

Facts & Figures:

68 partners, 10 countries

Start date: May 1, 2013

End date: April 30, 2016 Total budget: 82 M€ JU funding: I3 M€

National funding: 22 M€

NEWSLETTER

CRYSTAL (CRitical SYSTem Engineering Acceleration)

Background

Since May 2013, the ARTEMIS project CRYSTAL has been working with the goal of promoting interoperability when it comes to industrial engineering environments. In advancing interoperability technologies, the project is working to develop tools in system engineering, standards and methodologies.

- Working together
- **Special Points of** Interest:
- Seamless life-cycle collaboration
- Common interoperability standard
- Safety-critical embedded systems
- Cross-domain RTP
- Reduce costs throughout the entire life-cycle
- Reduced time to market
- Smart integration

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Picture 1: CRYSTAL connects

Technical Innovations presented in this newsletter

One of the major outcomes of the CRYSTAL project is the CRYSTAL Interoperability Specification (IOS) V2.0. The CRYSTAL IOS will increase the flexibility for all stakeholders and has the potential to deeply impact the market on a global level. OEMs can easily combine tools from different vendors, and tool vendors will be able to find new market opportunities in an open and extensible environment. Generic Engineering Methods are reference guidelines on how to use the IOS in order to realize workflows for safety critical system engineering. The application of the technology is demonstrated in an industrial use case.

The Path to foster an European Interoperability Standard

Successful continuation of the Interoperability Specification

The ARTEMIS project CESAR has selected the emerging open standard OSLC (Open Services for Lifecycle Collaboration) as basis for the CESAR interoperability specification (IOS). Three years later, we can say that this was the right decision. In an independent evaluation, the iFEST project came to the same conclusion that OSLC is the right approach for their interoperability needs. MBAT continued with the IOS foundation laid by CESAR and adopted it for their "Combined Model-based Analysis and Testing of Embedded Systems" methodologies. CRYSTAL continues this story: The aim is to bring these results to maturity and to a state where they can be taken for adoption in the industry. In the meantime, the open initiative has grown up from a "loosely coupled" web community to a member section of the open standard organization OASIS. The ARTEMIS projects are very well connected with the OSLC standard organization through key project members. Although OSLC is already an excellent basis for the CRYSTAL IOS, the project has already identified some additional needs for interoperability in their use cases, which will most likely lead to enhancements of the OSLC standard and an extension of the CRYSTAL IOS by other standards (http://open-services.net | http://oasis-oslc.org).



Collaboration as a Cornerstone

CRYSTAL brings the individual results together

Collaboration is the cornerstone of CRYSTAL's implementation strategy. Instead of being restricted to a pure competitive thinking, the mission of the project is to cooperate with other running European and national projects and to reuse the results of successful projects that are already finished. CRYSTAL brings the individual results together, harmonizes and enriches them. The overall aim is to bring promising results to maturity so that they can be taken up for adoption in the industry. Examples of related projects are CESAR, iFEST, MBAT, p/nSAFECER, SAFE, TIMMO-2-USE, OPENCOSS and EMC².

The CRYSTAL interoperability standard is also not necessarily a competitor to other standards. Instead of developing everything from scratch, CRYSTAL analyzes existing standards in the different areas, and incorporates successful elements whenever appropriate. Throughout the entire project, CRYSTAL will stay in close exchange with standardization organizations like ASAM, ProSTEP iViP, OASIS, OMG, CENELEC and others in order to build up on existing achievements and to join forces through collaboration in the standardization process.

A Uniform European Standard for Tool Interoperability make the big vision come true!

With a budget of more than 82 million Euro and 68 partners from 10 different European countries, CRYSTAL has the critical mass to creating and establishing a new standard on a large scale in an already consolidated market that cannot be achieved by small individual organizations. The funding that we received enabled us to get all the required stakeholders onboard. We are very thankful that the European Union and the National Funding Authorities made it possible with their funding to initiate such an endeavor as the CRYSTAL project.

Achieve sustainable interoperability for embedded systems

3rd European Conference on Interoperability for Embedded Systems Development Environments



Picture 2: Welcome Reception

The 3rd European Conference on Interoperability for Embedded Systems Development Environments took place on October 9th, 2014 in Paris, France. The conference had the major goal of proposing and discussing ways forward to achieve sustainable interoperability for embedded systems development environments. The 60 participants from different leading companies and research institutes made this event a success through interactive participation. The participants could listen to very interesting presentations focused on ALM (Application Lifecycle Management) and PLM (Product Lifecycle Management) interoperability by keynote speakers from industrial leaders. Interested companies presented posters with regard to "Interoperability for Embedded Systems Development Environments" in the exhibition area.

