ARTIST 2

Network of Excellence

IST-004527 ARTIST2:
Embedded Systems Design

Activity Progress Report for Year 2

JPRA-NoE Integration

Forums with Specific Industrial Sectors

Clusters:

Real-Time Components

Control for Embedded Systems

Execution Platforms

Activity Leader:

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Policy Objective (abstract)

In the first period of ARTIST2, it was found by the two clusters HRT and Components that meetings and forums with engineers from industry are a needed support for novel research directions and new fruitful activities to be undertaken. Collecting issues from industry in the two key sectors of automobile and aeronautics and interacting with high-level engineers from these industrial sectors will be the duty of this JPRA. Results will consist in a collection of findings and new issues and challenges that will in some sense complement and update the work already performed with the ARTIST Roadmap.

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1. Overview of the Activity

Real-Time Components (RTC) is a cluster resulting from the merge of the former two clusters on Hard Real-Time and Components. This merge has been effective since October 2005. This cluster is structured into four activities:

- Platform: Components Platform for Component Modelling and Verification.
- Cluster integration: Development of UML for Real-Time Embedded Systems.
- NoE integration: Forums with specific industrial sectors.
- NoE integration: Seeding new research directions.

This is the report of the third activity, which is a totally new activity.

This activity is jointly managed by Alberto Sangiovanni-Vincentelli from PARADES and Albert Benveniste from INRIA.

Clusters

Real-Time Components

Control for Embedded Systems

Execution Platforms

Policy Objective

This activity encompasses all research topics of the former clusters HRT and Components (diagnosis, semantic platform, heterogeneity, interfaces and composition, ET&TT, and, more generally, what is relevant to the concept of Real-Time Component). It consists in in-depth meetings and forums with engineers from industry.

Industrial Sectors

Addressing heterogeneity in embedded systems design is essential in the industrial sectors where large systems are built, involving multiple skills with different paradigms and tools. This includes the following sectors, with the first two sectors being the leading ones:

- Avionics (Event and Time-triggered systems are developed and effectively used at Airbus Industries);
- Automobile;
- Rail Transport;
- Energy Production.

1.1 ARTIST2 Participants: Expertise and Roles

Team Leader: Alberto Sangiovanni-Vincentelli (PARADES, Italy)

Areas of his team's expertise: strong interaction with automotive, design software and semiconductor industry (co-founder of Cadence and Synopsys); expertise in design flows, tools and modelling methodologies with particular attention to Hard Real-Time; Platform-Based Design and Metropolis design framework for integration of design processes from OEMs to suppliers involving functional and non functional aspects.
Role in the activity: organization and planning of meetings.

Team Leader: Albert Benveniste (INRIA, France)

Areas of his team's expertise: synchronous languages and heterogeneous systems modelling and deployment.
Role in the activity: organization and planning of meetings.

Team Leader: Hermann Kopetz (TU Vienna, Austria)
Areas of his team's expertise: inventor of the TTA concept.
Role in the activity: organization and planning of meetings.

Team Leader: Werner Damm (OFFIS, Germany)
Areas of his team's expertise: embedded system modelling and validation, deep involvement in cooperation with the automotive industries.
Role in the activity: organization and planning of meetings.

Team Leader: Paul Caspi (Verimag, France)
Areas of his team's expertise: synchronous languages and heterogeneous systems modelling and deployment; tight cooperation with Airbus.
Role in the activity: organization and planning of meetings.

Team Leader: Petru Eles (Linköping University, Sweden)
Areas of his team's expertise: schedulability analysis for heterogeneous systems.
Role in the activity: organization and planning of meetings.

Team Leader: Tom Henzinger (EPFL, Switzerland)
Areas of his team's expertise: development of abstract programming models for real-time computing [Giotto: time-triggered; xGiotto: both time- and event-triggered].
Role in the activity: discussion of and participation to meetings.

Team Leader: Rolf Ernst (University Braunschweig, Germany)
Areas of his team's expertise: formal performance models for networks-on-chip.
Role in the activity: discussion of and participation to meetings.

