traceability for System Information

- Business Case and Market: Product's data traceability through the lifecycle is the key for an efficient and integrated development. Our main focus is on system functional view and on the trade-off analysis in relation with the identified design alternatives. All the different applicable review and inspection activities that are foreseen, starting from concept definition toward system design would benefit of it.

- Roadmap for Exploitation: The needs for a System functional view are being analysed first in order verify current limitations from the tools and existing data models. A domain level approach will be defined in order to ensure a common understanding about the managed information and to allow collaborative developments.

- Expected availability for use: This activity has been already started in the first year of the project and, according to the adopted incremental approach, we plan to benefit from the first result in mid of 2014.

Expected Exploitable Result
- Description: Availability of a method and a framework for efficiently defining instances of a reference System Engineering Environment.

- Business Case and Market: A concrete reduction in time and increase of quality for setting up a proper system development environment can be achieved by: defining and implementing non-recurring cross project activities. They include planning and establishing a library of knowledge and practices applicable to the entire system lifecycle. This includes support for preliminary design, logistic engineering and change management processes. This knowledge will also represent the basis for training activities and for setting up SEE deployment, process automation and monitoring. This is an exploitation for activities undertaken within WP602.

- Roadmap for Exploitation: By formally specifying and consolidating an integrated "reference" toolchain we will be able to deploy a distributed and interoperable environment for enforcing the collaboration among company departments. The Reference data and process models will be defined in order to be re-used on coming projects. Proper checks on the formally defined SEE instances will be undertaken in order to avoid inconsistencies.

- Expected availability for use: At least the identified method for defining the SEE and the needed engineering functions will be applied within the project itself. In order to extend these benefits to a concrete industrial application we first need to consolidate a reference process and tool-chain. This is of course a "live" activity that continuously produces updates. Nevertheless a first reference knowledge base could be established before M20.

External exploitations

3.1.1 THALES ALENIA SPACE FRANCE

INDUSTRY PARTNER

Organization: Thales Alenia Space France	**Short Name: TASF**

Author: Gérald GARCIA

Relevant Markets of your company impacted by CRYSTAL
European leader for satellite systems and at the forefront of orbital infrastructures, Thales Alenia Space is a joint venture between Thales (67%) and Finmeccanica (33%) and forms with Telespazio a Space Alliance. Thales Alenia Space is a worldwide reference in telecoms, radar and optical Earth observation, defence and security, navigation and science. Thales Alenia Space has 11 industrial sites in 5 European countries

(France, Italy, Spain, Germany and Belgium) with over 7,200 employees worldwide.
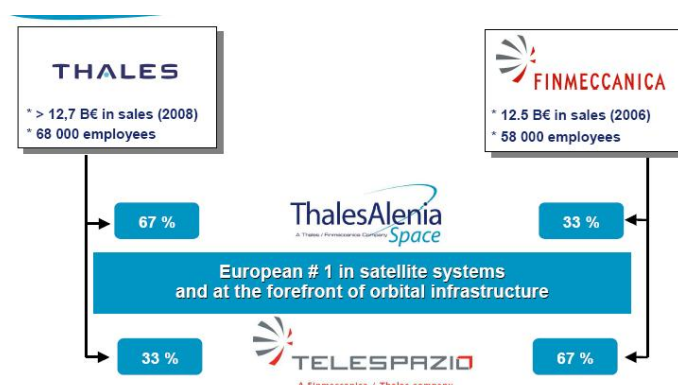
Thales Alenia Space is at the heart of the most high-performance satellite technologies in both civil and defence sectors.

The company is deeply involved in:

- Environmental projects based on Earth observation such as the Global Monitoring for Environment and Safety (GMES) program with Sentinel-1 and Sentinel-3, Meteorology such as MSG (Thales Alenia Space provided all the Meteosat satellites for Eumetsat), Climatology as satellite prime contractor for SMOS (Soil Moisture and Ocean Salinity) mission;
- Defense, as prime contractor for the French Syracuse (I, II and III) and the Italian (Sicral) telecommunication systems as well as for the Italian Earth Observation system COSMO-SkyMed and COSMO Second Generation; and main partner of the German telecom program (Satcom BW) and of the Earth observation programs Helios (France) and SAR-Lupe (Germany);
- Navigation with Galileo and prime contractor of EGNOS - the precursor of Galileo;
- Science and Exploration, as prime contractor for the GOCE satellite (Gravity Field and Steady-State Ocean Circulation Explorer), the Herschel and Planck spacecrafts, for the ExoMars mission - one of the most ambitious exploration missions in the near future -, for the Euclid spacecraft and for MTG satellites (Meteosat Third Generation) composed of 6 spacecrafts of two types (MTG-I, MTG-S)
- Space Infrastructure and Transportation as provider of 50% of the ISS pressurized volume.

Today, Thales Alenia Space is the **leading European supplier of satellite-based solutions for Defence and Security**, with strong positions in both space and ground segments. In addition, the company is the European benchmark supplier of facility operational services for the European Space Agency (ESA), the French space agency CNES, the Italian Space Agency (ASI) as well as for the French, Italian and German Ministries of Defence, the Defence procurement agency DGA and other major customers. Thales Alenia Space is also active in the civil-military satellite export market, through Koreasat 5 in South Korea, Star One in Brazil and Yahsat in United Arab Emirates.

Thales Alenia Space has signed an **industrial cooperation agreement with the Russian company NPOPM** to jointly develop a high-power multi-mission satellite platform (Express 4000) and buy from Russian suppliers common equipments for the Spacebus 4000 and Express-4000 series.

Crystal project is impacting all the Thales Alenia Space avionics business.

Major Benefits of CRYSTAL for your position in the Market
Thales Alenia space implication on CRYSTAL aims to improve the avionics engineering activities by the introduction of advances multi-view modeling tools and also multi-criteria trade-off analysis tools.

Using IOS standard and advanced modeling tools is expected to provide:
- an improved avionics design phase,
- an improve trade-off and impact analysis process,
- a reduction of development cycle and time to market,
- a reduction of systems development cost,
- a lean and effective customization of engineering frameworks thanks to the emergence of a tools interoperability standard.

Competitor description

Competitors of Thales Alenia Space are Airbus Defense and Space and OHB in Europe but also all the other satellite providers (Boeing, Space system Loral, Orbital, Koreasat, ...). Space business is very competitive at worldwide level.

Planned Exploitation of CRYSTAL

Internal exploitations

Multi-view point modelling environment

- Description: The technical solutions and the associated process enable the design of the spacecraft avionics following several viewpoints (power, mass, electrical budget, …)

- Business Case and Market: All the avionics engineers in Thales Alenia Space

- Roadmap for Exploitation: Following successful CRYSTAL use case, a adoption plan will be setup will associated internal funding to prepare operational deployment (industrialisation, user support, training, …)

- Expected availability for use: Some solutions are already available and operationally used (Eclipse based graphical modeller, …), full CRYSTAL solution will be deployed around 2017.

Multi-criteria trade-off environment

- Description: The technical solutions and the associated process enable evaluate architecture candidate according to a evaluation model merging several criteria (cost, complexity, performance, maintainability, reliability, …)

- Business Case and Market: All the avionics engineers in Thales Alenia Space

- Roadmap for Exploitation: Following successful CRYSTAL use case, a adoption plan will be setup will associated internal funding to prepare operational deployment (industrialisation, user support, training, …)

- Expected availability for use: CRYSTAL solution will be deployed around 2017.

External exploitations

Expected Exploitable Result

- Description: Adoption of IOS principles by the European space community and CRYSTAL open source solutions based on Eclipse

- Business Case and Market: All the European space industrials and the different space agencies (ESA, French CNES, German DLR, …)

- Roadmap for Exploitation: Several presentation of CRYSTAL results are foreseen during space conferences or workshops in order to present the interoperability approach, the open source Crystal tooling and the interest of it. The objective being to foster the European space actor efforts related to tooling towards a better cooperation on tools in order to reach together a stronger position.

- Expected availability for use: Dissemination already started, real adoption expected soon (2015).

3.1.2 VALEO

INDUSTRY PARTNER	
Organization: Valeo FR	**Short Name: VALEO**
Author:	

Relevant Markets of your company impacted by CRYSTAL

No input received from partner

Planned Exploitation of CRYSTAL

Internal exploitations
No input received from partner

Expected Exploitable Result
- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

External exploitations
No input received from partner

Expected Exploitable Result
- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

3.2 Technology Providers

3.2.1 ALL4TEC

TECHNOLOGY PROVIDER	
Organization: All4Tec	**Short Name: ALL4TEC**
Author: Frédérique Vallée	

Short description of your contribution to CRYSTAL

ALL4TEC is a small company (SME) fully independent of major companies. Over fifteen years of funding - Turnover of 4 M€ in 2011- 55 people. Two main activities: Consultancy & Expertise team for one side and Software solutions on other side.

Main skills: Complex Systems Engineering ; Dependability and Reliability Engineering ; Process Improvement Engineering

Existing tools: Matelo (for MBT - Model based testing) and Safety Architect (for MBSA - Model based safety analysis).

Standards: CMMI, all safety standards.

Market: Industry (Automotive, Railway, defense) and IT.

ALL4TEC will contribute to CRYSTAL in providing its tool and expertise in safety analysis and assessment of complex systems. ALL4TEC consultants have merged their skill in system engineering and safety analysis in order to propose a risk analysis method that can be applied at the different phases of complex systems definition and design. This method has been implemented in the ALL4TEC tool named: Safety Architect which offers facilities for generating automatically fault trees from a description of the functional or physical architecture of the system (or software) and an analysis of its elementary components failure mode (similar to a FMEA - Failure Mode and Effect Analysis).

Safety Architect is a MBSA tool that has been designed with the objective of being easy to use in a MBSE (Model Based System Engineering) process. In that sense its interfaces (inputs as well as outputs) have been thought in order to ease the exchange between Safety Architect and other MBSE tools (mainly specification and design tools as input and FTA (Fault Tree Analysis) tools as output).

Thus, one objective of ALL4TEC contribution in CRYSTAL is to integrate Safety Architect in the Artemis RTP.

The other objective is to provide ALL4TEC skill in a Railway use case in order to demonstrate the benefits of using ALLTEC tools and methods when complex critical systems must be designed and assessed.ALL4TEC MBSA method and tool can be provided to all markets facing critical complex systems such as Aeronautic, Automotive, Health Care, Defense etc.

Major Benefits of CRYSTAL for your position in the Market

From the moment where critical embedded systems (with critical embedded software) appeared till now, ALL4TEC has taken market shares to help industrial assessing their systems safety. Today this regularly growing sector represents half of our activity. The safety design and assessment of these systems combined with the emergence of very stringent standards are a stronger problem for the industrial community. Our tool, Safety Architect is one of our spearheads and compiles many of our know-how in safety. But this tool does not yet address all systems, in particular large interconnected systems. CRYSTAL can contribute fully to the further development of Safety Architect. Extending its functional and technical perimeters would help us to open new industrial markets: Aeronautics for example.

The expected benefits for ALL4TEC are:

•to have an offer which remains competitive in terms of training, expertise and studies and address even more new clients,

• to strengthen the functional and technical perimeters of our tool Safety Architect,

• to continue our company diversification.

Direct benefits in terms of employment can be evaluated to a dozen safety engineers' jobs in 3 years and probably the double at the horizon of 5 years. Benefits are also expected on our R & D team in charge of

designing and developing our products. One can imagine recruitment up to 5 R & D engineers int the 3 next years.

Competitor description

The main competitors to Safety Architect are:

- Medini tool from IKV+
- BPCDAS tool from DASSAULT System
- SIMFIA tool from APSYS (EADS)
- ITEM TOOLKIT from ITEM SOFTWARE
- IQRM tool from APIS

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result

- Description: Railway-specific features for Safety Architect

- Business Case and Market: All people involved into safety analysis in the railway domain will benefit from our new product facilities. They will be able to automate their safety activities on more and more complex systems and to link them with system engineering activities

- Roadmap for Exploitation: Marketing: creation of new plugins for Safety Architect

- Expected availability for use: 2015

3.2.2 ARCCORE

TECHNOLOGY PROVIDER	
Organization: ArcCore AB	**Short Name: ARCC**

Author: Johan Ekberg

Short description of your contribution to CRYSTAL

ARCCORE is a leading provider of state-of-art AUTOSAR products and services for the embedded systems market. Based on a solid expert knowledge in real-time platforms, we develop and market products for the software industry enabling our customers to develop innovative solutions in a faster and more cost-efficient way.

ARCCORE will bring its standard tools for Autosar development into the project and will adapt them so that they comply with the interoperability standard developed by CRYSTAL. By doing so ARCCORE can be part of the standardization process and give input to it so the standard develops in a direction that makes it easy to adapt other tools to the standard. This will give the standard a better ground and will lead to better acceptance by other tool vendors.

Major Benefits of CRYSTAL for your position in the Market

By being part of the CRYSTAL project ARCCORE can continue strengthen the product portfolio so it can be a tool that can fulfill one "brick" in a bigger tool-chain. It is important for a small company like ARCCORE to be part of a such a community of tool providers that makes it possible to be a supplier to the large companies of embedded software development.

The project will also create a network that small companies like ARCCORE can benefit from. This will strengthen the ARCCORE brand and create sales channels that have not been available to ARCCORE before.

In addition this work will be performed with the help of academic resources in order to bring in the latest state-of-the-art from research. This will help the tool vendors to develop the best of tools and because of the tight connection with real product development, these tools will be exploitable with low effort. In other words results of CRYSTAL can probably be put into operation as early as 1-2 years after project end.

Competitor description

Vector Informatic (Germany) – is the main player in the tool market to the Automotive industry. They are also one of the major vendors for Autosar tools and have been part of the Autosar standardization organization for a long time. The revenue of Vector was over 100 MEUR 2006.

MentorGraphics (USA) – is a tool vendor for many different markets. They have a long history of delivering real-time operating systems and also CAD solutions for electronic boards. During 2007 Mentor released a product portfolio that complies to the Autosar standard.

Elektrobit (Finland) – from the beginning a service provider that acquired 3soft from Germany a few years ago. 3soft has been around for many years in the Automotive industry where they have been delivered platforms complying to the OSEK standard. They also have an Autosar-product platform that is sold to OEMs.

KPIT (India) – one of the fastest growing tool providers. Today they provide development tools for Automotive, Energy and Industry. They have also expertise in Semiconductors.

Mecel (Sweden) – has developed a Autosar tool suite that will be used within Delphi organization but will also be sold to other parties. Mecel and MentorGraphics use a mutual development organization to develop their tools.

Planned Exploitation of CRYSTAL

Internal / external exploitations

Expected Exploitable Result

- Description: Framework to develop Automotive software in a multi user/multi tool environment

- Business Case and Market: The development of new Automotive ECU will benefit from a tool chain that can use multiple source of information to get a more reliable and correct behaviour.

- Roadmap for Exploitation: The product portfolio will be extended and the result will be used by internally in the company, customers and research programs.

- Expected availability for use: During the next five years

3.2.3 OBEO

TECHNOLOGY PROVIDER

Organization: Obeo	Short Name: OBEO

Author: Stephane Lacrampe

Short description of your contribution to CRYSTAL

Obeo is a leading company for the provision of model driven software solutions and services. Involved in several Eclipse projects and being an Eclipse Foundation Strategic member, Obeo provides key expertise in building products being commercial or open-sources, on top of the Eclipse technologies.

Obeo contribute strongly to SP6 by leading WP 6.9 for Multi-Viewpoint engineering. We will work on providing an open source component for graphical modelling in a multi-viewpoint environment, as well as providing a Web based solution for graphical modelling. Obeo will also work on requirement management in the context of multi-viewpoint modelling. Obeo will also support uses cases for integration and use of the provided bricks. Finally, Obeo will be involved in exploitation and dissemination.

The component that Obeo will provide as open source is already part of the Obeo Designer product (http://www.obeodesigner.com). It is already deployed and used by very large industrial companies on large scale projects. It is used in a very large variety of domains like defense, aerospace, transport, energy…

Major Benefits of CRYSTAL for your position in the Market

Obeo will be able to get substantial benefits from the CRYSTAL project.

Obeo will use the Eclipse Foundation (as a strategic member) and other open source dissemination like the PolarSys (http://wiki.eclipse.org/Polarsys) Industrial Working Group vector to disseminate its technology. This is a very important and strategic move for the company. We will take a unique position on the market

and the company will reshape its Business Model accordingly to the open source availability of this strategic component.

Our position will disturb the market and will enable us to reach a significant growth as we plan to have an increase by 2 of our revenue 2 years after the end of the project.

From a technical point of view, CRYSTAL will give us the opportunity to develop a Web version of our product. This will give us a technical advantage on the market as well as the opportunity to develop new Business Models using Web selling models.

Finally, the CRYSTAL project represents a great opportunity for Obeo to reach new large European customers and to develop its Business abroad as well as reinforcing its current partnerships with very large partners.

Competitor description

Main competitors for Obeo in the field of graphical modelling for DSLs are IBM (USA), NoMagic (USA) and MetaEdit (USA).

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result

- Description: Technology brick "Sirius" (http://www.eclipse.org/sirius): modeling technology to create easily industrial level modelling workbenches is exploited through a product called Obeo Designer.
- Business Case and Market:
  - The brick can be used by large industrial company to improve management of system complexity by providing a way to model system architecture et realize early validation at design time
  - Typical markets are industries like aerospace, aeronautics, defence, energy, transport including large system integrators.
- Roadmap for Exploitation: Exploitation has already started, one of our main customers being Thales for this brick. We are also targeting others French customers. We plan to exploit it in North America as well, starting mid 2014
- Expected availability for use: Obeo Designer 7.0 will be available by mid 2014 for exploitation and will include Sirius. Other versions will come next year with new versions of Sirius including further improvements.

Expected Exploitable Result

- Description: Technology brick "Sirius" (http://www.eclipse.org/sirius) including "Web modelling": modeling technology to create easily industrial level modelling workbenches is exploited through a product called. Obeo SmartEA
- Business Case and Market:
  - Obeo SmartEA is used for enterprise architecture, meaning a modelling practice for conducting enterprise and IT System analysis, design, planning, and implementation, for the development and execution of strategy
  - Typical markets are very large companies like banks, insurance, etc…
- Roadmap for Exploitation: Exploitation has already started as the product is on the market, but the product needs to be migrated to Sirius. As soon as it is done, we will exploit it on the French market and we are also targeting North America
- Expected availability for use: Obeo SmartEA 2.0 will be available in 2015.