During the poster session people could discuss different approaches. The panel discussion, moderated by Rainer Ersch (Siemens) with Dave West (Tasktop), Michael Azoff (Ovum) and Bill Chown (Mentor Graphics) gave an interesting insight into the world of ALM and PLM. But not only that, the participants have inspired the audience with their questions to exciting discussions. Activities to launch a further edition of such a conference in 2015 have already been started. The event was organized in collaboration with the ARTEMIS projects CRYSTAL and MBAT, and the EIT ICTLabs project CPS IIE. Get more information on:



Picture 3: Collaborative atmosphere

http://www.crystal-artemis.eu/events/3rd-european-conference-on-interoperability.html



Interoperability Specification V2

Engineering of Cyber-Physical Systems becomes more and more complex, crossing boundaries of multiple disciplines from embedded systems, software and mechanical engineering, and requiring multiple engineering competences across these disciplines. In consequence, their developments become a huge challenge to overcome by European developing organizations. In order to tackle this issue, CRYSTAL leverages on a momentum initiated by past and on-going ARTEMIS projects, in particular CESAR, iFEST and MBAT, around a common vision for the Establishment of Recognized International Open Standards of Lifecycle Tool & Data Integration Platforms for Systems Engineering (or "*Tool Chains*"). The main idea of the so-called *Interoperability Specifications* (IOS) initiated in these projects is to rely on common interoperability standards and services, providing a common ground for integrating lifecycle and engineering tools across different engineering disciplines and from multiple stakeholders involved in the development of large scale safety-critical systems (e.g., requirements engineers, developers, V&V experts, but also business analysts and managers). The common denominator of the IOS across the projects, and among the CRYSTAL's partners, is based on the following:

- A lightweight and domain-agnostic approach, providing basic capabilities for handling the whole lifecycle of engineering artefacts manipulated throughout the development of embedded systems. This part of the IOS is based on OSLC [1] and on CRYSTAL specific extensions.
- Existing Systems Engineering Standards widely adopted by CRYSTAL partners, for supporting in-depth Systems Engineering activities, encompassing, for instance, heterogeneous cosimulation, operational data measurements and calibration, synthesis of parallel systems, etc.

A first iteration of the CRYSTAL IOS deliverable has been released in 2014, and was used as a first reference document for implementing basic IOS/OSLC-compliant CRYSTAL *Bricks* focused on lifecycle interoperability scenarios, already covering a large part of the V-model, from requirements engineering to architec-



Picture 4: Scope of the Interoperability Specification

ture and quality management, including change request management and traceability throughout the development process.

We are currently releasing publicly the second iteration of this deliverable (*IOS V2*)[2], presenting the outcomes of extensive prestandardization activities that have been conducted in the second year of the project among representatives of all CRYSTAL's stakeholders (i.e., end-users from aerospace, automotive, healthcare and rail domains, tool and integration solution providers and technology brick providers). The aim of this document consists in reaching a first level of consensus regarding the shape, scope, and content of the CRYS-TAL IOS until its final version to be released by the end of the project. This deliverable consists of a set of CRYSTAL IOS extensions focused on various interoperability concerns such as Formal Requirement and Architecture Management, Safety/Risk Management, Testing & Quality Management, Configuration Management, Simulation, Variability Management, and Quality Metrics, among others.

Finally, in order to make the CRYSTAL IOS a sustainable result, it is important to gather experience from various European initiatives and to start communication with existing bodies regarding interoperability standardization. For that purpose, a support action called CP-SETIS [3], which was initially incubated in MBAT and CRYSTAL, has been officially kick-started in March 2015. Its goal is twofold: to co-

Gather experience from various European initiatives to make the CRYSTAL IOS a sustainable result! ordinate and align all IOS-related forces within Europe to support a common IOS Standardization Strategy, and the definition and implementation of sustainable IOS Standardization activities within existing structures that survive the lifespan of single projects. For more information, or if you are willing to join this initiative as an associated partner, please contact Juergen.Niehaus@safetrans-de.org and Frederic.Loiret@offis.de.