Team leader: Francois Terrier (CEA, France)
Areas of his team's expertise: Expertise: Modeling and analysis of embedded systems, UML development
Role in the activity: discussion of and participation to meetings.

Team leader: Pierre Combes (FTRD, France)
Expertise: Component modeling, Service integration and interference, performance analysis.
Role in the activity: discussion of and participation to meetings.

Team leader: Karl-Erik Arzen (Lund University, Sweden)
Expertise: relations between control and embedded software, effect of architecture on the performance of control, control techniques for architecture studies.
Role in the activity: discussion of and participation to meetings.

Team leader: Martin Törngren (KTH, Sweden)
Expertise: relations between control and embedded software, effect of architecture on the performance of control, control techniques for architecture studies, mechatronics.
Role in the activity: discussion of and participation to meetings.

1.2 Affiliated Participants: Expertise and Roles

Team Leader: Jan Romberg (TU Munich, Germany)
Areas of his team's expertise: synchronous dataflow notations and tools, distributed architectures in automobile.
Role in the activity: discussion of and participation to meetings.

Team Leader: Luciano Lavagno (Politecnico di Torino, Italy)
Areas of his team's expertise: IC design and algorithms for synchronous and asynchronous design.
Role in the activity: discussion of and participation to meetings.

Team Leader: Francois Pilarski (Airbus France)
Areas of his team's expertise: avionics industrial case study.
Role in the activity: discussion of and participation to meetings.

Team Leader: Heiko Dörr (DaimlerChrysler, Germany)
Areas of his team's expertise: automotive industrial case study.
Role in the activity: discussion of and participation to meetings.

Team Leader: Stephan Kowalewski (RWTH Aachen, Germany)
Areas of his team's expertise: automotive industrial case study.
Role in the activity: discussion of and participation to meetings.

Team Leader: Jakob Axelsson (Volvo, Sweden)
Areas of his team's expertise: automotive industrial case study.
Role in the activity: discussion of and participation to meetings.

Team Leader: Christofer Kirsch (University of Salzburg, Austria)
Areas of this team's expertise: development of abstract programming models for real-time computing [Giotto: time-triggered; xGiotto: both time- and event-triggered].
Role in the activity: discussion of and participation to meetings.

Team leader: Ivica Crnkovic (MdH, Sweden)
Areas of his team's expertise: component models, component-based software engineering,
Role in the activity: discussion of and participation to meetings.

Team leader: Marius Minea (Institute e-Austria Timisoara, Romania)
Areas of his team's expertise: Formal verification, specification of timed systems,
Role in the activity: discussion of and participation to meetings.

Team leader: Bernhard Steffen (Dortmund University, Germany)
Areas of his team's expertise: tool integration, modeling and verification, generation of models of communicating systems,
Role in the activity: discussion of and participation to meetings.

Team leader: Anders Ravn (Aalborg, Danmark)
Areas of his team's expertise: modeling and verification of timed systems.
Role in the activity: discussion of and participation to meetings.

Team leader: Peter Eriksson (ABB Automation Technology, Sweden)
Areas of his team's expertise: Construction of large complex embedded systems.
Role in the activity: discussion of and participation to meetings.

Team leader: Dominique Potier (Thales R&T, France)

Areas of his team's expertise: Construction of large complex embedded systems, Model driven development

Role in the activity: discussion of and participation to meetings.

Team leader: Alan Moore (ARTiSAN Software)

Areas of his team's expertise: technologies for embedded systems engineering, UML tool suites.

Role in the activity: discussion of and participation to meetings.

Team leader: Luca Carloni (Columbia University)

Areas of his team's expertise: tool integration, modeling and verification, design methodology, communication-based design, latency insensitive protocols.

Role in the activity: discussion of and participation to meetings.

1.3 Starting Date, and Expected Ending Date

Starting date: January 1st, 2006 (date of creation of RTC cluster).

Expected ending date: 31/12/2008 (end of Artist2)

1.4 Baseline

European automotive and aeronautics industries are experiencing an exponential growth in functionality, with a drastic increase of innovations realized in software. The paradigm is shifting from an original "1 function = 1 ECU = 1 supplier" partitioning to distributed realizations of functions across multiple ECU's involving multiple suppliers.