3.2.4 SYSTEMITE

INDUSTRY PARTNER	
Organization: Systemite AB	**Short Name: SYS**
Author: Johan Fritzson	

Short description of your contribution to CRYSTAL

Systemite is a company with a product, SystemWeaver active in the field of Embedded Systems Life Cycle Management (ESLM) since more than 10 years.

Systemite is mainly active in the Automotive and Truck&Bus domain currently. However the technology as such is not limited to be domain specific. One of the big benefits we expect from this project is the possibility to deploy SystemWeaver for new domains as medical and aviation. Our current installed base is about 4.000 licenses worldwide that all could have a benefit of a successful CRYSTAL project. Our product SystemWeaver will be a brick of its own inside CRYSTAL, but we will also develop new bricks for integrations in the Volvo use case. We currently support EAST/ADL, AutoSar, ISO 26262 and several other process and technology standards.

SystemWeaver as information plat form is already to use cross domain and doesn´t as such put any pre requisites as it is completely configurable through a meta model concept to support various technologies and processes. We expect that the output from our CRYSTAL efforts should be re-usable in several other markets. Our contribution will be to bring more than 10 years of experience in tool integration in large organizations to the project. Specifically but not limited to the automotive industry.

Major Benefits of CRYSTAL for your position in the Market

We expect that the RTP and IOS will enable us to easier exchange data with tools from other tool vendors. As the integration of other tools and exchange of data to our plat form is an essential part of our business model, we hope that RTP and IOS will enhance functionality, improve robustness and openness and of course by the end of the day save time and money for our customers. IF RTP and IOS arrives to be a market standard this will open up new opportunities that can increase our growth substantially. Just the fact we do not have to deal with the fear of potential buyers of doing business with a small company is a major reason that we are taking part of this project. The success of RTP and IOS will open new business possibilities in new segments, enable us to have partnerships with larger players as PTC and Siemens PLM and also increase our foot print globally in the Automotive industry. The impact of that is very difficult to forecast, but would probably mean a growth of at least 100% over 5-6 years for us in a type of business we simply cannot do today.

Competitor description

Siemens PLM. The big leader within mechanical PLM, with several interfaces to our activities.
PTC. That by the acquisition of MKS have a good offering also for Embedded Life Cycle Management.

Planned Exploitation of CRYSTAL

External exploitations

Expected Exploitable Result

- Description: Tool improvements in our background – the SystemWeaver platform.

- Business Case and Market: SystemWeaver, presented as background in CRYSTAL, will be improved to generate a foreground having e.g. better interoperability with other tools and formats. Our customers will benefit from the enhancements made to the bricks during CRYSTAL.

- Roadmap for Exploitation: Since the results of the CRYSTAL WP6.1 and 6.8, as technology bricks, is being integrated into the current state of our tools already in the market; it will be almost straightforward go generate a commercial version including some of the most interesting improvements achieved during CRYSTAL.

- Expected availability for use: New versions of SystemWeaver are released several times every year. The plan is to include selected improvements coming from CRYSTAL as soon as possible beginning already in 2014 and continuing till the end of the CRYSTAL Project.

3.2.5 ARCT

TECHNOLOGY PROVIDER	
Organization: Arcticus Systems AB	**Short Name: ARCT**

Author: Kurt Lundbäck

Short description of your contribution to CRYSTAL

Arcticus Systems provides methods and tools that support component-based and model-based development of reliable and cost effective construction of safety critical real-time systems. Such applications focus upon properties such as functionality, timing guarantees, quality, reliability, availability, provability, and reproducibility. Model based development for dependable real-time systems defines both the design methodology and scope of the Rubus tool suite.

Arcticus has participated in a number of state of the art research projects for more than 20 years. It has resulted in Rubus tools and methods for development of dependable safety critical real-time systems. The tools are recognised as state of the art and are industrially used by our customers to develop critical, predictable and resource efficient embedded systems, primarily within the business sectors of road and off-road vehicles.

The Rubus concept consists of the Rubus Component Model, Rubus Analysis Model and the Rubus Run-Time Model. Arcticus strategy is to coordinate and synchronise the models to achieve easiness of usage and a resource efficient as well as predictable generation of the resulting system.

There is a strong requirement from our customers to achieve a holistic software engineering process that includes our methods and tools for software implementation with models and tools aimed for efficient requirements management and early verification & validation techniques to achieve safe systems.

There is a need to increase the effort in software engineering to increase efficiency and productivity, enhance the software quality and reduce lead times.

The approach taken for Arcticus contribution to CRYSTAL is to satisfy the needs focuses on current industrial practice, but is at the same time inspired by research. The core is a use case based on the tool environment currently used at Volvo. This implies that the results of the project can be easily and straightforwardly exploited by product developers.

In the Timmo-2-USE project our task was to develop an EAST-ADL editor. Our experience of the EAST-ADL model in combination with our developed editor implies that we have knowledge and a platform that can be extended to support future interoperability between our customer's critical tool providers.

Our contribution in CRYSTAL:

-            The Brick 3.65 includes improvement of our tools to support interoperability with the CRYSTAL standard

-         Improvements and extensions of our off-line analysis in the Rubus Ananalysis Model supporting integration with other models.

Major Benefits of CRYSTAL for your position in the Market

After the project, we anticipate that we will have built essential cornerstones for achieving a considerable more efficient software development for our customers. Moreover, due to the tight connection with real product development, these cornerstones will be exploitable with low effort. We therefore estimate that most results could be put into principal operation within the project.

Our effort is to offer to our customer the software engineering tools that are a mean for them to be leading in theirs product development and to keep Sweden a country attractive to invest in for software development.

The base for our global companies to stay and prosper in Sweden is our capability to be on the edge of technology research commercialized by small companies as Arcticus.

By participating in the CRYSTAL project Arcticus together with the other partners will have impact in supporting our customers and other industry to increase its efficiency and productivity in its software development.

Our position on the market and the major benefit is related to our ability to improve and satisfy our customer's needs and requirements now and in the future.

The major benefit is that our customer increases its efficiency and ability and competitiveness in product development.

Competitor description
The Rubus concept defines tree different views of the software of a real-time system, each aiming at expressing and displaying different kind of information about the system supported by the tools: •   Viewpoint of the developer/development team   •   Viewpoint of the analysis framework   •   Viewpoint of the run-time systems   The Rubus concept is unique in supporting these viewpoints in its models and tools.

Planned Exploitation of CRYSTAL

Internal / External exploitations
Expected Exploitable Result   • Description: Improved model interoperability in our tools   • Business Case and Market: Our customers   • Roadmap for Exploitation: Extend functionality of our product line to our customers   • Expected availability for use: End of the project

3.2.6 SOYATEC

TECHNOLOGY PROVIDER	
Organization: Soyatec	**Short Name: SOYATEC**

Author: Yves Yang

Short description of your contribution to CRYSTAL
Soyatec has a deep knowledge and rich experience on the business modeling (EMF, UML and BPMN) and on the UI development. It could provide an adoptive and high extensible design tool to generative application UI based on business model.   Soyatec, a member of the Eclipse Foundation and Microsoft Partner, combines SaaS (Software as a Service) solutions with the open source Eclipse. Our strategy is to contribute to projects of great value for companies in ECLIPSE and lead the community to earn the authority and popularity. These allow, initially, the company to evaluate, develop applications without brakes while keeping the continuity of the solution, and then contact us and directly engage the services of maintenance, the expertise, the Adding new features and fixed project completion.

Major Benefits of CRYSTAL for your position in the Market
Model-Driven Engineering is a modern, standard and software engineering in the industry. It refers to a range of development approaches that are based on the use of modeling software. It is an innovative solution that fundamentally solves the problems of productivity. The software industry has traded to focus and invest in this approach.   Model-Driven Engineering Open Source presents a strong potential market for SaaS companies in the years to come. Modeling in Eclipse projects and projects of research in France and in Europe has demonstrated this tendency.   The UI is the visible part of the software. It is, in fact, the door by which the realized functionality is made available to users and it reflects the quality of the applications. The realization of Visual composition and interactivity is an important task of the programming of software applications. In the current state, the UI development suffers many ills: •   Execution environments very varied: Client heavy, Web, Mobile, Tablet, etc.;   •   Multiple specific technologies for each environment;   •   Lack of tools that the various experts of UI work together as ergonomists, graphic designers and computer scientists;   •   Very long evolution and development.

PMF is an innovation solution of Model-Driven Engineering for UI. It targets to resolve the above problem in the software engineering.

To Soyatec, CRYSTAL allows us to improve and extend our solution in a real application context, and promote this solution in a specific domain via wide partners.

This solution plays a capital role on this strategy SaaS. It plans to open 2 employees during the development. Afterwards, we expect to open 3 employees each year to focus on the custom services.

Competitor description

MDE for UI is new concept in software engineering. There are few products in software market. Some research projects and specifications are ongoing.

OpenXava - http://www.openxava.org

OpenXava is an AJAX Java Framework for Rapid Development of Enterprise Applications.

It is in fact a pure development tool, not a design tool.

UsiXML- http://www.usixml.org/

UsiXML (which stands for USer Interface eXtensible Markup Language) is a XML-compliant markup language that describes the UI for multiple contexts of use such as Character User Interfaces (CUIs), Graphical User Interfaces (GUIs), Auditory User Interfaces, and Multimodal User Interfaces.

In terms of design goal, UsiXML takes the same concept as PMF. It focuses on the functional design. PMF focuses on presentation Pattern. They are complementary. The goal of this project is to merge PMF with UsiXML progressively.

Planned Exploitation of CRYSTAL

Internal exploitations

No input provided

Expected Exploitable Result
- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

External exploitations

No input provided

Expected Exploitable Result
- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

3.2.7 TASE

TECHNOLOGY PROVIDER	
Organization: THALES ALENIA SPACE ESPANA, SA	**Short Name: TASE**
Author: Angel Alvaro Sanchez	

Relevant Markets of your company impacted by CRYSTAL

TASE equipment has been based in fixed program devices such as antifuse FPGAs and ASICs. This strategy proves to be obsolete and brings limitations to our products such as the Telecom On Board Processor (AmerHis) for broadband IP communications through satellite. This product is entirely based on ASICs to perform on board signal processing functions. This approach was the only available when the program was started, but burdens our product as long as, once the ASIC is manufactured, any evolution in the standards or in the requested functionality is not supported. Cisco has started to develop a solution based in US ITAR microprocessors with redundancy and voting. If we want to keep ourselves in the market we need to develop a programmable solution. Manycores are foreseen to implement the 5 present ASICs inside one single FPGA SoC. Therefore TASE has a running R&D project self funded to implement a manycore based on the instantiation of several LEON4 IPs inside a single FPGA. This development has several product targets:

1) Video Data Processing: Thales Alenia Space España is responsible within Thales Alenia Space Corporation of the Medium Resolution Sensors for Optical Earth Observation; This means that we develop Video Compressing Units and Data compressing units for space applications. Here the manycores will have a very relevant role in two fields:

      A) Manycore Video Processor can be used for flight adding voting and redundancy techniques to achieve lighter more powerful processors with lower power consumption. Ideally, these processors should be Radiation Hardened, but, if not possible, the very manycore architecture can be used to provide resistance to the effects of space radiation through graceful degradation and active reconfiguration techniques.

      B) Video Chain Simulation: Manycores can be used to simulate and optimise the entire Satellite Video Chain prior to its manufacturing and launch.

      2) Telecom On Board Processor: Manycores are foreseen to implement the 5 present ASICs inside one single FPGA SoC.

Major Benefits of CRYSTAL for your position in the Market

The proposed CRYSTAL developments will provide an entire toolset to define the system, certify the software and reuse the different elements for different equipment implementations, accelerating and improving this transition plan from ASICs to manycore-based SoC architectures.

From a quantitative point of view, the following impacts of CRYSTAL project are foreseen:

•   R&D Acceleration: TASE original program has foreseen to have the first space-worh Leon3 SoC for 2016 and the Leon4 SoC not earlier than 2018. The acceleration provided by CRYSTAL in terms of tools and portability will allow TASE to aim directly for the Leon4 SoC that will be now available by the end of 2015, while the first breadboards both in terms of HW and SW should be available by the end of 2014. This means a reduction of the overall R&D plan of around 2 years with the corresponding impact in sales as long as TASE will be leading this transition to the multicore application for space.

•   Bussiness Increase: The results from CRYSTAL will impact in the business figures by providing new elements and design tools to improve the performances of our products and therefore to increase their marketability. For example, in the On Board Processor product line, CRYSTAL will allow TASE to develop its next generation of On Board Processor that will be properly defined as Space Router. This new space router will have reconfigurable protocols and waveforms allowing it to be adapted to new standards others than the present DVB.Concrete added value from these results will be:

-Open Access to the US and Asia markets for our new Space Routers
-This will mean multiply by 4 the accessible market (from 12 to 50M€ accessible per year)
-With present market share, CRYSTAL improvements will allow increasing Space Router Sales from 8M€ to 24M€ by 2015.

•   Employement Increase: The market impact foreseen for CRYSTAL and presented in the previous section will have a direct translation in a headcount increase in TASE digital engineering department, where the incorporation of, at least, 5 electronic engineers is foreseen. In addition to this, the development of the new SoC capabilities in TASE will call for the close cooperation with Universities. In this domain, TASE foresees to sustain up to two PhD Scholarships per year in the period 2012-2015.

Competitor description

EUROPEAN:

-ASTRIUM: Leader in Video processing units for earth observation

-RUAG: Manufacturer of Processor Based Data Handling Equipment

AMERICAN:

-SEAKR: Main competitor in manufacturing Space Router Data Processors

-BOEING: Manufacturer of Processor Based Data Handling Equipment

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Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description: Image Data Processing

- Business Case and Market: Image Compressing Units and Data compressing units for space applications.

- Roadmap for Exploitation: The results from CRYSTAL will impact in the business figures by improving methodologies, elements and design tools to improve the performances of our products and therefore to increase their adaptability, and thus, their marketability.

- Expected availability for use: In a 5-years term

Expected Exploitable Result

- Description: Telecom On Board Processing

- Business Case and Market: Processors with several cores are foreseen to implement the 5 present ASICs of AmerHis project inside a single/double FPGA SoC

- Roadmap for Exploitation: tbd

- Expected availability for use: In a 5-years term

Expected Exploitable Result

- Description: Rover exploration

- Business Case and Market: Autonomous control and guidance units for future planetary rovers missions

- Roadmap for Exploitation: tbd

- Expected availability for use: In a 5-years term

3.2.8 TRT

TECHNOLOGY PROVIDER

Organization: Thales Research & Technology France	**Short Name: TRT**

Author: Le Noir Jérôme

Short description of your contribution to CRYSTAL

Thales develops its strategic capabilities in component, software and system engineering and architectures through its R&T organization. Designing and developing the mission/safety-critical information systems that underpin the company's leadership in aerospace, defence and security markets calls for comprehensive expertise in increasingly sophisticated technologies and the ability to integrate these technologies with large-scale software driven systems.

Thales SA is involved in the project through its corporate research center, the Thales Research &Technology

centre from Palaiseau (France), more especially the Model Driven Engineering Lab (MDEL) which competences are structured in two fields:

Modeling core technologies which covers the underlying technologies visible or not to tool environment end-users but which are necessary to support specialized engineering features in term of architecture style and/or required quality of service.

Specialized engineering features dedicated to specific domains (e.g. component based modeling for safety critical avionics). Specialized engineering feature is also a large field covering component based engineering, service based engineering, massively parallel architecture engineering, and several quality of service engineering concerns such as security, performance and safety.

Within Thales Research & Technology, The Model Driven Engineering Lab mission is to provide innovative solution for system and software engineering. This lab works with ESS (Engineering Shared Services) for providing short- and long-term competitive advantage to the Thales Group by capitalizing and transferring leading edge Engineering knowledge, processes, best practices, as well as solutions, technologies & skills.

Planned Exploitation of CRYSTAL
Internal exploitations Expected Exploitable Result • Description: MVE environment • Business Case and Market: Thales system engineers will benefit from the MVE environment in order to create their own views • Roadmap for Exploitation: Enhance good practices in viewpoint creation • Expected availability for use: 2016

3.2.9 TRAIL

TECHNOLOGY PROVIDER	
Organization:	**Short Name: TRAIL**
Author: Peter Tummeltshammer	

Short description of your contribution to CRYSTAL
As a competence centre in Austria, Thales is responsible for the "TAS Platform", a technology platform for all types of safety critical transport applications. It consists of a range of hardware and software components with associated methods and tools for creating safer and more reliable real-time embedded systems, and is used in about 60 percent of worldwide Signaling Solutions installed by Thales. In addition, the success of ERTMS / ETCS applications (European Rail Traffic Management System / European Train Control System) has made the location in Vienna a centre of excellence for ETCS Level 1 technologies. As such, it has not only implemented the first commercial solution successfully in 2001 in Bulgaria, but is now a global market leader with a global market share of around 30%. As a total system supplier Thales provides solutions for the infrastructure as well as on-board systems.