- [1] Open Services for Lifecycle Collaboration http://open-services.net
- [2] http://www.crystal-artemis.eu/deliverables.html

[3] CP-SETIS: Towards Cyber-Physical Systems Engineering Tools Interoperability Standards



Generic Engineering Methods

Interoperability is an important goal for improving system engineering environments: our engineers want to focus on creating a great product without having to think about tools too much. Where to start with interoperability? What should have priority? What should be enabled and what can be ignored? The Engineering Methods applied in a project provide the essential context for interoperability work.

The CRYSTAL project is strictly use case driven - the real life projects, their work processes and bottlenecks direct our efforts in achieving interoperability. Therefore, the various industrial partners in aerospace, automotive, health care and rail described a number of typical partial work processes called Engineering Methods to specify the intended way of working. This includes what is needed (preconditions), what is done (engineering steps), what is the result (post-conditions) and what software objects are changed (artefacts). Also, the expression of the Engineering Method in IOS artefacts and services was explored.

A total of 185 Engineering Methods was created. Quickly it became clear that considerable overlap exists and that each company has a specific implementation of an Engineering Method. How to deal with this diversity? The CRYSTAL team decided to create Generic Engineering Methods as an example of how Engineering Methods can be expressed in IOS. In elaborating teleconference work sessions, the team built a consensus on a minimal required set of engineering functions needed to perform the Engineering Methods. Currently, Generic Engineering Methods focus on: simulation management, test coverage of requirements (both finished), safety risk management, certification management, version control (in progress).



Picture 5: Relationships between Generic Engineering Methods using ISO 15288

Example: Simulation Management

With the important role of simulation models in system engineering, simulation models require reliable management for use in design space exploration (what is the performance of this high level system design for certain key performance indicators?) and system verification (does the implemented design meet the requirements?). As modelling teams grow and models become distributed, management of models is indispensable.

In many cases, previous versions of simulation models need to be retrieved for reuse or referred to for traceability of design decisions.

In several teleconference sessions across work packages, a Generic Engineering Method was created including design space exploration, system verification and model searching. The expression of the engineering functions in IOS was added as guidance for IOS implementers.

Picture 6 shows parts of the steps in the Generic Engineering Method for design space exploration and the corresponding expression in IOS.



Picture 6: Partial diagram and IOS expression for Simulation Management



Public Aerospace Use Case Demonstrator

Status Public Aerospace Use Case

Since End of 2013 a Public Aerospace domain demonstrator is available • that is able to show traceability among lifecycle artefacts on a de-icing • system using OSLC as basis for tool connections. Over the last months • we have significantly extended the use case to address additional engi- • neering methods, especially on heterogeneous simulation and trade-off • analysis.

A new demonstration is now available that shows how to run an integrated simulation using models defined with Modelica, SysML and Simulink using FMI as integration standard.

As a next step we want to focus on integrating the OSLC based traceability of lifecycle data (including simulation models) with the FMI based heterogeneous simulation approach.

In addition, we have started to work on the challenge of versioning and configuration handling in a heterogeneous tool environment.

Major Public Aerospace Dissemination Events

- Artemis Co Summit, Stockholm (Dec 2013)
- ProSTEP iVIP Symposium, Berlin (May 2014)
- Eclipse Toulouse-France (June 2014)
- Eclipse Europe, Germany (October 2014)
- PDT Europe, Paris (October 2014)
- 3rd European Conference on Interoperability, Paris (October 2014)
- CIISE 2014, Rome (Italy), (November 2014)
- IBM World Wide Customer Event, Las Vegas (February 2015)
- Artemis Co-Summit, Berlin (March 2015)
- REConf, Munich (March 2015)
- INCOSE IL, Israel (March 2015)
- ProSTEP iVIP Symposium, Stuttgart (May 2015)



A control panel has been defined to simulate the de-icing

We have established traceability links between different types of lifecycle data, including requirements, functional and physical behavior model artefacts, test cases, and 3D Geometry. We are able to navigate accross the links e.g. to quickly assess the impact of change requests.

As result of the physical behavior simulation we have obtained several KPIs for two alternative de-icing solutions (e.g. ice melting rate, power consumption, max. accumulated ice). This data can be used to compare both alternatives as part of trade-off analysis.



CRYSTAL Highlights

ProStep iViP - Stuttgart, May 2015

ProSTEP is one of the most important standardization organizations in the field of embedded systems engineering. Most of the major OEMs are members of the ProSTEP association and the ProSTEP Symposium is a top-class event with excellent networking opportunities where the key decision makers meet. The case Study "Seamless Integration of Calibration Data Management (CDM) in the Overall Automotive Development Process" was presented along with a presentation and demonstration of the Public Aero Use Case by Airbus and IBM.