Several de-facto standards such as CAN, Flexray and the various OSEK extensions have found their way into series development. Model based development is increasingly gaining momentum, often involving automatic code generation. These processes are reaching substantial levels of maturity for single ECU implementations, including advanced capabilities for rapid prototyping and (hardware-in-the-loop) testing.

However, system-oriented design and virtual integration are supported only weakly, leading to late detection of integration problems. The OEM-supplier relation is mainly relying on textual initial requirements and well-established processes of delivering increasingly mature prototypes. Late requirement changes, incomplete initial requirements, or even inconsistent requirements are often leading to late design iterations or changes, with high-incurred costs.

Already today, privately funded key initiatives like Autosar demonstrate the commitment of this industrial sector to reducing costs. One way to achieve this is by harmonizing platforms and decoupling functional architecture design from target platforms.

While these initiatives are demonstrating the industrial pull in the required direction, they are only making the first move. Challenges required to obtain the targeted growth rates, and not yet achieved, include:

1. The need for boosting re-uses across all design levels. This requires component models capturing the complete space of non-functional constraints (time, dependability, safety, scheduling, resource consumptions), as well as functional and protocol aspects in order to achieve drastic cost reductions.
2. The need for ensuring high quality and optimizing electronics despite the exponential growth in system complexity. This requires strong advances in enhanced virtual

(sub)system integration and analysis, in order to reduce the number of deep iteration loops. Since subsystems are typically developed by multiple suppliers, this entails the need to integrate models from different modeling tools.

3. The need to optimize cross-supplier development processes. This requires early assessment of risks caused by late requirement changes, fast turn-around times in integrating resulting changes, and design space exploration across boundaries of the supplier chain.

To summarize, large European systems industries must maintain their competitive position in the future. This requires improving substantially the entire OEM-supplier chain and the design methodology used to develop embedded systems. The methodology has to take into consideration that industry must completely revisit the way systems are decomposed into subsystems to facilitate development by suppliers, and integration by the OEMs. This move will require that virtual design (i.e., design based on computer modelling and analysis) be performed systematically to discover errors at early stages of systems development. Using virtual engineering will require changing the technology, skill set, and support make-up of industry in a profound way. This course of action will require mastering heterogeneity in large design flows involving concurrent activities. Therefore, we need deep innovations in architectural abstractions capturing functional and non-functional features, in formal modelling (semantic based integration of heterogeneous system models with component models covering all non-functional constraints), and in formal multi-viewpoint analysis covering functional, timeliness, safety, and dependability requirements performed across all system design abstraction levels.

1.5 Problem Tackled in Year2

The objective of this action is to reproduce more systematically the type of meeting and discussion forum the former HRT cluster held in Rome, in January 2005, where engineers from GM and BMW participated to the discussion on *merging ET with TT.* The minutes collected from this meeting were quite rich and useful for us in guiding our research activities. We think that this type of prospective activity must be sustained by the academic community, and we believe that ARTIST2 is the adequate place to handle it.

This year we focus our activities on the automotive sector. The meeting Beyond AUTOSAR was organized in Innsbruck, co-located with the industrial meeting Modellierung 2006. See below the detailed report. We summarize here the main issues in this industrial sector.[1]

Automotive embedded systems have evolved enormously over the past decades. It is clear that a very large portion of innovation and improved functionality in vehicles is due to the advances in software and electronics (this portion is sometimes stated to be as high as 90%). A Mercedes car in 1986 contained six microprocessors; these were implemented as six stand-alone controllers (in the automotive industry referred to as ECUs, standing for Electronic Control Unit). In 1998 a corresponding Mercedes car contained some 60 microprocessor systems, together forming a distributed system including four networks (not to mention in addition some 113 electrical motors!).