Planned Exploitation of CRYSTAL
Internal exploitations Expected Exploitable Result • Description: Tool support for capturing safety driven design features derived from safety requirements and safety analysis • Business Case and Market: Validation time reduction through facilitation of the validation of design measures stemming from safety requirements. • Roadmap for Exploitation: Use of methodology in future safety analyses on products based on model driven engineering • Expected availability for use: 3-5 years

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Expected Exploitable Result
- Description: Tool support for model based automated test generation
- Business Case and Market: Shorter time-to-market and cost reduction through ease of the V&V process.
- Roadmap for Exploitation: Implementation of automated test case generation as part of the standard testing methodologies within the working group
- Expected availability for use: 3-5 years

3.2.10 TGS

TECHNOLOGY PROVIDER	
Organization: Thales Global Services	**Short Name: TGS**
Author: Daniel Exertier	

Short description of your contribution to CRYSTAL

Thales Global Services SAS is a corporate unit of the Thales Group which centralizes Shared Services for all Thales operational Units in the domains of Engineering, Information System, Purchasing, Quality, Human Resource, etc. For the Engineering domain, TGS supplies services in terms of knowledge sharing, methodologies, tools, workbenches, maturity assessment and continuous improvement. TGS is in charge of developing and deploying workbenches based on "Model Driven Engineering (MDE)" technologies. TGS has a lot of expertise in architecture engineering workbenches for different applications and for different specialities. TGS implements the Thales strategy in term of partnership for technical innovations and is fully involved in this project, as well as in the projects ITEA2 OPEES, Artemis MBAT and FSN/BGLE AgeSys and Sys2Soft.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result
- Description: MBE environment
- Business Case and Market: Case: Development and usage of Model Based Engineering environments, extension of these environments with Engineering Viewpoints (know-how capitalisation & reuse). Market : internal (Method&Tools engineers, System engineers, Engineering Experts)
- Roadmap for Exploitation: Create a Thales internal Kitalpha training course
- Expected availability for use: 2016

3.2.11 TTTECH

TECHNOLOGY PROVIDER	
Organization: TTTech Computertechnik AG	**Short Name: TTECH**
Author: Andreas Eckel	

Short description of your contribution to CRYSTAL
For a brief company introduction for TTTech, please refer to the description provided as an industry partner in chapter 3.1.17. Please note that TTTech acts as an Industrial Partner and Tool Vendor Partner.
TTTech will work on three different Bricks within WP 6.5. These comprise
- a) theTTTech TTEthernet design and development tools and the configuration tools for the TTTech SoS Infrastructure currently under definition and development. Such tools will be integrated into the

RPT / IOS in order to allow seamless use within the state of the art automotive tool framework generally applied in today's automotive design and development processes. These TTTech tools will require significant enhancement compared to the currently available COTS products in order to fulfil all required functionality for application of TTTech SoS Infrastructure (see Figure)

b) the TTTech SoS Infrastructure Middleware Bricks provided in order to support all data communication and control communication tasks on the SoS Infrastructure. Their basic design needs further enhancement and research in order to finally satisfying commercial requirements.

c) The TTTech SoS Infrastructure wireless interface (see Figure) that will allow to connect the OEM to the car (car2x) and to connect the cars among each other (car2car) communication. It will also connect the car to the world wide web. All together this will also support the efforts to provide an "Apps Store" functionality as well as sophisticated DAS implementation.
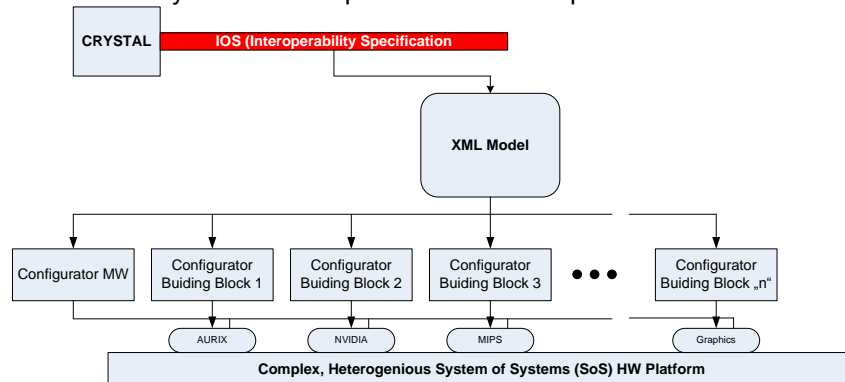
Figure: basic Bloc Diagram of the TTTech SoS Infrastructure

Cross domain, similar applications are detected in the area of off-shore wind power plants when connected to the internet. Off shore power plant OEMs target is to use control functionality via secured data communication transmitted via standard internet channels. In addition such application is also found useful in aerospace and railway domains.
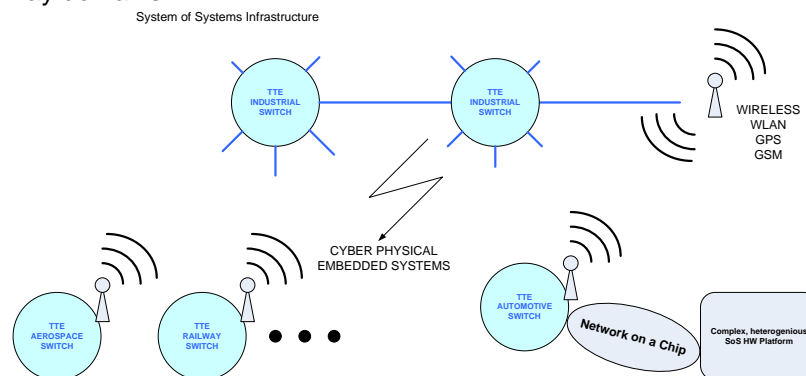
Figure: Wireless connection for cyber physical, embedded systems within the SoS Infrastructure

Major Benefits of CRYSTAL for your position in the Market

Concerning particular benefit resulting from the improved tools and other bricks and their integration in the RTP / IOS TTTech needs to state that a view detached from the considerations provided as Industrial Partner are not justifiable. Since the tools and bricks considered here are solely provided by TTTech they are essential to use the SoS Infrastructure efficiently and thus will also require to seamlessly fit into the tools landscape of today's state of the art design and development process. The TTTech goals formulated within the Industrial Partner considerations are impossible to meet in case the tool and bricks sector would lack behind.

Competitor description

Apart from Robert Bosch GmbH and Continental we would add Elektrobit and potentially dSpace here. However, the competition in the concerned area of Tools related to the TTTech offer is somewhat different since the TTTech Tools currently enjoy a monopoly situation on the market. The competition is more seen on

a technology level than with respect to tools themselves.

Again Elektrobit and dSpace do also offer a wide range of development tools which can be interpreted as an "indirect competition" to TTTech's offer.

Planned Exploitation of CRYSTAL

Please refer to the description provided as an industry partner in chapter 3.1.17

3.2.12 REUSE

TECHNOLOGY PROVIDER

Organization: Centro de Innovación y Soluciones Empresariales y Tecnológicas, S.L.	Short Name: REUSE

Author: José M. Fuentes (josemiguel.fuentes@reusecompany.com)

Short description of your contribution to CRYSTAL

Description of the company

The REUSE Company (referenced as REUSE as its short name), as a trademark of CISET, S.L.U., is a SME that was created in 1999 as a spin-off of the Carlos III University of Madrid. The company was created by a group of engineers and researchers with experience in Software and Systems Engineering as well as Information Science. The mission of REUSE was (and is) to improve the maturity of Software and Systems engineering processes by the application of ontology driven solutions and services

The REUSE Company is one of the three brands held under the CISET S.L.U umbrella (together with OVERTI and CISET). The REUSE Company: commercializing solutions and services aligned with the contribution of the company to the CRYSTAL project

•   Requirements management, requirements quality and reuse

•   Knowledge representation and knowledge management

•   Semantic indexers and search engines

•   Training center with a wide courses portfolio about ITIL, ISO 20000, PMP, CMMI and other IT topics.

Contribution to CRYSTAL

REUSE will be the leader of WP6.7. REUSE will contribute with the following bricks:

•   Requirerments Quality Analyzer

•   Requirements Authoring Tool

•   knowledgeREUSER

Furthermore, REUSE has an important knowledge and expertise in other bricks such as:

•   Ontology approach

•   Boilerplate approach

•   Pattern based approach

Our mission in the CRYSTAL project is to enhance the methods, and apply them to enhance the technology and the tool bricks described in this document. According to our experiences, both empirical but also practical in our customer's houses, this kind of approaches can be used to:

•   Provide accurate quality analysis on system requirements specifications based on a CCC criteria

•   Provide assistance for system engineers and business analysts while they are writing requirements

•   Give support to automatic traceability among different kind of assets produced all over the System Development Life-cycle

•   Provide a way of fine-grain reuse capabilities

The proposed CRYSTAL developments will provide an opportunity to gather needs and requirements from companies involved in really big projects, as well as a testing benchmark of our enhanced tools in such big projects. Furthermore, the integration of our tools and technologies into the IOS proposed by CRYSTAL will provide the System Engineering companies with a toolset to be applied to some new kind of artifacts not yet covered by our tools (e.g. test scenarios, risks…), where the results could be as positive as they're today when we apply our technology to requirements specifications.

All the tools and methods described in these two lists can be easily applied to many different domains, all of

the included in the CRYSTAL project, as well as other domains not covered by this project.

Major Benefits of CRYSTAL for your position in the Market
R&D Acceleration
The effort of at least one more person will be applied to the current team thanks to the CRYSTAL project. Furthermore, the current R&D our company is outsourcing in some universities in Spain, as well as the current agreements with some universities out of Spain, will be strengthen thanks to the CRYSTAL project. These R&D agreements are aiming some of the same goals we are aiming to cover in the CRYSTAL project. On the other hand, joining together such big companies in the same project will accelerate the way of obtaining results and gather experiences from real users.
Joining together these two points, The REUSE Company plans to reduce in 1 year the launching of a brand new version of our toolset by reducing (reducing in time, while intensifying in a matter of effort) the R&D stage.

Business increase
The opportunity that CRYSTAL projects offers us to really focusing on big System Engineering companies, instead of the focus our company had until year 2011 on Software Development companies, will open a broad set of possibilities that will really impact the business figures of the company.
In this way, The REUSE Company is planning the lead –worldwide- the market niche of tools focused on assessing the quality of requirements specifications.
Furthermore, the challenge of opening to new markets out of Europe will contribute to increase our exports in the line the Spanish Government is currently pushing all the Spanish companies. US and Asia will be explored thanks to the enhancement of the tool. Also, becoming a well-known toolset among all the European companies involved in the CRYSTAL project will accelerate the speed our technology can be spread in other countries.

Employment increase
The market impact described in the previous sections of the document will have a direct impact in the HR needs that will be able to cover all the market cycle. While the incorporation of at least 2 technical roles will be needed in order to create a ready-to-market toolset, the most important employment increase is planned for the marketing and commercial aspects of putting a new product to the market and opening to new markets. The REUSE Company foresees to start with one representative in the US and other one in Asia, even though these figures could be increased if needed in case the sales would follow an increasing line.

In addition to this, and following the current line of collaboration among The REUSE Company and Spanish universities, REUSE foresees to sustain at least one university scholarship per year in the period 2012-2015.

Competitor description
Our area of competition related to CRYSTAL are those tools aimed to enhance the quality of system and software requirements specifications. So far, it's almost a blue ocean (no too many competitors), even though there are some pre-competitive approaches that can easily be transformed into commercial tools due to the benefits that this kind of technologies can provide to the development process in general, and the requirements management process in particular.
Our main competitors are the following:
•　　　Requirements Assistant: (by Sunny Hills Consultancy B.V.) this tool is able to find those invalid terms in the requirements specifications that may lead to completeness and correctness analysis (+info: http://www.requirementsassistant.nl/)
•　　　Lexior: (by Cortim) this tool/service is able to carry out lexical analysis over every individual requirement checking the grammar of every requirement. Lexior can also generate a report including aspects such us detection of forbidden terms or ambiguous grammars, duplicated identifiers, multiple need expressed within the same requirement (+info: http://www.cortim.com/)
•　　　DESIRe®: (by HOOD group) this tool is able to analyse a requirement and ask for particular questions trying to solve the incorrect wording in the requirement (e.g. ambiguous words or verbs). DESIRe includes up to 80 different ambiguous words for English and German and supports an easy customization of this list of ambiguous words (+info http://www.hood-group.com/en/products/tools/requirements-engineering/desirer/)
•　　　QuARS: (by   ISTI-CNR) this tool to generate two different kinds of reports: expressiveness

evaluation (identifying ambiguous or difficult to understand requirements) as well as a clustering view (grouping the requirements according to the subjects targeted on them) (+info http://quars.isti.cnr.it/index.html)

Planned Exploitation of CRYSTAL

External exploitations
Expected Exploitable Result

- Description: Tool improvements: RQS (http://www.reusecompany.com/requirements-quality-suite)

- Business Case and Market: Those tools presented as background in CRYSTAL will be improved to generate a foreground more aligned with the user needs coming from industrial customers. Our customers will benefit from the enhancements made to the bricks during CRYSTAL.

- Roadmap for Exploitation: Since the main outcome of the CRYSTAL WP6.7, as technology bricks, is being integrated into the current state of our tools already in the market; it'll be almost straightforward go generate a commercial version including some of the most interesting improvements achieved during CRYSTAL.

- Expected availability for use: The plan for Requirements Quality Suite (RQS) is to issue 2 major versions every year. The plan is to include some improvements coming from CRYSTAL from the second version of 2014 (end of 2014), and keep including improvements every year till the end of the CRYSTAL Project.

3.2.13 SISW

TECHNOLOGY PROVIDER	
Organization: SIEMENS INDUSTRY SOFTWARE GMBH & CO KG	**Short Name: SISW**

Author: Matthias Frische

Short description of our contribution to CRYSTAL
Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with 7 million licensed seats and more than 71,000 customers worldwide. The solutions that Siemens PLM Software develops are open, to give customers the freedom to use and combine whatever tools and information you need. Siemens PLM Software has customers in 80 countries and a workforce of more than 8.000 employees.
Siemens PLM Software is the developer of the market leading product data management system "Teamcenter". Siemens PLM Solutions has a dedicated service organization that provides the support for Teamcenter customers to adapt the Teamcenter solution to industry specific and customer specific requirements. Siemens PLM Software is already supporting many companies that need to enhance workflows that support their systems engineering processes. Enhancements to Teamcenter have been continuously implemented in projects at industrial partners that also will participate in the CRYSTAL project. Industry templates and an interoperability specification that allows to quickly integrate authoring tools into the systems engineering processes will speed up the setup of a systems engineering environment while enhancing quality of the implementation by relying on commonly agreed on standards. Siemens PLM Software already has experience with the process of establishing open industry standards i.e. ISO/PAS 14306:2011 Industrial automation systems and integration - JT file format specification for 3D visualization. This has to be one result of the CRYSTAL project. A IOS/RTP standard that is accepted and implemented by the leading software vendors that are relevant for this domain. This will be a key contribution to the CRYSTAL project. SISW will focus on an outcome of CRYSTAL that lays the basis for a long lasting commercial solution that is based on industry standards that we will help to establish. This will be done in an open way in terms of the technical solution but also in terms of gathering the input of relevant software vendors that are not participating in the CRYSTAL project.
Smaller companies will need more efficient systems engineering environments. Currently they are not able to implement a powerful PLM System supporting their systems engineering environment because of the complexity and effort of the customization that is usually involved. They will greatly benefit because a "systems engineering template" based on Teamcenter will lower the entry cost for such a system and the

IOS/RTP based interoperability will allow them to plug-in new authoring tools as needed.

For larger enterprises a Teamcenter based systems engineering environment that supports the IOS/RTP based interoperability will allow to implement seamless engineering workflows in shorter time, with better control and less cost. These companies have large numbers of engineers that need to be connected to such a system. These customers want improve the efficiency of their engineering departments and this extension of Teamcenter will allow them to do so.

In general the rising complexity of products is forcing more and more companies to use an efficient systems engineering process.

Competitor description

In the PLM area Siemens PLM Software with the Teamcenter PLM solution is the clear market leader. Notable competitors are Dassault Systemes (Enovia) and PTC (Windchill). We see our role as the market leader to discuss the concepts and content of the PLM related parts of the interoperability standard with our key competitors in order to ensure the creation of a commonly acceptable standard.

Planned Exploitation of CRYSTAL

Internal / external exploitations

Expected Exploitable Result

- Description: Industry templates for Teamcenter based on CRYSTAL interoperability specification.
- Business Case and Market: Our CRYSTAL Teamcenter templates will improve tool chains in systems engineering and by doing so enhance SME´s ability to develop and maintain complex products. This will allow wider use of Teamcenter in this growing market and encourage SMB´s to deploy a Teamcenter based systems engineering environment.
- Roadmap for Exploitation: For Siemens PLM Software the CRYSTAL project consist of three phases Requirements Gathering, Architecture and System Design, Proof of concept. In the Proof of concept phase Siemens PLM Software will create domain specific templates supporting a limited number of engineering methods. This will be the basis for an industrialization of the templates.
- Expected availability for use: Hopefully a commercial software solution can be created in a year´s timeframe after the end of the CRYSTAL project. This is hugely based on the customer acceptance of the concepts that are created in the first two years of the CRYSTAL project.

3.2.14 TECNALIA

TECHNOLOGY PROVIDER	
Organization: FUNDACION TECNALIA RESEARCH & INNOVATION	Short Name: TECNALIA

Author: Miguel Melchor, Susana Perez-Sanchez

Short description of your contribution to CRYSTAL

TECNALIA is a private non-profit applied research centre of international excellence with a great impact on local industry. TECNALIA has a staff of 1,500 employees, a turnover of more than 125 million Euros, and targets different strategic sectors, such as Aerospace, Automotive, Construction, Energy, Railway, Metal Casting, Environment, Shipbuilding, Health and Quality of Life, Iron and Steel, Information Society, Software, Information Technologies and Telecommunications. TECNALIA has a strong market orientation aiming at achieving the major impact in economic terms, through the innovation and the technological development. TECNALIA brings to the project its expertise in tools for the management of software variability (PLUM) and a new design methodology for Autonomous Fault Tolerant Systems for FPGA-based systems (AFTS-DM). PLUM is a Product Line Variability tool that aids in the variability analysis and capture, reusable components construction and final product resolution, also providing with the adequate variability traceability evolution mechanisms that allow an easy architecture evolution management. Within the scope of this project TECNALIA will enhance PLUM with impact analysis and product line simulation mechanisms, product line

evolution management, improved user experience and integration with domain specific modelling.
AFTS DM is a new development to take advantage of the available open-source PR design tools in order to create an efficient, robust and reliable design methodology for systems that require fault tolerance. ATFS DM is a cross-domain technology that targets systems in harsh environments (e.g. space), where Single Event Upsets (SEU) are likely to occur, and security critical systems (e.g. railway equipment), where the correct operation of the circuitry must be guaranteed without interruption.