8th IEEE International Conference on Software Testing, Verification and Validation (ICST) - Graz, April 2015

CRYSTAL was invited to present the project and to present a booth including a demo. ICST is the premier conference for research in all areas related to software quality. ICST seeks to meet these challenges by bringing together researchers and practitioners for a conference that includes all aspects of software testing, verification, and validation. It provides an ideal forum where academics, industrial researchers, and practitioners can present their latest approaches for ensuring the quality of today's complex software systems, exchange and discuss ideas, and compare experiences.

ICES 2015 Focus Group on Tool & Data Interoperability Workshop - Stockholm, April 2015

Presentation and discussion of OSLC based applications (notably from Airbus and IBM in MBAT and CRYSTAL), followed by presentation and discussion on Swedish use cases focused on engineering tool & data integration in order to elicit commonalities between them. IBM presented a CRYSTAL overview, the Public Aero Use case and showed a short demonstration of results within Crystal. 5 world famous Swedish engineering companies were represented along with a number of smaller specialist consultant and design houses. Volvo presented aspects of their Crystal use case.

Read more: http://www.ices.kth.se/events.aspx?pid=3&evtKeyId=318b6e3bde9b4519ac778011cfadb7ea

ARTEMIS Co-Summit - Stockholm, March 2015

CRYSTAL was present at this event with a booth with a perfect presentation of the aerospace public use case. Visitors from public authorities and industry were brought to the project booths and they could listen to exciting project presentations. The project leader, Christian El Salloum, gave a short introduction on the project and on the today's situation at industrial companies and the vision of CRYSTAL. The presentation was closed by interesting discussions with the audience.



Picture 7: Booth presentation

7. Grazer Symposium Virtuelles Fahrzeug - Graz, May 2014

The topic of the symposium is the interdisciplinary development of road and rail vehicles. CRYSTAL gave a project overview at this event with a special focus on interoperability in the development of the automotive systems.

3rd European Conference on Interoperability - October 2014



As a key player in the interoperability community CRYSTAL was the main organizer of the 3rd European Conference on Interoperability which took place on October 9, 2014 in Paris. To make this conference a success and to reach a wide audience, CRYSTAL invited MBAT, EMC² and EIT ICTLabs as co-organizers. Thus, CRYSTAL brought together a large number of leading technical experts to follow the vision of a common European interoperability standard.

Picture 8: The audience is listening

Read more: http://www.crystal-artemis.eu/events/3rd-european-conference-on-interoperability.html

Pan European April 2014

Horizon 2020 Projects spoke to Christian El Salloum, the co-ordinator of the ARTEMIS CRYSTAL project: "Underscoring the importance of improving interoperability in industrial engineering environments".

Read more: http://www.artemis-ia.eu/publication/download/publication/996/file/ARTEMISIA_Crystal_Standard_PanEuropean.pdf



Major Milestones and Next Steps



- Further extension and consolidation of the IOS based on the evaluation results
- Continue collaboration with other European initiatives to make the CRYSTAL IOS a sustainable result

Events

Partners at General Assembly Meeting, Paris 2014

• First version of the platform builder which assists system inte-

• Prototypes of integrated system engineering environments in the 4 domains (aerospace, automotive, health care & rail)

ments

grators to compose integrated system engineering environ-



Picture 9: CRYSTAL project partners

Upcoming events

- May 18-20, 2015: 8. Grazer Symposium Virtuelles Fahrzeug, Graz (http://www.gsvf.at/index.php/en/home)
- May 20, 2015: 18. SafeTRANS Industrial Day, Renningen (http://www.safetrans-de.org/de_18_Industrial_Day.php)
- June 10-11, 2015: ARTEMIS Summer Camp, Helsinki (https:// artemis-ia.eu/calendar/387-artemis%20summer%20camp% 202015.html)
- June 17–18, 2015: CRYSTAL 2nd Annual JU Review, Hamburg
- September 29-30, 2015: CRYSTAL General Assembly Meeting, Rome
- October 6-8, 2015: ARTEMIS Technology Conference, Turin (https://artemis-ia.eu/events_media.html)
- October 20, 2015: ProSTEP iViP OASIS OSLC Conference in conjunction with 4th Interoperability conference, Sindelfingen (http://www.prostep.org/en/events/topic-specific-events/ oslc.html)
- Spring 2016: "Software Innovation Forum" hosted by ARTE-MIS-IA and ITEA3

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