Many of the ECUs of a modern vehicle are provided by external suppliers, who work with many different car companies (or OEMs: Original Equipment Manufacturers), providing similar parts. The role of the OEM is thus to provide specifications to the suppliers, so that the component will fit a particular car, and to integrate the components into a product. Traditionally, suppliers

[1] Courtesy of Martin Törngren, who participates to the team preparing the conclusions of this meeting.

have developed physical parts, but in modern cars they also provide software. This constitutes a challenge for the OEMs since they have to test and verify systems including software. Moreover, the trend has been that OEMs have outsourced the development of many ECUs, implying that the OEMs are no longer in control of the actual behaviour of the car anymore. Because of this situation where subsystem suppliers provide ECUs and because of their desire to not disclose their expertise in e.g. brake control, the ECUs have been treated as black boxes that are not fully open to the OEMs. An implication of this is that new functions often are implemented as new ECUs – not exploiting the possibility to have several functions on the same ECU.

The current development trends in automotive software call for increasing standardization of the software structure in the nodes. The need to integrate software from different suppliers, supporting dependable real-time execution, and managing changes all call for a well-defined structure. The node architecture (see Figure 1) includes several important parts:

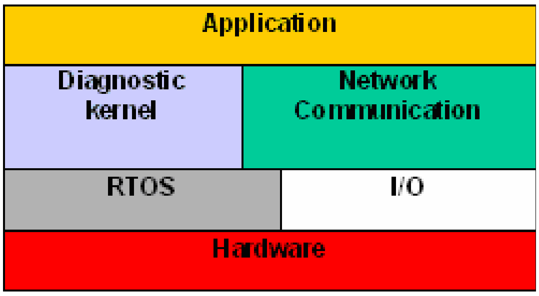

Figure 1. Typical software architecture of an ECU.

Diagnostic kernels provide an implementation of the diagnostic services that each node must implement to act as a client towards the off-board diagnostic tool. It relies on the communication software to access the networks and on the operating system to schedule diagnostic activities so that it does not interfere with the application functionality. Network communication software provides a layer between the hardware and the application software, so that communication can be described at a high level of abstraction in the application, regardless of the low-level mechanisms employed to send data between the nodes. Real-Time Operating Systems (RTOS) provide services for task scheduling and synchronization.

All these components interact with each other and with the application, and must therefore have standardized interfaces, and at the same time provide the required flexibility. To minimize the use of hardware resources, the components are configurable to only include the parts that are really necessary in each particular instantiation.

For future system development, an important aspect is to create a more flexible software partitioning. The main use for this is probably not to find the optimal partitioning for each car on a given platform, since that would create too much work on the verification side, but to allow parts of the software to be reused from one platform to the next. This puts even higher demands on the node architecture, since the application must be totally independent from the hardware, through a standardized interface that is stable over time. Therefore, further standardization work is pursued within the ***Autosar*** initiative.

Automotive embedded systems are further characterized by the following:

- **Users**. In contrast to many other advanced machines, such as airplanes and medical devices, automotive products are utilized by most people. This has an important impact on the usability, service and dependability expected of the products.
- **Dependability requirements**. Automotive embedded systems have a fairly long life time and users expect the vehicles to function over extended periods of time, leading to strict

requirements on reliability, availability and maintenance. Automotive control systems are safety related. Not only is the control system required to operate reliably; the design of the system and its context must be carefully analyzed to consider what might go wrong, and what the system should do in such cases. In addition, security is becoming of increasing importance because of the possibilities and relative ease with which embedded control systems behavior can be modified, e.g. by replacing memories/chips or by network intrusion.