Major Benefits of CRYSTAL for your position in the Market
TECNALIA's turnover on the product line engineering business amounted to 3.5 M€ in 2011. This figure includes PLUM sales and services and consultancy services either to introduce this technology or to evaluate the current practices at the customer facilities. With the improvements planned for the tool in CRYSTAL, TECNALIA is confident that this business will prosper at 20% rate per year in the near future. More than a hundred customers (half of them SMEs) and more than 600 professionals will benefit from this technology every year.
TECNALIA will put the AFTS DM technology in the public domain and will make reasonable economic efforts to ensure its widespread dissemination and acceptance by the community of FPGA-based systems developers. The technique will be published in relevant conferences and journals, such as the International Conference on Field Programmable Logic and Applications (FPL), the IEEE Symposium on Field-Programmable Custom Computing Machines (FCCM), the International Conference on Reconfigurable Computing and FPGAs (ReConfig), and others. Moreover, as a member of the Xilinx Alliance Programme, TECNALIA will write an Application Note to describe this new technique and provide tutorial examples as basic reference designs, and evangelize AFTS DM in Xilinx's Newsletter and Xilinx's XCELL journal.
TECNALIA's leadership in these new techniques will help us to increase our market share in the design and integration of System on Programmable Chip (SoPC) for FPGAs in a wide range of applications such as DVB data broadcasting, GPON network analysis and GNSS signal receivers, and target new market domains such as aerospace.

Planned Exploitation of CRYSTAL

Internal / External exploitations
Expected Exploitable Result
- Description: PLUM v4.0

- Business Case and Market: This is targeting embedded software developers in the automation of the variability management of their products. PLUM enables to define a product line, based on decisions that the different stakeholder sin the product development have to make. These decisions are the automated into reusable pieces of code that based on the decision resolution will automatically generate the final product. At the same time the tool can generate documentation or any other type of files (configuration files, etc.)

- Roadmap for Exploitation: Based on needs of the CRYSTAL projects there will be improvements undertaken in the tool, these improvements vary from usability issues to actual specific enhancements dealing with code generation and automation. The main idea will be in the use of the tools as the basis for evolution of TECNALIA's expertise in product line automation. It will be provided to all audience as a full functionality tool for trial purpose. For commercial purpose specific agreements with TECNALIA should be reached.

- Expected availability for use: Currently PLUM 3.0 is ready to use but when talking about PLUM 4.0 it depends in the flow of the project and the internal usage in the industrial cases. We expect that it will be ready for use in May 2015.

3.2.15 IST

TECHNOLOGY PROVIDER

Organization: Testing Technologies IST GmbH	Short Name: IST

Author: Theofanis Vassiliou, Stephan Pietsch

Short description of your contribution to CRYSTAL

Testing Technologies IST GmbH (short TestingTech) is tool provider in the area of test automation. Its product TTworkbench integrates with a variety of different technologies. Tool integration questions are a reoccurring on our and 3rd party tool chains. They are still unsolved in general, and in particular in the area of testing. This limits the tool applicability across various domains.

In the context of CRYSTAL Testing Technologies will act as a Brick provider for ModelBus. ModelBus is an integration framework that was widely used in CESAR RTP instances. Testing Technologies will contribute to definition and specification of IOS. Furthermore, we are interested to finalize the industrialization of the Brick ModelBus by integrating IOS results as well as end user needs. The goal is to achieve a high maturity of the product ModelBus during CRYSTAL that is well accepted by Testing Technologies partners and CRYSTAL participants. The product ModelBus should help us to provide an integrated bundle of tools to our customers based on the CRYSTAL achievements in the domain of quality assurance and testing.

Major Benefits of CRYSTAL for your position in the Market

Technology transfer from CRYSTAL partners (demonstrator, papers)

The results of CRYSTAL – which are going to be manifested in new brick developments and extensions, use case and user story realisations, and demonstrators – will help us to communicate our advanced technology portfolio in a broader context. New potential customers can be easier attracted and they can better understand the real benefit of the technology assets. The usage of these assets in the CRYSTAL use cases helps us to ensure market readiness of our bricks as we can gather in this way early and direct feedback from end users. In that way we will be able to enter the market in less time and with pre-validated products. Furthermore, the context of the CRYSTAL project gives us the ability to architect comprehensive development and test solutions in a very large scale. This approach helps us in creating similar large scale solutions in today's customer specific environments. Collaboration in the CRYSTAL project will improve the general awareness of recent requirements regarding development process automation with particular emphasis also on testing workflows.

In short, with CRYSTAL results we try to overcome the above mentioned limitations and we strive to increase the tool and technology reusability across our addressed vertical markets.

Competitor description

Dealing with the interoperability within the development processes is a complex subject and different approach emphasise certain aspect of them. So the following list of competitors comprise other interoperability approaches in the domain, which are focusing on particular aspects and which can be used in a complementary way.

IBM Rational: Jazz has a different technological approach compared to ModelBus. It addresses the interoperability problem with a more fine grained approach and with RESTful services. It is not working on models but on shared data. ModelBus and Jazz can be used in parallel and potentially their combination gives an added value to end users.

Dassault Systemers: Enovia is an in-house integration framework. It is used mainly for the integration of the Dassault tool portfolio. It offers a high level of integration in that particular tool area. However, the underlying integration technologies are controlled by Dassault only. This limits the feasibility of extending the set of integrated tools by 3rd party service providers and vendors. However, the combination of an Enovia integration solution and an CRYSTAL IOS based solution via specific integration paths may overcome these limitations.

Best of Breed solutions: There are a couple of service providers which created custom-made integration solutions, which do not adhere to any interoperability standard. These solutions do address only limited integration scenarios and can hardly be extended and are by no means interoperable with other approaches.

Planned Exploitation of CRYSTAL

Internal exploitations

Expected Exploitable Result

- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

External exploitations
Expected Exploitable Result
- Description: Tool Interoperability Method based on IOS

- Business Case and Market: The goal is to develop an exploitable method that supports potential customer to establish tool interoperability based on the CRYSTAL IOS principles. The business case is to provide tool interoperability consultancy to our existence customer and potentially to new customers form CRYSTAL's domains.
- Roadmap for Exploitation: Roadmap is not defined yet, due to the early stage of the IOS definition. The Roadmap will be defined after first release of IOS.
- Expected availability for use: as soon as stable

Expected Exploitable Result
- Description: ModelBus - Modeling Tool Interperability Framework

- Business Case and Market: The ModelBus interoperability Framework will be based on the CRYSTAL IOS principles. The aim is to offer tool adapters, specific transformations as well as models to the market under the name "ModelBus". Potential customers are able to reduce their integration effort by using CRYSTAL IOS principles and consolidated domain knowledge to attract new customers.
- Roadmap for Exploitation: Roadmap is not defined yet, due to the early stage of the IOS definition. The Roadmap will be defined after first release of IOS. The first version of the Roadmap will identified Go-to-market partners as well as a detailed business model canvas.
- Expected availability for use: as soon as stable

3.2.16 VIF

TECHNOLOGY PROVIDER	
Organization: Kompetenzzentrum - Das virtuelle Fahrzeug, Forschungsgesellschaft mbH	**Short Name: VIF**
Author: Daniel Watzenig, Andrea Leitner	
Short description of your contribution to CRYSTAL ViF will contribute to SP3 (automotive domain) and SP6 (analysis tools, simulation models, variability management). More precisely, ViF will work on: • Defining processes, methods, data models, and tools (tool chains) to support the design and management of domain-specific assets (WP 3.3, 3.4, 3.o) • Support the CRYSTAL consortium in terms of efficient integration of the different bricks (e.g. data backbone, meta-models, analysis and test tools) • Multi-physical modeling (WP 3.4, 6.14) • Design for re-usability and model-based variants handling (WP 6.3) • Modeling of software architectures (WP 6.3) • Multi-domain simulation (WP 3.3, 3.4, 6.14) • Concepts and methodology for RTP tailoring (WP 3.3, 3.4) • Support to RTP architecture and evolution of IOS (WP 3.3, 3.4) • Implementation of use case relevant bricks / interfaces to RTP using IOS (WP 3.3, 3.4, 3.o)	

ViF will be strongly involved in the interoperability activities and RTP tailoring for the automotive domain. ViF will bring in its gathered platform configuration and tailoring experiences from former ARTEMIS projects like CESAR and MBAT, as well its safety experience from ARTEMIS SafeCer. In addition, ViF will contribute to the technology bricks analysis tools, model library, multi-domain simulation, and variability management.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
ViF is embedded in Graz University of Technology and hence, is strongly involved in teaching activities, student projects, Bachelor and Master theses. The University offers special courses on automotive embedded systems, system architectures, real-time systems, design patterns, and automotive communication systems. Several employees at ViF are engaged in teaching activities at Graz University of Technology fostering the dissemination of CRYSTAL research and development results to students and possible future researchers in upcoming ARTEMIS projects.

ViF is member of the previous ARTEMIS CESAR and ongoing ARTEMIS MBAT project and is involved in the specification, implementation, deployment, and tailoring of model-based integrated tool-chains (RTP instances) especially for the automotive domain with focus on hybrid powertrains. In addition, ViF has a strong background and interest in generic hybrid control software development, multi-domain co-simulation, and software components variant management (reusability). ViF is also partner in the ARTEMIS projects POLLUX, p/nSafeCer, and VeTeSS working on system and safety modeling, HW/SW co-design, and model-based development, control, validation, and test.

Given this ARTEMIS history and research topics portfolio, ViF's focus is on acquiring additional services and complementary national / European funded projects beyond CRYSTAL and ARTEMIS projects to build a critical mass regarding interoperability, standardization activities, and model-based development.

Research activities within CRYSTAL will lead to publications at scientific and industrial conferences, journal articles, but also Master theses and one Ph.D. thesis. ViF hast itself positioned as an independent industry-driven research institute aiming at bridging the gap between academic research and industrial needs. ViF is strongly interested to extend its scope of research and development particularly in the fields of model-based techniques, interoperability, platform building and tailoring, variability management, system analysis, and multi-domain simulation in order to provide solutions applicable in industry. The results of CRYSTAL will strengthen ViF's market position and also emphasize ViF's position as an application-oriented research center covering the domains electrics/electronics, software, acoustics, mechanics, and thermodynamics.

ViF's interest is to extend its model-based design methods, tools, and processes to foster the reduction of development cycles and time-to-market.

External exploitations
Expected Exploitable Result
- Description: Semi-formal requirements authoring tool
- Business Case and Market: many companies facing the problem of bridging the gap between natural language creation of a new tool requirements and more structured representations
- Roadmap for Exploitation: tbd
- Expected availability for use: after the project

3.2.17 MATE

TECHNOLOGY PROVIDER	
Organization: Mate Consulting	**Short Name: MATE**
Author: Federico Gilblas, Gregorio Barberio	
Relevant Markets of your company impacted by CRYSTAL Mate Consulting is an information technology company, and develop software in the sector of conventional and high speed railway lines and urban rail transport systems. European Railway system is a fertile domain in which many innovative projects are currently under	

development. The development of ERTMS (European Rail Traffic Management System) is one of the most important innovation in rail domain. It should be able to replace all the incompatible national European solutions, already developed in the past, with a single train control system. It could be considered as the best performing train control system in terms of safety, reliability, traffic capacity as well as maintenance costs. Because of system's high complexity and heterogeneity, the required validation and testing effort to implement ERTMS solutions must not be underestimated: while safe transportation system and innovative embedded systems seem to be an inseparable binomial, the increasing complexity of the latter often becomes an insurmountable obstacle. Since the product quality is one of the key attributes for the European System Companies, a very high price is often paid to keep a performing market position.

Moreover, the rail business in general is rattled by high competition and low profit margins. Improvements in the development process for such systems resulting in higher productivity, better product quality, and improved time-to-market will be therefore highly desirable. The CRYSTAL project meets exactly these critical areas in the development process.

Major Benefits of CRYSTAL for your position in the Market
The expected results of CRYSTAL will affect the entire V&V process in all the customer projects in progress, starting from key customer projects. We expect to improve our time to market in railway IT sector and its market position especially compared to international competitors.

Competitor description
Engineering spa - is an international player and the first Italian operator in software and services, among the top 10 in Europe. We are a unique Group thanks to our integrated along the entire software value chain: consulting, system & business integration, outsourcing services, vertical products and solutions.
Specialisation by markets and integration of all our know-how ensures a global vision of the complexity of IT.
AlmavivA spa - AlmavivA offers its customers solutions and systems spanning all Information & Communication Technology components. The Almaviva Transportation BU offer its expertise on Industry-specific business processes and its ICT solutions supporting Operations Planning Management. Deep Industry and Customer business knowledge allows AlmavivA a constant business requirement monitoring, by promptly making available key elements for an optimized management of Industry-specific success critical factors.

Planned Exploitation of CRYSTAL

External exploitations
Expected Exploitable Result
- Description: IOP test writer Tool
- Business Case and Market: The tool allows the creation of scripts defined in IOP language. The IOP language is specific of rail domain, a tool that supports the generation of test script in IOP language offers great benefits to the railway industry accelerating the test activities to be carried out on a real environment or through a simulator.
- Roadmap for Exploitation: Creation of a new product and customisation support.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: Log Analyzer Tool
- Business Case and Market: The tool allows to analyze the test execution log and to support the engineering team in the identification of failed tests and requirements not correctly implemented. The features introduced by the tool reduce the time required to implement changes to get a working system.
- Roadmap for Exploitation: Creation of a new product and customisation support.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: IOS/OSLC expertise
- Business Case and Market: One of main topic in Crystal is the IOS (tool interoperability specification). The interoperability specification defined in Crystal can be extended to companies interested to use OSLC/IOS in their development process.
- Roadmap for Exploitation: Consultancy services.
- Expected availability for use: End of project

Expected Exploitable Result
- Description: Rail Model
- Business Case and Market: The tool provides a software solution, initially focused for the rail domain that allows the modelling of the behaviour of complex and synchronous systems. The adoption of the tool in the rail domain industries, allows to save time and to reduce the costs of these activities. The support offered to the technical team in the generation of test cases, helps the industries to be more competitive.
- Roadmap for Exploitation: Consultancy services on customizations of the modelling environment and on tools for the automatic test case generation.
- Expected availability for use: End of the project.

3.2.18 PS-TECH

TECHNOLOGY PROVIDER

Organization: Personal Space Technologies	**Short Name: PS-TECH**

Author: Marc Lausberg

Relevant Markets of your company impacted by CRYSTAL
PS-Tech B.V. is a spin-off company from the National Research Institute for Mathematics and Computer Science in the Netherlands, CWI (www.cwi.nl). PS-Tech has expertise in the field 3D visualization and 3D interaction solutions (Virtual Reality). Our tech roadmap developments are mainly for the medical industry. CRYSTAL will impact several markets. First and foremost will be PS-Techs technology find its way to the Medical Industry, in operating theatres in hospitals. These medical industry is global and a billion Euro market.
Secondly the experience and developments in the medical field will also have its spin-off effects in other industries. The advances in medical 3D visualization will have its benefits for Industrial Design, Modelling, Oil and Gas, Aviation and Car industry. In these industries the usage of large 3D datasets is becoming more important. The need for new tools and solutions, provided by companies such as PS-Tech, to handle and analyse these datasets is also imminent.

Major Benefits of CRYSTAL for your position in the Market
Up to now PS-Tech, as an SME, has limited exposure in the medical world. The technology has been identified by medical experts as high value and high potential and is moving from research users to medical practice. CRYSTAL is important to embed the technology in the day to day workflow of hospitals and thus creating acceptance and ready to use solutions for end-users. CRYSTAL will further accelerate PS-Tech's possibilities and ambitions to become a global player in the medical industry.

Competitor description
PS-Techs competition comes from several directions. There is competition in the field of Visualization and also from Interaction.
PS-Tech's solutions however do not focus on Visualization as such. It is always offered to clients combined with interaction tools, which make the analyses of complex medical data easy. The combination of

Visualization and Interaction (in 3D, Virtual Reality) is seldom seen and not main stream. Competitors in this area are companies as Virtual Proteins in the Netherlands and Volume Interactions in Singapore. These are both small companies. The other competitors are the global players in the medical imaging industry such as General Electric, Philips, Siemens, Toshiba and the OEMS that develop (TV) screens, such as Samsung, Sony and Philips.

The competition in the Interaction field comes from companies that have a position in Optical Tracking in Operating Theatres in hospitals. The main competitor is Northern Digital Inc. (NDI) from the US. NDI is the global leader in optical tracking in hospitals.

Planned Exploitation of CRYSTAL

Using NobiVR as a library offering that includes the VR layers and the 3D visualization engine.

This library can be used internally and externally.

Exploitation of PS-tech makes use of the following PS-tech developments within Crystal:

- Remote rendering and remote collaboration of 3D data.
- Multi user and Multi location collaboration of 3D data.
- Allow other programs and tools to utilize the 3D visualization of NobiVR.

These allow PS-tech to extend its offering internally to bring its core technology to a higher level.

Externally it allows PS-tech to offer this library to other tools/applications that want to include 3D visualization and VR layers in the tool.

Expected Exploitable Result
- Description: NobiVR
- Business Case and Market: Very few 3D interactive tools support use in a Virtual Reality (VR) environment, many times due to the lack of expertise in this specific field of 3D. These products are used in industries such as Medicine, Industrial Design, Modelling, Oil and Gas, Aviation and Car industry. NobiVR is intended as a VR layer which application developers can integrate to gain VR capabilities without having to implement all the typical VR functionalities (3D stereo/multiview rendering, VR space configuration, tracking device input).
- Roadmap for Exploitation: Software component / Consultancy services
- Expected availability for use: End of project

Expected Exploitable Result
- Description: GPU in the Cloud
- Business Case and Market: For the end-users of PS-Tech's (medical) visualization products a centralized environment brings many benefits such as centralized data, resource optimization, location flexibility, IT maintenance, remote collaboration possibilities. To make this possible with the advanced visualisation techniques of PS-Tech's products, the GPU needs to be virtualized (in the cloud).
- Roadmap for Exploitation: Centralized thin-client version
- Expected availability for use: End of project

Expected Exploitable Result
- Description: IOS/OSLC expertise
- Business Case and Market: One of main topic in Crystal is the IOS (tool interoperability specification). The interoperability specification defined in Crystal can be extended to companies interested to use OSLC/IOS in their development process.
- Roadmap for Exploitation: Improved product interoperability, Consultancy services.
- Expected availability for use: End of project

3.2.19 PTC

TECHNOLOGY PROVIDER	
Organization: Parametric Technology GmbH	**Short Name: PTC**
Author: Peter Mair	

Partner description
As one of the world's largest and fastest-growing technology companies, PTC helps manufacturing leaders address the biggest business challenges they face today. Our solutions for Product Lifecycle Management (PLM), Computer Aided Design (CAD), Application Lifecycle Management (ALM), Supply Chain Management (SCM) and Service Lifecycle Management (SLM) let you aggregate, analyze, and deploy product information to drive the strategy and dynamic decision-making processes on which your success depends. Our solutions help you optimize the activities within individual functions of your organization, and aligned across your entire enterprise: from engineering to supply chain and manufacturing, and sales and service.

Planned Exploitation of CRYSTAL

Internal exploitations
Expected Exploitable Result

- Description: Integrate Systems Engineering Methods and System Engineering Interoperability in an IT solution
- Business Case and Market: A standardised format allows easy data access and exchange without additional middleware or interfaces between different SW tools and application. Industry benefits to establish rapidly and cost effectively new complex engineering development environments
- Roadmap for Exploitation: white paper, pilot environment in use cases for best practices
- Expected availability for use: first prototype readiness in different use cases before M 20

3.2.20 IBM (NL, UK)

TECHNOLOGY PROVIDER	
Organization: IBM Nederland B.V., IBM United Kingdom LT	**Short Name: IBM-NL, IBM-UK**
Author:	

Relevant Markets of your company impacted by CRYSTAL
Not input received from partner

Major Benefits of CRYSTAL for your position in the Market
Not input received from partner

Competitor description
Not input received from partner

Planned Exploitation of CRYSTAL

Internal exploitations
Not input received from partner

Expected Exploitable Result
- Description:

- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

External exploitations
Expected Exploitable Result
- Description:
- Business Case and Market:
- Roadmap for Exploitation:
- Expected availability for use:

3.2.21 Elektrobit

TECHNOLOGY PROVIDER	
Organization: ElektroBit	**Short Name: Elektrobit**

Author: Irfan Delbassez (Irfan.Delbassez@elektrobit.com)

Partner description
Elektrobit France SAS is the French branch of Elektrobit Automotive GmbH, an embedded software development company. During the last 20 years we specialized on embedded automotive software and products, and are now worldwide engaged within automotive software projects. At the end of 2011 about 1000 employees worked for Elektrobit Automotive GmbH. We are a leading AUTOSAR solution provider, with a deep understanding of automotive communication stacks like CAN, LIN; MOST or FlexRay. Our white label navigation software is well established within the Automotive market. The development of modern multi-display HMIs is done by our GUIDE tooling. Many multifunctional HMIs of modern cars were created with it. The development and test of safety-critical driver assistance systems is supported by EB Assist ADTF, a domain specific test framework.

Planned Exploitation of CRYSTAL

Internal / External exploitations
Not input received from partner

Expected Exploitable Result
- Description: Guideline for software architecture development for multicore applications
- Business Case and Market: Any automotive company interested in developing an application using multicore microcontrollers
- Roadmap for Exploitation: Roadmap is not defined yet, due to the early stage of the guideline definition.
- Expected availability for use: Not before the end of the project

Expected Exploitable Result
- Description: The OS has been adapted to allow the development of automotive applications using multicore microcontrollers for safety embedded ecu
- Business Case and Market: Any automotive company interested in obtaining a OS multicore/safety for the development of complete embedded application.
- Roadmap for Exploitation: Creation of a new product under licensing

• Expected availability for use: First prototype End of 2016

3.3 Academic partners

3.3.1 ITI

ACADEMIC PARTNER	
Organization: Instituto Tecnológico de Informática	**Short Name: ITI**
Author: Ruben de Juan	

Short description of your contribution to CRYSTAL
As a research and technological partner, ITI will mainly contribute to horizontal SP6 (IOS Evolution & Development, Standardisation, RTP builder) providing an ICT perspective to the IOS. ITI will contribute with its expertise on embedded systems and SOA technologies acquired through multiple European and national projects as REMPLANET or B2B Services and its active participation in INTEROP-VLab, the "International Virtual Laboratory for Enterprise Interoperability", developing platforms like ColNet, which is aimed to support the management of non-hierarchical manufacturing supply networks based on the concept of Digital Ecosystems, making use of a BPMS approach and supported by a SOA approach, and working strongly on the interoperability and RTP tailoring and configuration activities. In addition, ITI will contribute to the technology bricks analysis tools, multi-domain simulation, real time-execution of critical features, test specification and traceability and performance modelling. It will participate in different WPs where different Bricks will be designed/adapted to provide a closed solution to the UCs requirements.
ITI will also contribute to vertical SP4 (healthcare domain) and SP1 (Aerospace domain), in becoming the technological link to the UCs in which ITI Brick are used. The main contribution will be to provide the expertise on identified tools and bricks required to implement both Use Cases. Aerospace UC is related to the definition of an appropriate toolset for Control Unit Software generation, test, V&V and Certification in which guaranteeing real time scheduling is critical. Healthcare UC is related to implement an intelligent infusion controller for Blood Pressure regulation in Operating Room which requires guaranteeing safety, interoperability and performance for the system designed.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
ITI is a research and transference centre, and therefore, it has a lot of experience in the organization and stimulation of using technologies amongst companies and researchers through teaching and research activities. Its facilities provide better distribution of the research groups, as well as a technical education classroom, a seminar room library and laboratory with specific equipment for every group. Moreover, the Institute has a hardware and software testing laboratories, prototype laboratories, training rooms, meeting rooms, etc. ITI's mission is to research, develop and innovate in ICT technologies to improve and maintain the competitive position of technology companies, generating and transferring knowledge to the industry and society.
ITI currently has a network of associates composed by the major companies involved in carrying out R&D&I around ICTs. Main associated companies are regional based, according to the geographic proximity to take advantage of the services the Institute provides. But it also includes national reference companies with which the Institute collaborates continuously.
ITI will take advantage of the activities developed in CRYSTAL project for generating a) New cooperative projects with companies in the sector developing basic and applied research projects related to interoperability and embedded systems, b) individual projects following ITI's research lines to build new solutions (products and services) for Automotive, Aerospace and Healthcare global markets, c) technology spreading actions attending conferences and other forums of scientific and industrial knowledge, d) innovation management actions in companies, e) supporting technological spin-offs.

Other external exploitations

Expected Exploitable Result
- Description: Scheduling Requirement Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of timing requirements initially focused for the aerospace domain. With IOS/OSLC support. Devoted to aerospace companies developing critical embedded systems.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: Functional and Performance Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of functional and performance requirements fulfilment in architecture models initially expected for healthcare domain. With IOS/OSLC support.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: Interoperable Architecture Analysis Tool
- Business Case and Market: The tool provides early and continuous validation of interoperable fulfilment requirements in architecture models. Initially expected for healthcare domain. With IOS/OSLC support.
- Roadmap for Exploitation: Creation of a new product under licensing and customisation support. Public through a devoted webpage.
- Expected availability for use: First prototype end 2015. Ready for exploitation first half 2017.

Expected Exploitable Result
- Description: IOS/OSLC expertise
- Business Case and Market: Consultancy IOS/OSLC support. Intended for companies interested to use OSLC/IOS in their development process.
- Roadmap for Exploitation: Enhance good practice by spreading results through consultancy services. Listed in the services provided.
- Expected availability for use: End of the project.

Expected Exploitable Result
- Description: Methodology for EN IEEE/ISO 11073 modelling
- Business Case and Market: Methodology and consultancy for modelling interoperability aspects in healthcare devices according to EN IEEE/ISO 11073. Companies of the healthcare domain.
- Roadmap for Exploitation: Consultancy services. Listed in the offered services.
- Expected availability for use: End of the project.

Expected Exploitable Result
- Description: Simulator with HiL
- Business Case and Market: Simultator with HiL tailoring, supporting IOS/OSLC.
- Roadmap for Exploitation: Customisation support service.
- Expected availability for use: End of the project.

3.3.2 MU

ACADEMIC PARTNER	
Organization: Masaryk University	**Short Name: MU**

Author: Jiří Barnat

Short description of your contribution to CRYSTAL Masaryk University will primarily contribute to CRYSTAL project by providing an existing formal verification tool (model checker DiVinE) and all the necessary knowledge on formal modelling and verification. DiVinE is a parallel and distributed-memory tool for model checking systems against properties formalised by means of Linear Temporal Logic. The tool is world-wide unique due to its capability to employ aggregate power of network interconnected workstations to handle one large verification task. Integration of new formalisms as developed within the project into DiVinE will immediately provide all the developers using the new modelling formalisms with a tool support for validation and verification of their models.

Planned   Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research Masaryk University offers a master degree programme in embedded systems which is taught in English and is accessible to international students. Masaryk University will make sure that the experience gained with the embedded systems during the participation of MU employees in the CRYSTAL project will get into the corresponding individual courses of the programme. MU also aims to use the CRYSTAL partnership with the Honeywell unit placed in Brno for supervision of CRYSTAL related master theses and for students' industrial placements. The MU team participating in the CRYSTAL project will use the knowledge and experiences gained from the CRYSTAL project to drive its future research. In particular, the team will look closely to the possibilities of combining symbolic and explicit model checking techniques as an option that would allow the tool to handle even larger industrial verification cases. Positive results and successful application of explicit or semi-explicit model checking to industrial use cases might trigger an activity to start a spin-off company that would provide consultancy in application of the formal verification methods, model checking in particular, to other commercial companies dealing with embedded systems development. **Other external exploitations** Expected Exploitable Result • Description: New methodology for application of model checking to safety analysis in the process of development of safety critical systems, e.g. new methods for identification of minimal cut sets during safety analysis. • Business Case and Market: Cost reduction in system development. • Roadmap for Exploitation: Identification of applicability of model checking technique to safety analysis. Development and evaluation of the method. Adoption for Crystal RTP. • Expected availability for use: At the end of the project.

3.3.3 OFFIS

ACADEMIC PARTNER	
Organization: OFFIS e. V.	**Short Name: OFFIS**

Author: Bernhard Josko (bernhard.josko@offis.de)

Short description of your contribution to CRYSTAL

OFFIS will mainly contribute to SP6. On the one hand OFFIS will be strong involved in the interoperability activities. OFFIS will bring in its gathered interoperability experiences from former ARTEMIS projects like CESAR and MBAT, as well from German national projects like SPES2020. In these projects OFFIS contributed in particular to semantical aspects including meta model specifications (conceptual one as well concrete implementation). OFFIS will use this knowledge to contribute to the CRYSTAL interoperability specification. Furthermore, OFFIS will address the RTP tailoring process to build specific instances: Within the requirement engineering brick (WP6.2) OFFIS will contribute to the formalisation of requirements and its usage to enhance analysis techniques addressing the Completeness / Correctness / Consistency criteria and subcriteria as defined in the CESAR project. The approach will be integrated in a requirement process supporting domain ontologies, boilerplates and formalisation steps from boilerplates to formal patterns.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research

As a so called „An-Institut" there is a strong relationship to the University of Oldenburg, and professors at the university are engaged in the institute OFFIS. The Department of Computer Science offers for its Bachelor degree a specialisation course on embedded systems and has a dedicated Master course on Embedded Systems and Microrobotics. These courses offer excellent opportunities to teach topics addressed within CRYSTAL.

The CRYSTAL results will have an impact on our future research activities. On the one hand, research activities within CRYSTAL will lead to publications at workshops and conferences and are starting points for PhD studies. As an application oriented research institute our aim is provide solutions applicable in industry and to transfer research results to industry. The results of CRYSTAL will extend our portfolio of verification and analysis techniques and hence will strengthen our position in the market and will make OFFIS attractive as a partner in industry driven research projects. Our interest is to further extend a seamless model-based design methodology for safety critical systems supported by various analysis and verification techniques addressing compositional and virtual integration aspects.

There is a strong interest regarding interoperability of methods and tools in particular with respect to the underlying conceptual and semantical models. Regarding this topic, OFFIS was and is strongly involved in several research projects including the ARTEMIS projects CESAR, MBAT and national projects SPES2020, SPES XT and ATAMiS. In particular, OFFIS was involved in the business model working group for the CESAR RTP. OFFIS is active within EICOSE (an ARTEMIS Center of Innovation Excellence) to define and install a so called Corporation Reference Technology Platform (CRTP) based on the CESAR RTP. OFFIS is interested to continue these activities based on the CRYSTAL results and to support the standardization activities.

The results of CRYSTAL will be used to extend our consultancy offer on the efficient transfer of research results to industry applications. OFFIS support the foundation of spin-off companies and has set up specific guidelines for that. In the past several spin-off companies have been founded out of OFFIS. If there is a market and the results have reached an appropriate maturity level exploitation through a new founded spin-off company will be one opportunity.

Other external exploitations

Expected Exploitable Result

- Description: Timing tools and optimization Brick

- Business Case and Market: Industrial and academic partners, who have architectural and timing use cases

- Roadmap for Exploitation: The timing and optimization brick should be made visible to other projects and teaching. Therefore, we plan to use an open interface which supports the easy interaction with other tools. By this we are also able to transfer in a more efficient way our results to industrial projects and also to enable in a more efficient way the students can access during teaching more complex tool chains.

- Expected availability for use: mid of 2015

3.3.4 AIT

ACADEMIC PARTNER	
Organization: Austrian Institute of Technology	**Short Name: AIT**

Author: Erwin Schoitsch

Short description of your contribution to CRYSTAL
AIT will contribute, based on its previous project experience and project results in FP6, FP7 and ARTEMIS and national projects, to CRYSTAL a series of bricks concerning
• model based test case generation and test evaluation derived from UML models (UMMU)
• model based test case generation and test evaluation derived from SCADE models (SCAMU)
• workflow engine for analysis, certification and test (WEFACT),
• model based (safety) analysis (MB-RAMS),
• data time flow simulation (DTFsim).
The bricks are applicable in several domains, i.e. fit for cross-domain use.
AIT will support particularly AVL and Volvo in their automotive use cases and Thales Austria and Ansaldo STS in their rail use cases. Furthermore, AIT has many years' experience in dissemination (workshop organization, SAFECOMP co-organizer, EWICS and ERCIM research groups, booths at fairs and exhibitions) and standardization, with focus on functional safety and related aspects, being active in ISO TC 22 SC3 and IEC TC65, IEC TC 56 and ETSI M2M, ITS and MTS as national expert or member, and having been the technical manager in the ARTEMIS driven support action ProSE (Promoting Standards for Embedded Systems).
AIT leads the research sub project in MBAT and is partner in Artemis projects p/n-SafeCer, Pollux and R3COP, contributing specifically to the V&V parts, interoperability, cross-domain and platform concepts, and therefore well suited for continuing and improving work done there within CRYSTAL. Bricks have been partially developed in the ARTEMIS projects, the FP6 IP DECOS, and the FP7 project MOGENTES, complemented by national projects like TRUFAL and FANIT.
In detail, AIT will work on:
• Supporting automotive VOLVO Use Case UC3.1, Bricks DTFsim, UMMU (WP 3.1)
• Supporting AVL use case UC3.3, Brick WEFACT (WP 3.3)
• Supporting ASTS Use Case UC5.1, Brick UMMU (WP 5.1)
• Supporting Thales Austria UC UC5.2, Bricks UMMU, SCAMU, WEFACT, Model-based RAMS (WP 5.2)
• IOS WP, Standardization support, focus on Functional Safety, Process Issues and related aspects (see company description on standardization activities) (WP 6.1)
• Analysis Tools: Integration and further enhancement of the DTFsim tool (Data Time Flow Simulator) (WP 6.3)
• Tools for Safety: WP lead, handling bricks for safety engineering of critical systems from several partners; integration, adaptation and enhancement of AIT tools UMMU, SCAMU, WEFACT, MB-RAMS (see list above)
• Dissemination (organization of workshops at conferences, exhibition booths, papers and presentations) (WP 1.2)

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
AIT Austrian Institute of Technology GmbH will exploit the CRYSTAL results within the scope of its industrial and future research work, as consultant for industry, SMEs and public authorities or governmental organizations. Furtheron, AIT will provide themes for academic studies (Master, PhD) (Education and Training role), and especially be active in its role as technology transfer organization between research and industry or SMEs, respectively (e.g. in organizing technology transfer seminars through its Technology Transfer Centre TTZ in Leoben or through partner organizations).
The main goal of CRYSTAL as an AIPP (Industry-driven Application project) to (re)use, improve and implement existing bricks for industrial use in practice is a key reason for AIT to participate and contribute its bricks, developed in a series of research projects with industrial partners as users, by integrating, enhancing and adapting them so they fit into the larger context of the Common ARTEMIS RTP and become much more

industrially used and marketed. It should be noted that a considerable part of AIT income has to be generated by commercial industrial projects.

Specifically, AIT will exploit the results of the project in several the following ways:

• Tools for designing and testing critical systems will be commercially exploited through cooperation with industrial companies or SMEs (as users or tool providers). AIT will in this case provide the tools adapted and enhanced in CRYSTAL, the partner company's role is to launch the products and market them. Modelling techniques for safety and risk analysis as well as model-based analysis tools will be exploited for improving efficiency in the development of dependable embedded systems, and testing and simulator tools will in particular allow model-based automatic test case generation for requirements-based system tests of target applications.

• In addition, AIT will broaden the usability of their test automation and execution environment for supporting establishment of safety cases (WEFACT) to be able to offer new services.

• AIT will introduce the experiences gained into its lectures for Universities of Applied Sciences (closely related to post-professional studies) and industrial technology transfer seminars provided in context of several organizations involved in this area in Austria.

• AIT as an applied research organization will use the results in context of its consulting services to Austrian industry and SMEs, which is part of its official mission.

• AIT will further use the experiences for the ARTEMIS E&T Working Group by taking them into account for the ARTEMIS Strategic Research Agenda and White Paper for E&T concerns with regard to embedded systems education and professional training curricula.

• AIT as member of the ARTEMIS Standardization WG and the ProSE project, and of several international and national standardization committees, will support standardization efforts towards acceptance of CRYSTAL results as part of recommended practice in standards and of interoperability standards for tool chains and reference platforms (according to statements of the EC and the reviewers of the ETPs (European Technology Platforms) standardization is a key issue and one of the important means of exploitation of research results). .

• AIT activities in CRYSTAL will lead to publications, workshop contributions and conference papers, and to PhD and master thesis in co-operation with universities and universities of applied sciences.

AIT is particularly interested to extend its scope of research to provide solutions to industry driven by a deeper insight in industrial requirements and needs as demonstrated by the CRYSTAL Use Cases, and expects intensive future research co-operations with industrial and academic/research partners particularly from the CRYSTAL consortium.

Other external exploitations

Expected Exploitable Result

- Description: AIT Bricks (Tools and methods)

- Business Case and Market: AIT and customers, future project partners (research and commercial)

- Roadmap for Exploitation: Flyers, demonstration at Booths at Conferences (with exhibition) and Fairs

- Expected availability for use: starting 2015 with enhanced, existing tools

Expected Exploitable Result

- Description: AIT Bricks (Tools and methods)

- Business Case and Market: AIT and customers, future project partners (research and commercial)

- Roadmap for Exploitation: Transfer by lectures and (industrial/academic) seminars, tutorials

- Expected availability for use: starting 2015 with enhanced, existing tools

Expected Exploitable Result

- Description: AIT Bricks (Tools and methods)

- Business Case and Market: AIT and customers, future project partners (research and commercial)

- Roadmap for Exploitation: Commercialization as part of industrial projects, consulting to industry

- Expected availability for use: 2016ff

3.3.5 CTH

ACADEMIC PARTNER	
Organization: Chalmers tekniska högskola	**Short Name: CTH**
Author: Matthias Tichy	

Short description of your contribution to CRYSTAL

In the CRYSTAL project, CTH will address model-based requirements engineering in WP 3.1 and WP 6.14. Our approach is based on existing work on formal models with a clear and consistent semantics, e.g., block diagrams, timed automata, and live sequence charts, to capture requirements for automotive software, particularly, heavy duty vehicles. These models formally define the expected behavior in a consistent and unambiguous way compared to informal text. Furthermore, vehicle functions have to consider hard real-time constraints. Thus, real-time annotations are an integral part of the requirement models.

Furthermore, it is possible to execute and prove the correctness of the formal models already before the actual development begins. Thus, errors in the requirements can be found and corrected very early in the development process and therefore, the extra costs induced by these errors can be reduced. Moreover on later stages, the very same models serve also as input to model-based testing approaches and provide metrics about the ratio of successfully implemented requirements.

The behavioral requirements models are accompanied and supported by a validation and verification process. This process defines when requirements and at which abstraction level they will be formalized and formally proved. Both these process aspects are of crucial importance to the successful application in industrial software development.

We will apply the behavioral requirements modeling and verification aspects as implemented in the tool chain on the two Volvo use cases. However, the results will address the domain of embedded software engineering in general. Thus, they are applicable to the other domains in the CRYSTAL project as well.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research

CTH together with GU offers bachelor and master programs in software engineering. Several courses are related to the topics addressed in the CRYSTAL project, e.g., Design and Development of Embedded Systems, Model Driven Development, and the project Industrial IT and Embedded Systems in the bachelor program as well as Requirements Engineering, Model-Driven Engineering, and Software Engineering with Formal Methods in the master program. The activities in CRYSTAL will have an influence on the course contents by, e.g., providing real-world case studies for course projects and providing topics for bachelor and master thesis.

The CRYSTAL topics and results are in line with the research agenda in the Software Engineering division, particularly with the research conducted in the Software Center. The results of CRYSTAL will enable further application-oriented research in the Software Center as well as with other partners in Sweden and Europe. Furthermore, results from CRYSTAL will probably lead to new research questions, which will be addressed in the future. Additionally, the CRYSTAL results will be presented at international workshop and conferences as well as in leading international journals. The results of CRYSTAL will also enable further empirical research with respect to effects of the CRYSTAL results on the employed software development processes and software companies' organization in general. Furthermore, the CRYSTAL results will be extended towards embedded systems with self-* properties (self-healing, self-optimization, etc.) in the future. The model-based requirements tools and techniques have to be extended to also consider these systems, which change their requirements and implementation at runtime.

Chalmers at large and the computer science department and the Software Engineering division have a long history of successful spin off companies. Currently, 17 spin-off companies have been successfully founded in the information and communication technology field employing around 700 people. The innovation arena at Chalmers is represented by different organizations such as incubator, institutes, venture capital and entrepreneurial schools, most of them supporting spin off companies. If the CRYSTAL results have reached an appropriate level of maturity level, founding a spin-off company is possible that will benefit from the mentioned supporting organizations.

Other external exploitations

Expected Exploitable Result
- Description: Model-Based Engineering techniques (e.g., requirement engineering and state of the art in MBE)
- Business Case and Market: Exploitation in Teaching: Courses, Bachelor/Master Thesis
- Roadmap for Exploitation: transfer/sustainability: include results of Crystal into Course Material, use results of Crystal as foundation for bachelor/master thesis
- Expected availability for use: M16

Expected Exploitable Result
- Description: Model-Based Engineering techniques (e.g., requirement engineering and state of the art in MBE)
- Business Case and Market: Exploitation in other research collaborations
- Roadmap for Exploitation: transfer: results of Crystal as foundation for new research projects in the field of embedded systems engineering
- Expected availability for use: M21

3.3.6 UNIGE-DITEN

ACADEMIC PARTNER	
Organization: University of Genova	**Short Name: UNIGE-DITEN**
Author: Francesco Bellotti	

Short description of your contribution to CRYSTAL
ELIOS Lab will bring to the project its experience, gained in several EU 5th, 6th and 7th Framework Programme projects, on modelling and developing systems for the automotive world.
The ELIOS contribution in CRYSTAL will focus on the modelling and implementation of a safety-related sub-system to be integrated inside the whole automotive system.
In particular, in CRYSTAL, DITEN will work in strict cooperation with CRF in all the tasks foreseen on this topic (WP3.5 - Use Case 3.5, "ISO 26262 safety assessment and functional assessment for type of fluid changing in a climate control unit with a CRF tool chain"). In particular, the tasks will involve: definition of the use case and of the requirements; definition of the subsystem's model and of is modules' interfaces; implementation of the use case operational workflow and models and integration in the CRYSTAL platform; execution and assessment of the use-case.
In all these steps, DITEN will contribute by exploiting existing state of the art development tools (Matlab-simulink and EAST-ADL), methods and standards (in particular: ISO 26262 for whole-cycle functional safety) applying them to the issue of upgrading the climate control sub-system and integrating it in the overall automotive system meeting the safety requirements.
The developed knowledge will be useful to understand possible improvements/optimizations with respect to the state of the art, while the developed algorithms will be re-usable in similar cases in other application domains (e.g., domotics, other means of transports, etc.).

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
The expertise and knowledge gained in CRYSTAL will be useful for teaching at MSc and PhD level. In particular, the ELIOS Lab will exploit the experience in the "Cyberphysical Systems" course at the 1st year of the MSc in Electronic Engineering, especially concerning the development of a real-world case study on the design of complex embedded systems and integration of systems of systems. A PhD project will be created on the CRYSTAL topic either in the Interactive and Cognitive Environments (ICE) Erasmus Mundus PhD course, coordinated by the University of Genoa, or in the University of Genoa PhD course on Electronic, robotic, telecommunications and computer engineering.

The work in CRYSTAL is expected to provide knowledge usable also for writing new articles that we foresee to submit to high-quality, peer-reviewed S&T conferences and journals.

Development of commercial business is not the primary direct goal of our participation in CRYSTAL (which is scientific and didactic, according to the University's institutional aims). However, we intend to exploit CRYSTAL to grow several students who will be in strict contact with the CRYSTAL industrial partners, and will be solicited to improve the state of the art in order to better meet the current demands and consider possible business exploitation as self-employers and for the set-up of a new company. The target is to make them concretely aware of the possible socio-economical impact and business opportunities of their work and expertise.

Other external exploitations
Expected Exploitable Result
- Description: Model-Based Engineering techniques (e.g., requirement engineering and state of the art in MBE)
- Business Case and Market: Exploitation in Teaching: Courses, Bachelor/Master Thesis
- Roadmap for Exploitation: transfer/sustainability: include results of Crystal into Course Material, use results of Crystal as foundation for bachelor/master thesis
- Expected availability for use: M16

Expected Exploitable Result
- Description: Model-Based Engineering techniques (e.g., requirement engineering and state of the art in MBE)
- Business Case and Market: Exploitation in other research collaborations
- Roadmap for Exploitation: transfer: results of Crystal as foundation for new research projects in the field of embedded systems engineering
- Expected availability for use: M21

Expected Exploitable Result
- Description: MSc student training on Model-Based System Engineering
- Business Case and Market: Electronic Engineering MSc students. The activity is no profit in schools. Training for teachers, trainers and workers could be developed as well
- Roadmap for Exploitation: A first set of lectures (for MSc students) is being released in March 2014 (SysML basic). The next releases (periodical) will involve more examples and models, typically coming from the automotive domain. This will allow also extending the audience reach, in particular in the direction of industrial training
- Expected availability for use: First results by march 2014, then periodical updates

3.3.7 FBK

ACADEMIC PARTNER	
Organization: Fondazione Bruno Kessler	**Short Name: FBK**
Author: Marco Bozzano	

Short description of your contribution to CRYSTAL
FBK's main contribution will be in SP6, namely in the interoperability activities. FBK will bring to the project its previous experience from the ongoing ARTEMIS projects pSafeCer and nSafeCer. FBK will play the role of design and verification technology provider. It will contribute to the project by designing and implementing interoperability standards, and integrating technology bricks. Finally, FBK will contribute to the methodology

and techniques for certification and re-certification of embedded systems.

More in detail, FBK will investigate the design and implementation of interoperability standards and specifications used for analysis, verification and validation within the industrial domains (WP6.1). FBK will contribute to Task 6.1.1 with an analysis of the results of the ARTEMIS projects pSafeCer and nSafeCer for a possible re-use in CRYSTAL, and to Task 6.1.2, in particular to the extension of the IOS for taking into account the validation and verification tools provided by FBK. FBK will also participate to define an extension of the meta-model to take into account the functionality provided by FBK tools (WP6.2). Finally, FBK will contribute to the integration of technology bricks, such as NuSMV, within the specific technology platforms built within the project, and make them interoperable according to the developed IOS (WP6.3, WP6.4).

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research

FBK has a close relationship with the University of Trento. Several researchers from FBK are engaged in teaching activities. Moreover, FBK is involved in student projects, Bachelor and Master theses, and sponsors the University International PhD program; according to this program, several PhD students every year are hosted and supervised by people from FBK. In this respect, we plan to disseminate the research and development results of CRYSTAL to both students and FBK researchers that may participate in upcoming Artemis projects.

FBK is involved in the ongoing Artemis projects pSafeCer and nSafeCer, which focus on efficient methods and processes for development and certification of safety-relevant embedded systems, in various industrial domains. FBK intends to foster this link, and disseminate relevant knowledge in both directions. FBK will also disseminate in other EU-funded projects in which it is involved.

The research and development results obtained in CRYSTAL will be published in international workshops, conferences, and journals. Technology transfer is part of the core mission of FBK. Hence, FBK will put emphasis on the applicability and practicability of the results, and will transfer as much as possible the results to the industry. We expect that the results obtained in CRYSTAL will strengthen the competitive positioning of FBK in the field of model-based techniques for development and verification of embedded systems, in particular for what concerns interoperability with other tools and platforms. In particular, we expect that the results of CRYSTAL will be directly incorporated into the state-of-the-art NuSMV model checker (and its extensions), which is developed by FBK.

Other external exploitations

Expected Exploitable Result

- Description: The extended version of the NuSMV model checker, including the plugin for Crystal RTP

- Business Case and Market: Industries in the field of embedded and safety-critical systems, e.g. in the fields or aeronautics, aerospace, railways, automotive, energy production

- Roadmap for Exploitation: Technology transfer in order to enhance good practice. Licensing of tools for evaluation purposes. Joint proposals for new research projects. Possibly, commercialization.

- Expected availability for use: For evaluation: 2016. For commercialization: 3-5 years after the end of the project.

3.3.8 FhG

ACADEMIC PARTNER

Organization: Fraunhofer	**Short Name: FhG**

Author: Martin Becker, Christian Hein

Short description of your contribution to CRYSTAL

The main contribution of Fraunhofer is in the Avionic, Automotive, and Technology work packages. Fraunhofer focuses on contributions with respect to bricks. Contributions of Fraunhofer are mainly in the fields of interoperability specification, tool integration, safety analysis, variability management, requirements

engineering, and multi languagemodelling and simulation.

Fraunhofer FOKUS provides the ModelBus as an existing integration framework to CRYSTAL. ModelBus was already used in several RTP tool chains within the CESAR project. Fraunhofer FOKUS also contributes to the definition of the Interoperability Specification (IOS) of CRYSTAL which is also based on the work of CESAR IOS. In addition to that Fraunhofer FOKUS interacts as a moderator between IOS and tool provider on the one hand and end users and use case provider on the other hand by supporting to realize use cases and user stories with methods and technologies from R&T activities SP including adaption and customization of bricks, process flows, information mapping (model transformations), data consistency and team collaboration. Fraunhofer FOKUS will also work in the field of configuration and tailoring generic RTP concepts by supporting the specification and the implementation of RTP Builder.

Fraunhofer IESE focuses in the field of safety engineering on the provision of the C²FT and SCT bricks. Both bricks are based on existing Fraunhofer methods and tools, which are extended based on the needs from the use cases and connected to the CRYSTAL RTP.

Regarding variability management the focus will be on the System Family Engineering Framework and the Variant Analysis tool. The first brick will be based on the FraunhoferPuLSE (Product Line Software Engineering) framework. Specific features that will be added are planning (esp. scoping) and specification of high-integrity families, modularization approaches and model-based orthogonal variability management. The latter brick will extend the Fraunhofer Variant Analysis tool to be applicable also on non-code artefacts as e.g. requirements, design models, and test artefacts and integrate it with the RTP.

Regarding Requirements Engineering, Fraunhofer IESE will focus on the elicitation, modelling, verification and validation of project and system constraints. Constraints represent non-negotiable limitations the project and the product has to conform to, e.g. regulations, laws of nature, existing technology. The expected output is a statement about the completeness and the consistency of a constraint model limiting the solution space for a product under development.

Regarding multi-language modelling and simulation the simulation of holistic system models and error propagation in the avionics domain is the main objective. In this domain, system prototypes often consist of a number of heterogeneous models that need to be evaluated individually. An integrated simulation enables the evaluation of error effects across different models, including environmental models, communication networks, and aircraft functions. This enables a much more precise prediction of the impact of design decisions on system level.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research

Fraunhofer will exploit CRYSTAL results in lectures at universities where industrial application is an important part of academic education (e.g. Requirements Engineering, Product Line Engineering).

Fraunhofer will extend its service and product portfolio for consulting services based on CRYSTAL results, significantly. Experiences gained in the cooperation with industrial partners will be used to direct Fraunhofer's future research agenda. Established contacts with CRYSTAL industrial and research partners will be used to acquire further R&D projects.

We also expect that the challenges addressed in CRYSTAL use cases are relevant for numerous partners in other application domains as well. Therefore, we plan to develop concrete consulting products and novel technology also beyond the CRYSTAL domains based on the CRYSTALCRYSTAL results and thus multiply the project impact.

Fraunhofer FOKUS will integrate IOS results in their tools and methods portfolio for conducting industrial R&D activities.

Fraunofer IESE will use the developed bricks and gained experiences in the field of safety analysis, variability management, requirements engineering, and multi-language modelling and simulation to enhance the existing service portfolio.

Other external exploitations

Expected Exploitable Result

- Description: System Family Engineering Framework

- Business Case and Market: Use results in cooperation projects with industrial partners to improve their product line engineering capabilities.

- Roadmap for Exploitation: Improve existing Product Line Engineering training and Product Line Engineering lecture at TU-Kaiserslautern. Enhance Fraunhofer IESE services for Potential Analysis,

Scoping, Variability Management, Product Line Requirements Engineering and Product Line Architecture Design

- Expected availability for use: 2014-2016

Expected Exploitable Result

- Description: Variant Analysis
- Business Case and Market: Use results in cooperation projects with industrial partners to analyse the reuse potential in their existing code and model artefacts
- Roadmap for Exploitation: Extend Fraunhofer Variant Analysis to support also non-code artefacts as requirements, test specifications and design models. Integrate the Fraunhofer Variant Analysis tools into the CRYSTAL RTP.
- Expected availability for use: 2014-2016

Expected Exploitable Result

- Description: Model-based Requirements Engineering approach
- Business Case and Market: Use results in cooperation projects with industrial partners to improve requirements engineering capabilities by adopting model-based approaches, e.g. for quality specification.
- Roadmap for Exploitation: Improve existing System and Requirements Engineering trainings and Requirements Engineering lecture at TU-Kaiserslautern. Enhance Fraunhofer IESE services for System and Requirements Engineering
- Expected availability for use: 2015-2016

Expected Exploitable Result

- Description: Simulation Framework
- Business Case and Market: Use results in cooperation projects with industrial partners to simulate various system aspects in a holistic way in early development phases
- Roadmap for Exploitation: Enhance existing Fraunhofer Simulation Framework and Fraunhofer IESE services around it
- Expected availability for use: 2015-2016

Expected Exploitable Result

- Description: C²FT and SCT
- Business Case and Market: Use results in cooperation projects with industrial partners model and analyse safety aspects in modular systems and system of system settings
- Roadmap for Exploitation: Extend existing modeling approaches according to the CRYSTAL project partner needs and integrate the modeling approaches into the CRYSTAL RTP
- Expected availability for use: 2014-2016

Expected Exploitable Result

- Description: Tool Interoperability Method based on IOS
- Business Case and Market: The goal is to develop an exploitable method that supports potentiel constumer to establish tool interoperablity based on the CRYSTAL IOS princples. The business case is to provide tool interoperabilty consultancy to our existence customer and potentially to new customers form CRYSTAL's domains.
- Roadmap for Exploitation: Collaborative activity with IST. Roadmap is not defined yet, due to the early stage of the IOS definition. The Roadmap will be defined after first release of IOS.
- Expected availability for use: as soon as possible

3.3.9 TUG

ACADEMIC PARTNER	
Organization: Technische Universität Graz	**Short Name: TUG**

Author: Bernhard Aichernig, Florian Lorber

Short description of your contribution to CRYSTAL
TUG will mainly cooperate with AIT in SP6. More precisely TUG will apply, adapt, integrate and enhance their tools in WP 6.4. TUG has and is developing scalable fault-based test case generation tools in other projects (MBAT, MOGENTES, TRUFAL). The tools implement a technique called model-based mutation testing. In this technique faults are modelled by mutation. A mutation syntactically alters a given model. A test case is generated that will detect whether this fault has been implemented. The technique is new and not yet commercially available. In CRYSTAL we will apply our technique to the industrial demonstrators, compare it to other test-case generation techniques and study how our novel testing techniques can be best integrated into an industrial development process with safety analysis. This includes modelling techniques with different levels of abstraction and the investigation of the relation between fault-tree analysis and model-based mutation testing. With respect to tool adaptation we plan to adapt the architecture of the tools such that its tasks can easily run concurrently in the cloud.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
The results of the CRYSTAL project will be exploited in TUG's courses, research and industrial collaborations.
TUG has a strong collaboration with the automotive industrial cluster in Graz (Magna, AVL, KTM etc.). The integration of its test case generators will be of mutual benefit, fostering the transfer of new CRYSTAL technologies to our local industrial partners.
TU Graz has a number of local research projects on model-based testing. The biggest is the Softnet Austria Competence Network which is coordinated by TU Graz. The results of CRYSTAL, especially the new insights in combining testing and safety analysis techniques will be exploited in these projects.
The group at TUG is responsible for a number of courses where model-based testing is covered. About 300 students per year take these courses. The results of the CRYSTAL project will be integrated into these courses. Furthermore, we envisage a number of bachelor, master and PhD thesis projects on this topic. Hence, young researchers will be trained in the methods and techniques resulting from CRYSTAL.
The results of our research in CRYSTAL will be disseminated through the high-level conferences our researchers are involved in.
For model-based mutation testing no commercial tools exist yet. In CRYSTAL we will also investigate if there is a need and market for this testing technique. If positive, we will develop strategies with our partners how to commercialize the techniques.

Other external exploitations

Expected Exploitable Result
- Description: Integration of CRYSTAL Results in TU Graz Courses
- Business Case and Market: The integration of research and science is implemented by incorporating the results of science in Telematics master courses for about 300 students per year.
- Roadmap for Exploitation: Integration in the courses "Selected Topics in Software Technology 2014, 2015, 2016"
- Expected availability for use: Already in use

Expected Exploitable Result
- Description: Integration of CRYSTAL Expertise in industrial collaborations
- Business Case and Market: The TU Graz is strongly collaborating with the automotive industrial cluster in Graz (AVL, KTM, Magna) and the expertise gained within this project will strongly influence

and improve future industry projects.

- Roadmap for Exploitation: Knowledge transfer to future Artemis projects (e.g. MBAT2?)
- Expected availability for use: 2015

Expected Exploitable Result
- Description: Improvement of our test case generation tools
- Business Case and Market: Students and future industrial / scientific partners will benefit from a more stable and mature version of our tools.
- Roadmap for Exploitation: Allowing Non-Determinism in MoMuT::TA, improving MoMuT::Reqs
- Expected availability for use: 2014

3.3.10 U3CM

ACADEMIC PARTNER	
Organization: Universidad Carlos III de Madrid	**Short Name: U3CM**
Author: Anabel Fraga	

Short description of your contribution to CRYSTAL
The combination of Large Enterprises, SME and Research centers in a balanced consortium for CRYSTAL is designed to be "a virtuous circle", where large enterprises take the clear role of industrial tractors of needs, tools and methodologies. On the other side, research centers provide the consortium with   innovative solutions to the large enterprises needs at a precompetitive level of maturity. Finally, in between, European SMEs produce the commercial tools that will reach the market, knowing that they already fit with industrial customer's needs.
Incentive effect
The results from CRYSTAL will impact in the business participants by providing new elements and design tools to improve the performances of their products and therefore to increase their marketability. It will allow them to become visible in diverse markets around the world, increasing their sales. CRYSTAL will also impact the research activities of the group in the University providing a platform for interacting with industry and providing research results applied to the industry environment. It will also increase the visibility of the research group among researchers in the whole world.

Employment increase
The university foresees to incorporate two professionals/technical profiles. Also, a project like this will increase the participation of all the members of the research group in the tasks described. The group foresees to offers new PhDs and Postdoc Scholarships during the project time.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
The Knowledge Reuse Group (KR) is a multi-departmental research group formed by Professors, researchers and Scholarships from the Informatics Department and the Library Science Department at the University Carlos III of Madrid. At present time more than 40 members form their staffs, where 3 of them are full professors. The group will be involved in the CRYSTAL project and it will give feedback to the staff regarding better applied teaching activities and even Final Projects for students willing to participate in small parts of the project. It will allow students to be involved in real European projects and touch a little part of the real professional world, where they will go to work once they get the degree.
The group will increase its research activities in the following general-topic lines:
- Knowledge Representation, Retrieval and Reuse
- Software Development, Management and Measurements Processes
- Ontology oriented Systems Engineering
The concrete research activities of the KR members are being developed within the previously defined

general-topic areas. Among them, the most relevant research niches are: Semantic Indexing and Retrieval Systems, Structured Information Search Engines, automatic Ontologies creation, Ontologies driven requirements engineering, Automatic Online Assistants, CMMI, Software Process Improvement metrics. The KR has developed more than 80 projects in its 20+ years of existence, where around 60% of them have been funded by private companies and organizations as Private R+D+i. The public funded projects represent today around 40% of the research. The group expect to achieve more advances in the research activities and also an improvement in the quality of the teaching activity. As part of the work of the group, consultancy could be an interesting perspective for the staff, where they could increase his/her capacities and knowledge in the topics of the CRYSTAL project as well as increase its participation as researchers and teachers in the scientific world to be recognized as one of the leaders in their field of research, getting closer industry and academia at the end.

Other external exploitations

<u>Expected Exploitable Result</u>

- Description: Enhanced know how on:
    - OCLC Methods for sharing Ontologies and Requirements descriptions and Quality
    - Improvements on Modeling and graph based systems representations, also formalization of requirements based on boilerplates and patterns
    - Improvement of Requirements quality
- Business Case and Market: CRYSTAL results will strongly influence the future research of the group Knowledge Reuse (KRG) in the Department of Computer Science and Engineering of University Carlos III of Madrid.
- Roadmap for Exploitation: Integration of public results of project in academic courses for enhancing teaching quality.
- Expected availability for use: Considering that major result to exploited is enhanced "Know how" for improving quality of academic courses. Every Milestone of the project will produce an advance in "know how" which will be reflected in an increase of quality of courses. Also, improvements will be included in tools owned by REUSE (the Spin-off company of the research group).

3.3.11 POLITO

ACADEMIC PARTNER

Organization: Politecnico di Torino	Short Name: POLITO

Author: Sergio Chiesa

Short description of your contribution to CRYSTAL

Politecnico di Torino will participate involving the Department of Mechanic and Aerospace Engineering (DIMEAS) and the Department of Automation and Informatics (DAUIN). Polito will participate to the following Work Packages:

•   WP 1." Dissemination and Exploitation of Results: Polito will contribute to the activities of T1 Dissemination activities and T2 Exploitation activities of the Italian Aerospace Domain. Workshops, seminars, and courses for innovation result sharing with scientific community will be held and dedicated tools for allowing the exploitation of the results will be created.

In SP 2 Aerospace Domain to the following Work Packages:

•   Use Case 2.2 – "Alenia" - Preliminary Design for a new Regional Turboprop – :Polito will provide its competencies in Aerospace Engineering and Informatics Engineering to the Use Case Process definition and development in collaboration with the Use Case Leader (i.e. AleniaAermacchi). System Engineering competences will be a key element in order to support the Use Case Leader activities in the improvement of existing technology bricks and the development of brick integration. Polito will participate to T1 Use Case Definition (Collect RQ), T2 Prototyping IOS concepts (Definition), T3 Building SEE (Integration), T4 SEE and Bricks assessment (Assessment)

• WP 2.m Public Use Case AEROSPACE: As far as the Public Use Case AEROSPACE is concerned, as for the WP 2.2, Polito will provide its above mentioned competencies in order to support Use Case leader in the extrapolation of a Public Aerospace Use Case. Polito will participate to T1 Use Case Definition (Collect RQ), T2 Prototyping IOS concepts (Definition), T3 Building SEE (Integration), T4 SEE and Bricks assessment (Assessment)

• WP 2.n Specifying Domain Ontology AEROSPACE: Polito will provide its competencies in Informatics Engineering in order to participate to definition and development of Meta-models and new interoperability standards for Aerospace Domain ontology and semantic. Polito will participate to T1 Use Case Definition (Collect RQ), T2 Prototyping IOS concepts (Definition), T3 Building SEE (Integration), T4 SEE and Bricks assessment (Assessment)

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
Politecnico di Torino will contribute to the Dissemination and Exploitation of results concerning the Italian Aerospace Domain. The objective of this activity will be to ensure the uptake of project results in a large range of appropriate applications and identify necessary work to further develop CRYSTAL and get it adopted by the stakeholders. There are intentions of communicating to the wider world appropriate information on the CRYSTAL approach (with the benefits) that this EU supported research has created. Finally dissemination of accumulated knowledge within the member companies, organizations and above all academic students shall occur.
Dissemination
The objective the activity will be:
• Disseminate information outside the consortium. In order to communicate efficiently with the project partners and the academic students for formation purposes the following actions will be undertaken:
o Organization of two workshop (i.e. one intermediate workshop and one final workshop) The workshop will be presented by the leading experts within the consortium in order to raise awareness among companies and the scientific community.
o Organization of open seminars and courses so that results of CRYSTAL can be shared with students and all interested person of the scientific community. The role of CRYSTAL in the formation of future engineers is a key elements of Dissemination.
o Dissemination of results of Italian Aerospace Domain through papers in technical reviews, specialized press and on CRYSTAL public web site.
o Dissemination of results of Italian Aerospace Domain by participating to congresses and conferences where CRYSTAL results will be diffused

This will be undertaken without revealing commercially sensitive information. These are the prime vehicles for dissemination of knowledge within the academic and industrial research community. Papers will be encouraged from all engineers involved in the programme. This will raise awareness among a greater community and encourage the use of the technology within other industry sectors.
Exploitation
The objective of this activity is to:
• Undertake the required steps to produce an Exploitation Plan with the cooperation of all partners of Italian Aerospace Domain and to conduct the Project technology to higher TRLs. The Exploitation Plan will encompass the following activities:
o Demonstrating the benefits of the research
o Creation of Interactive Databases so that results of the research can easily understandable and exploitable by a generic person interested in CRYSTAL results applications.
o Documenting the ownership of results
• Italian Aerospace Domain will be requested to identify where the technology that has been generated can be used, with timescales and any possible applications.
CRYSTAL results will strongly influence the future research of Department of Mechanic and Aerospace Engineering (DIMEAS) and the Department of Automation and Informatics (DAUIN) of Politecnico di Torino. POLITO will acquire relevant "know how" in the modern Aircraft Preliminary Design process management. This will allow to reach new and relevant results in the field, as an example, of long-term-future aircraft design thanks to acquired technologies for variability management which is a key element of complex trade-off analysis. As a conclusion CRYSTAL will have strong impact also on the success rate of POLITO in the European and National Calls for Proposal contests by generating a quality boost of POLITO future research.

Other external exploitations

Expected Exploitable Result

- Description:

  Enhanced know how on:

  - Modern Engineering methods for Aircraft Design process

  - Model Based System Engineering

  - Tools Interoperability

- Business Case and Market: CRYSTAL results will strongly influence the future research of Department of Mechanic and Aerospace Engineering (DIMEAS) and the Department of Automation and Informatics (DAUIN) of Politecnico di Torino.

- Roadmap for Exploitation: Integration of public results of project in academic courses for enhancing teaching quality.

- Expected availability for use: Considering that major result to exploited is enhanced "Know how" for improving quality of academic courses. Every Milestone of the project will produce an advance in "know how" which will be reflected in an increase of quality of courses.

3.3.12 SUN

ACADEMIC PARTNER	
Organization: Second University of Naples	**Short Name: SUN**
Author: Beniamino di Martino	
Short description of your contribution to CRYSTAL The main contribution of the SUN unit to CRYSTAL is related to the definition of methods and tools related to the Verification and Validation of railway systems. In particular the focus will be on the creation of languages aiming to properly describe system and requirements according to model driven principles. The definition of such languages will be also supported by the definition of model-to-model transformations able to provide a translation of high level models into more analyzable models. SUN unit will also bring to the project its experience in the field of Distributed Computing (in particular in Cloud contexts) as it is proved by several research project. This field will also become the natural domain of application and reuse of CRYSTAL products and artifacts in particular in the topic of the Verification and Validation of both qualitative and quantitative properties of this kind of systems.	
Planned Exploitation of CRYSTAL	
Planned activities regarding Teaching and further Research The biggest influence that CRYSTAL project will have on SUN unit's research activities are related to the improvement of the expertise of the group in the V&V field and to an easy reuse and application of this expertise to other challenging research topics present in Cloud Computing field where V&V activities are at the starting point and constitute an interesting future research trend. **Other external exploitations** Expected Exploitable Result - Description: Tool set for test case generation from high level specification of system. - Business Case and Market: The tool set will be designed basing on the UC 5.1 but, according to the constraint of the input language, the application range of such toolset could be wider than railway domain and can be extended to all the applicative domains present in Crystal. - Roadmap for Exploitation: After the building of the toolset, the application on some case studies by the industrial partners in Crystal (railway first) will be the first step. Then, the results will be properly disseminated by means of journal publications and presentations within international conferences.	

| • | Expected availability for use: End of the project. |

3.3.13 TUB

ACADEMIC PARTNER	
Organization: Technische Universität Berlin	**Short Name: TUB**

Author: Kerstin Hartig, Marc-Oliver Reiser, Thomas Karbe

Short description of your contribution to CRYSTAL TU Berlin will be represented in CRYSTAL by the Software Engineering Research Group (SWT) at the Faculty IV – Electrical Engineering and Computer Science. This division is closely linked to Fraunhofer Institute for Computer Architecture and Software Technology (FhG FIRST) through its head Prof. Dr. Stefan Jähnichen. Within CRYSTAL, TU Berlin will concentrate on variability management and functional safety / ISO26262 support. This work is planned to be conducted in close cooperation with Daimler AG through the Daimler Center for Automotive Information Technology Innovations located at TU Berlin. TU Berlin's main focus in CRYSTAL is Work Package 3.2 with the use case "Development of a safety related assistance system". This comprises contributions to requirements elicitation, design, and assessment / validation for the CRYSTAL tool chain. SWT has built a strong competence in software engineering over many areas, including requirements engineering and testing, software product families and variability management, modeling standards like UML2, aspect oriented programming (AOP), visualization of software processes and formal aspects of software engineering methodologies. Through many projects with industrial partners – for example Daimler AG and Carmeq GmbH, a subsidiary of Volkswagen AG – there is substantial experience in the adaptation of these scientific concepts to the practical needs of the automotive industries.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research Experience from industrial research projects such as CRYSTAL is invaluable for university education. A close link between research, practice and teaching – esp. the direct contact to colleagues from industry within such projects – is a prerequisite for preparing courses that are interesting, motivating and inspiring for students. At the same time, such insight in industrial practice is required in order to tailor courses to the actual needs and expectations of industry, helping both companies to find employees with a relevant skill set and students to later find jobs that suit their interests and expectations. In addition, the participation in CRYSTAL will provide TU Berlin with valuable insight and experience that will influence and help improve our research approaches and/or tool prototypes that have been devised and developed in our group over the past few years. This includes, for example, an approach for variability management in automotive software development and accompanying tool prototypes. Thanks to the broad spectrum of application domains addressed by CRYSTAL (transportation domains other than automotive, health care), the experience from this project will enable us to investigate if and how our research approaches and tools, that currently have a strong focus on the automotive domain, can be adapted to other industrial domains of embedded systems development. Finally, our close cooperation with Daimler AG in CRYSTAL will help us to further strengthen our research cooperation with the Daimler Center for Automotive Information Technology Innovations (DCAITI). In terms of future research, TU Berlin plans to take up research questions and topics that might arise from CRYSTAL within the context of future project proposals on national and European levels, in order to continue the work and consolidate results and approaches. Expected Exploitable Result • Description: IOS/OSLC expertise, Variability Management Expertise, Functional Safety Expertise, Requirements Management Expertise • Business Case and Market: Exploitation in Teaching: Courses, Bachelor/Master/PhD Thesis

- Roadmap for Exploitation: Use results of Crystal as foundation for bachelor/master thesis
- Expected availability for use: M12 – M36

3.3.14 UNIFED II

ACADEMIC PARTNER	
Organization: University of Naples "Federico II"	**Short Name: UNIFED II**

Author: Valeria Vittorini, Nicola Mazzocca

Short description of your contribution to CRYSTAL
The contribution of UniFEDII unit to CRYSTAL is its participation in the definition of validation methods and tools and other life-cycle management tools in relation to two specific domains. On one hand it is involved in ERTMS/ETCS systems testing (railway domain), on the other it is involved in aerospace domain.
In both of them UniFEDII unit will be able to contribute to the definition of both methods, techniques and tools by means of both simulative and formal approaches. The results of the project (both in terms of developed techniques and tools) will be re-used in other application domains such as automotive, embedded systems and physical protection systems in which UniFedII is involved by several collaborations with other industrial partners.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research
On the side of teaching activities, the CRYSTAL project will improve the existing course of "Security and Dependability of Computer Systems" and the course of "Formal Methods" that is going to be activated. Both courses are related to the Master degree in Computer Engineering of the University of Naples "Federico II". Moreover consulting services and the constitution of academic spin-offs will be possible.

Other External exploitations
Expected Exploitable Result
- Description: Enhanced know how on verification processes in the railway domain, Model Based System Testing and Tools Interoperability.
- Business Case and Market: CRYSTAL activities will results in a positive influence on the research and learning activities of the Electrical and Information Technology Department (DIETI) at the University of Naples Federico II
- Roadmap for Exploitation: Public results from the research activities will be integrated in academic courses as well as in learning projects for graduated students
- Expected availability for use: tbd

3.3.15 TNO

ACADEMIC PARTNER	
Organization: Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek	**Short Name: TNO**

Author: Sytze Kalisvaart

Short description of your contribution to CRYSTAL
TNO's contributions will be primarily in the health care domain (SP4) and bricks development (SP6).
It will use its expertise in multi-physics modelling of distributed systems for analysis of performance and reliability of complex systems and handling of errors in SP4 Health care domain and for bricks B4.06 and B4.09 on performance simulation and hardware in the loop simulation. Based on this application experience,

TNO will define appropriate processes and methods to create the IOS concepts and evaluate these.

TNO will lead SP 4.o on health care ontology where it will apply its interoperability expertise. In this work, TNO will emphasize best practice health care work processes and translate these into a common ontology for health care development tool interoperability.

Finally, TNO will use its experience in medical safety consultancy for SP4 and for brick 3.6 on FMEA and fault tree analysis. In particular, TNO will pay attention to safety of complicated systems within the complex usage context of the operation room.

TNO applies its expertise on distributed systems in the health care, automotive market and defence market. The CRYSTAL tool platform will be of significant relevance for system development, e.g. collaborative driving and military monitoring in combat. Model driven system engineering is a core activity also in TNO's space (e.g. ESA) and semiconductor market (e.g. ASML). The CRYSTAL will help streamline and accelerate development in these markets.

Planned Exploitation of CRYSTAL

Planned activities regarding Teaching and further Research

As a contract research organization, TNO has an important role in on the job training of students and young professionals. Using the CRYSTAL results, these innovators can learn to manage system complexities far beyond the small team capacity. Through its contract research for SMEs and multinationals and through mobility of personnel, TNO spreads the power of the CRYSTAL results in industry and helps.

TNO foresees a large role for early performance modelling of systems to reduce development risks and reduce the number of development iterations. Modelling keeps the development agile until key performance parameters have come under control. Then, traditional engineering can start efficiently. This changes the way that contract research is performed for partners. CRYSTAL strongly enforces TNO's strong role in model driven system design.

TNO adopts an open innovation approach, amongst others with Shared Research Programs. The interoperability of the CRYSTAL approach is a strong benefit in such collaborative projects.

Other external exploitations

Expected Exploitable Result

- Description: Tool chain suitable for a wide range of industrial users

- Business Case and Market: The tooling being developed fills the gap between expensive commercial modeling tools (like Matlab and Rhapsody) that require detailed modeling, often close to the level of code, and drawing tools (such as Visio and UML drawing tools) that do not allow simulation. There is a lack of tool support for the early phases of system development, where requirements might not yet be very clear and many decisions have to be taken about the structure of the system, the responsibilities and behaviour of the components, and their interaction. Any company involved in complex system development will benefit from a high level modelling approach and is applicable to many domains.

- Roadmap for Exploitation: To disseminate the POOSL tooling and possible ways in which it can be used, a number of activities will be planned. There will be a web site with downloads, documentation (including a tutorial), and examples. The tooling will be used in a number of TNO-ESI projects with the high-tech industry where the aim is to transfer the tools and knowledge to industrial users. Presentations and demonstrations will be given at industrial events for the high-tech industry and special interest groups of architects. Finally, the competence development program of TNO-ESI will be updated to assist in the transfer to industrial users. Whenever possible, we will ask our first industrial users, e.g. from our user forum, to present their experiences.

- Expected availability for use: The starting point of the work is a prototype of the Eclipse editor with some basic functionality and the possibility to start and stop the existing simulator. This prototype is already available. This prototype will be used to discuss and refine the user requirements. The additional functionality will be implemented in three main increments, estimated dates being June 2014, October 2014, and December 2014. Focus of the first increment is an improvement of the editor with techniques such as scoping and validation to detect modeling errors as soon as possible. The second increment addresses the inspection of models during simulation. The third increment concerns visualization of models and simulation results. Each major increment also includes user documentation and is evaluated by our industrial user group. A mature release is expected to be

delivered end 2014, including documentation, tutorial and web site.

3.3.16 TU/e

ACADEMIC PARTNER	
Organization: Technical University Eindhoven	**Short Name: TU/e**

Author: Martijn van den Heuvel

Short partner description
TU/e is represented in CRYSTAL by the System Architecture and Networking (SAN) and the Software Engineering and Technology (SET) groups, both from the Department of Mathematics and Computer Science, and by the Control Systems Technology (CST) group from the Department of Mechanical Engineering. SAN and SET contribute to CRYSTAL with their expertise large-scale, reliable software systems, in particular, methods for the prediction of performance and safety of distributed systems (SAN), and model based software engineering and the design, development and integration of domain specific languages (SET). CST brings its expertise in robotics, here applied to the safe motion control of an X-Ray scanner.

Planned Exploitation of CRYSTAL

Other external exploitations
Expected Exploitable Result
- Description: The tool (Gazebo) has been adapted and evaluated in an industrial context
- Business Case and Market: Any company interested in obtaining insights in their software/system simulation process.
- Roadmap for Exploitation: Dissemination activities around Gazebo would depend on the outcome of the industrial evaluation during the CRYSTAL project.
- Expected availability for use: tbd

Expected Exploitable Result
- Description: The tool (FRASR) has been adapted and evaluated in the industrial context.
- Business Case and Market: Any company interested in obtaining insights in their software/system development process.
- Roadmap for Exploitation: Dissemination activities around FRASR would depend on the outcome of the industrial evaluation during the CRYSTAL project.
- Expected availability for use: tbd

3.3.17 ALU-FR

ACADEMIC PARTNER	
Organization: University of Freiburg	**Short Name: ALU-FR**

Author: Bogomolov Sergiy

Partner Description
University of Freiburg is one of the oldest German universities (founded in 1457) and is these days one of the leading national research and teaching institutions. In 2007, the University of Freiburg received the elite status and since then belongs to the only nine German Universities of Excellence with a membership in the League of European Research Universities. It actively fosters interdisciplinary research and it is one of the few universities offering world-class research environments in classical as well as in modern disciplines. The University of Freiburg actively promotes international exchange. The Technical Faculty of the University of Freiburg, which hosts the Institute for Microsystems technology and the Department of Computer Science is internationally regarded as a constellation of two of the most promising technologies for the future and holds an outstanding position worldwide.

Planned Exploitation of CRYSTAL

Other external exploitations
Expected Exploitable Result
- Description: Tool support for interoperable data management
- Business Case and Market: Daimler and suppliers (research and in-house use)
- Roadmap for Exploitation: pilot project and company roll-out.
- Expected availability for use: As soon as stable

3.3.18 CIC

ACADEMIC PARTNER	
Organization: Creative Intellect Consulting Ltd.	**Short Name: CIC**

Author: Bola Rotibi

Partner Description
Creative Intellect Consulting is an analyst research, advisory and consulting firm founded by Bola Rotibi, an experienced and renowned expert analyst in the field of software development, delivery and lifecycle management processes, technologies and tools.

The company's key areas of analysis are software development, delivery and lifecycle management across the Software and IT spectrum (e.g. Cloud, virtualisation, SOA, PLM, SPL, PLE, Systems Engineering, Analytics and Intelligence, Agile, Mobile and mobility, etc.) along with their impacts on and alignment with business.

Planned Exploitation of CRYSTAL

Other external exploitations
Expected Exploitable Result
No input received from partner
- Description:
- Business Case and Market:

- Roadmap for Exploitation:
- Expected availability for use:

4 Terms, Abbreviations and Definitions

CRYSTAL	**CR**itical S**YST**em Engineering **A**cce**L**eration
TI	Technical Item
PI	Project Innovation
G	Goal
SG	Sub Goal
tbd	To be defined

Table 4-1: Terms, Abbreviations and Definitions

5 Annex

Annex I: Preliminary list of TI's

Please note that this is an initial draft version of the CRYSTAL TIs. The process of identifying these TIs has just started and a significant extension of this list will be provided in the upcoming version of this document D102.070 (M24).

TI_ID	Short Name of TI	Kind of TI	Next Planned Release Date	TECH_REF_REQ_ID	Brick_ID	PI_ID	TRL
TI_0001	OSLC RM provider DOORS 9.5	Interoperability	15.01.2014	TECH_REF_REQ_0002;#2	B2_16	PI_0001;#1	1
TI_0002	OSLC RM consumer DOORS 9.5	Interoperability		TECH_REF_REQ_0002;#2	B2_16	PI_0001;#1	1
TI_0003	OSLC RM Consumer for FaultTree+	Interoperability		TECH_REF_REQ_0003;#3	B2_22	PI_0001;#1	1
TI_0006	Visualization Capabilities of 3D models from ps-tech for DOORS	General		TECH_REF_REQ_0004;#4	B2_16		1
TI_0007	Integration of ps-tech 3D visualization capabilities for DOORS	General		TECH_REF_REQ_0004;#4	B4_1	PI_0017;#17	1
TI_0008	Reqlf or common schema/format across customer interfaces	Interoperability		TECH_REF_REQ_0005;#5	B3_89		1
TI_0009	FMU conforming simulation host that supports model exchange and co-simulation	Interoperability		TECH_REF_REQ_0008;#8;#TECH_REF_REQ_0009;#9	B2_47		1
TI_0010	Simulation adapter for Simulink to integrate Simulink into Simulation Host	Interoperability		TECH_REF_REQ_0010;#10	B2_48		1
TI_0011	IOS Adapter that enables model discovery, possibly through model repository server						1
TI_0012	Enrich Simulation Models with Meta Data						1
TI_0013	Automatic Setup of Simulation scenarios/experiments	General					1
TI_0014	Traceability Table linking Requirements versions and Model versions						1

TI_0015	Traceability Table linking Model versions to Test Results versions						1
TI_0016	Tracing combined Models/Simulation Scenarios back to individual simulation models						1
TI_0017	ARQE.xml schema	Interoperability	29.10.2013	TECH_REF_REQ_0014;#14			1
TI_0018	Sirius - refactoring for initial contribution	General			B2_31b	PI_0011;#11;#PI_0017;#17;#PI_0012;#12	1
TI_0019	Sirius - Multi Viewpoints Graphical Modelling environment - Prototype	General			B2_31b	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0031	Sirius - Modularization	Interoperability			B2_31b	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0032	Sirius - Ecoretools 2	General			B2_31b	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0033	OSLC RM Adapter for connection to Integrity	Interoperability		TECH_REF_REQ_0015;#15	B3_100		1
TI_0034	OSLC CM Adapter for connection to Integrity	Interoperability		TECH_REF_REQ_0016;#16	B3_100		1
TI_0035	OSLC TM Adapter for connection to Integrity	Interoperability		TECH_REF_REQ_0017;#17	B3_100		1
TI_0037	VEVAT OSLC Adapter	Interoperability					1
TI_0039	ReqPro -> asureSign interface	Interoperability	01.12.2014	TECH_REF_REQ_0019;#19;#TECH_REF_REQ_0020;#20	B3_91		1

TI_0040	EMF-based editor for POOSL	General		TECH_REF_REQ_0021;#21;#TECH_REF_REQ_0022;#22;#TECH_REF_REQ_0023;#23;#TECH_REF_REQ_0024;#24;#TECH_REF_REQ_0025;#25	B4_9	PI_0017;#17	1
TI_0041	Eclipse-based frontend to POOSL simulation engine	General		TECH_REF_REQ_0026;#26;#TECH_REF_REQ_0027;#27;#TECH_REF_REQ_0028;#28;#TECH_REF_REQ_0029;#29	B4_9	PI_0017;#17	1
TI_0042	API extension of POOSL simulation engine	General		TECH_REF_REQ_0030;#30	B4_9	PI_0017;#17	1
TI_0043	PMF - Implementation of Meta-model	General			B2_31c	PI_0023;#23	1
TI_0044	PMF – Integration with EGF	General			B2_31c	PI_0023;#23	1
TI_0045	PMF – Generation of Properties View	General			B2_31c	PI_0023;#23	1
TI_0046	PMF - Integration with XWT	General			B2_31c	PI_0023;#23	1
TI_0047	Model co-evolution – State of the Art	General	01.05.2014		B2_31e	PI_0012;#12	1
TI_0048	Multi-viewpoint Environment - State Of the Art	General	01.01.2015		B2_31a	PI_0012;#12	1
TI_0049	Co-Evolution Prototype	General	01.05.2014		B2_31e	PI_0012;#12	1
TI_0050	Co-Evolution Specification	General	01.05.2014		B2_31e	PI_0012;#12	1
TI_0051	Identification of/Mapping between model components	Interoperability		TECH_REF_REQ_0037;#37	B3_3		1
TI_0052	Implementation of the Transformation Process	Interoperability		TECH_REF_REQ_0037;#37	B3_3		1
TI_0053	GUI implementation for simulation result analysis	General		TECH_REF_REQ_0038;#38	B3_3		1

TI_0054	Implementation of the Ethernet protocol	General		TECH_REF_REQ_0038;#38	B3_3		1
TI_0055	GUI implementation for simulation model configuration	General		TECH_REF_REQ_0038;#38	B3_3		1
TI_0056	Test Specification Patterns	General		TECH_REF_REQ_0039;#39	B5_1	PI_0013;#13	1
TI_0057	Modelling formalisms experiment	General		TECH_REF_REQ_0040;#40	B3_12		1
TI_0058	Requirements evolution study	General		TECH_REF_REQ_0041;#41	B3_12		1
TI_0059	Requirements complexity study	General		TECH_REF_REQ_0041;#41	B3_12		1
TI_0060	System Patterns	General		TECH_REF_REQ_0039;#39	B5_1	PI_0013;#13	1
TI_0061	Framework for modelling requirements.	General		TECH_REF_REQ_0040;#40;#TECH_REF_REQ_0041;#41	B3_12		1
TI_0062	Test Case Generation Process	General		TECH_REF_REQ_0039;#39	B5_1	PI_0013;#13	1
TI_0063	Eclipse EMF/GMF – based tool editor for rail domain models	General		TECH_REF_REQ_0042;#42	B5_1	PI_0011;#11	1
TI_0064	Definition of a formal language based on State Machine for the Railway domain	General		TECH_REF_REQ_0042;#42	B5_1	PI_0011;#11	1
TI_0065	Test Sequences Generator	General		TECH_REF_REQ_0042;#42	B5_1	PI_0011;#11	1
TI_0066	IOP Test Writer	General		TECH_REF_REQ_0043;#43	B5_3	PI_0017;#17	1
TI_0067	Tool Log Analyzer	General		TECH_REF_REQ_0044;#44	B5_4	PI_0017;#17	1
TI_0068	OSLC adapters solution	Interoperability		TECH_REF_REQ_0045;#45	B5_1	PI_0012;#12	1
TI_0069	OSLC adapters solution	Interoperability		TECH_REF_REQ_0046;#46	B5_3	PI_0012;#12	1
TI_0070	OSLC Adapter for Artisan Studio	Interoperability		TECH_REF_REQ_0015;#15	B3_79		1

TI_0071	Structure of WLTP	General		TECH_REF_REQ_0040;#40;#TECH_REF_REQ_0041;#41	B3_7	PI_0001;#1	1
TI_0072	SysML Profile for WLTP	General		TECH_REF_REQ_0040;#40;#TECH_REF_REQ_0041;#41	B3_7		1
TI_0073	OSLC adapter for the extended version of the NuSMV model checker	Interoperability		TECH_REF_REQ_0050;#50;#TECH_REF_REQ_0051;#51	B2_43	PI_0001;#1;#PI_0013;#13	1
TI_0074	Exnteded version of the NuSMV model checker, including the NuSMV/OCAS plugin	General		TECH_REF_REQ_0052;#52	B2_43	PI_0001;#1;#PI_0013;#13	1
TI_0075	Kitalpha - Modularity	Interoperability			B2_31a	PI_0011;#11;#PI_0017;#17;#PI_0012;#12	1
TI_0077	Preliminary study for requirements management integration into MBE environment	General			B2_31f	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0078	Dashboard for Dynamic Risk Management	Interoperability			B3_06		1
TI_0079	Clinical behaviour models related to safety risks	General			B3_06		1
TI_0080	Structure Excel Risk Matrix	Interoperability			B3_06		1
TI_0081	Translation of FTA between similar system units	Interoperability			B3_06		1
TI_0082	Link system unit FMEA to FTA	Interoperability			B3_06		1
TI_0083	Engineer simulates safety behaviour with fault tree	General			B3_06		1

TI_0084	Turn fault trees into two-way cause-effect nets	General			B3_06		1
TI_0085	Engineer receives incident stories as input into FMEA	General			B3_06		1
TI_0086	Availability to the project team of clinical behaviour models from previous projects	General			B3_06		1
TI_0087	Analyse underlying details for incident through Qlikview, through Trackview	Interoperability			B3_06		1
TI_0088	Automated comparison of residual and field risk profile	Interoperability			B3_06		1
TI_0089	Generate residual risk profile automatically	Interoperability			B3_06		1
TI_0090	Aggregate FMEA to useful level for fault tree	Interoperability			B3_06		1
TI_0091	Direct query on experience database	Interoperability			B3_06		1
TI_0092	Reuse FMEAs based on fault tree	Interoperability			B3_06		1
TI_0093	Find causes for complaints using cause-effect net	General			B3_06		1
TI_0094	Turn fault trees into two-way cause-effect Bayesian nets	General			B3_06		1
TI_0095	Prototype of the MBE development environment (MBE DE)	General			B2_31a	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0096	Prototype of the MBE execution environment (MBE EE)	General			B2_31a	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1

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TI_0097	Specification of Transposer	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0098	Prototype of Transposer	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0099	Specification of Composer	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0100	Prototype of Composer	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0101	Specification of Accuracy	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0102	Prototype of Accuracy	General			B2_31d	PI_0011;#11;#PI_0012;#12;#PI_0017;#17	1
TI_0103	Extend NobiVR to improve 3D engine compatibility	General			B4_1		1
TI_0104	Extend NobiVR to support remote rendering	General		TECH_REF_REQ_0053;#53;#TECH_REF_REQ_0054;#54	B4_1		1
TI_0105	Extend NobiVR to support head-mounted displays	General			B4_1		1
TI_0106	Extend NobiVR to support remote collaboration	General		TECH_REF_REQ_0053;#53;#TECH_REF_REQ_0054;#54	B4_1		1

Table 5-1: List of Technical Items