- **Heterogeneity**. Automotive embedded systems are heterogeneous. They handle many different types of tasks with widely varying requirements. For example, the motion control related ECUs include functionality that can be characterized as hybrid systems, being composed of components that are best described by continuous-time dynamic systems and finite state machines. Motion control is one central part of ECS. Although it’s absolute size e.g. in terms of lines of code typically is relatively small compared to other functionality, the motion control functionality is coming along with real-time constraints, environment dependencies, and safety criticality. To handle this heterogeneity the embedded systems are normally structured into a system platform and applications, each with their own hierarchy in order to facilitate changes and reuse. Responsibilities of the system platform include for example logging, communication services and drivers for sensor readings. For the application there will be activities such as motion control, estimation of the environment state, and human machine communication.
- **Real-time constraints**. These constraints arise due to interactions with the environment. From control system specifications, for example referring to required speeds of motion, the timing requirements on the embedded control system can be derived. The speed (or bandwidth) of the closed loop system will provide requirements on the timing of the controller, including the sampling periods and delays that can be allowed. These properties can also be taken into account in the control design, however, providing an additional dependency between the controller and its implementation.
- **Resource constrained implementations**. Automotive embedded systems are often highly resource constrained because of the large series being produced. In such applications, trade-offs between the system behavior (quality of service) and the resources required (processing, memory and power) is essential.
- **Distributed systems**. Over the last decades, there has been a strong trend to connect stand-alone controllers by networks, forming distributed systems. Another and closely related trend has been modularization, where for example, an electronic control unit is physically integrated into an engine, forming a sort of mechatronic module. Combining the concepts of networks and mechatronic modules makes it possible to reduce both the cabling and the number of connectors, the result of which is facilitated production and increased reliability. Distributed control systems first appeared in process control, and later in the 80s in aerospace, and in the 90s in the automotive industry. Distributed systems are characterized by the mapping problem, i.e. the need to assign functions to different nodes of a distributed system, to define the tasks of the system, and their implementation in software and/or hardware.
- **Tight coupling to the environment**. The tight coupling between the control system and the controlled process is manifested in several ways. Apart from aspects related to physical integration and protection against a harsh environment, the control system is also fundamentally related to the controlled process. Typically, models of the environment are used in control design. In many cases, the control algorithms are synthesized from a validated model of the controlled system. In other cases, the controller parameters are tuned based on the overall system behavior. For control systems this creates a dependency between the environment and the control system, creating a kind of contract between these two entities. Another type of environment coupling exists with humans

interacting with the embedded control system. A driver "in the loop" is typical for vehicular systems. The situation arises where conflicts can occur – who is deciding the motion of the vehicle at any given point in time? Careful analysis is required and special care has to be given to the human/machine interface.

- **Parallel activities and triggering**. Since the real world is truly parallel, there is typically a need to describe and handle several parallel activities. A typical control system normally includes both time- and event-triggered activities. In many cases, time-triggering follows naturally from the development of discrete time (sampled data) functions. However, in other cases the controlled process can be inherently event-triggered. This is the case for inherently sampled systems, one example being control of injection in a combustion engine; the point in time of injection depends on the speed and angular position of the engine parts. Event-triggered functions thus include those who are inherently sampled and other functions who are not dictated or preferably implemented as periodic activities.

Vehicle embedded systems have grown in a bottom-up fashion, from stand-alone functions to distributed functions. New vehicle level functions, for example dealing with active safety, have the characteristic that they take inputs from many sensors, act upon many actuators and span the traditional domains and networks.

All in all, the use of embedded control systems has paved the way for large improvements of machinery in terms of improved performance, flexible tailoring of product variants and by enabling completely new functionality such as for example active safety functionality in cars. As a consequence, product complexity is becoming a crucial issue in system development. Systems integration is today a serious problem in the automotive industry. This increased product complexity calls for more mature engineering approaches including the use of model and component based development.

The ***Autosar*** (http://www.autosar.org/) initiative aims at addressing the above issue. The meeting this activity organized aimed at analysing the related technical issues.

2. Summary of Activity Progress

2.1 Previous Work

Since this is a new activity, there is no previous work.

2.2 Current Results

2.2.1 Technical Achievements / Outcomes / Difficulties encountered

As expected, the forums organized in the framework of this activity are an important contribution to the interaction between industry and academia in the considered sector. Less expected, they also appear to be a forum where different ARTIST2 clusters meet. This activity therefore plays an important role in NoE integration.

Meeting *Beyond AUTOSAR*

http://www.artist-embedded.org/FP6/ARTIST2Events/Events/Innsbruck06/

This meeting was held March 23rd - 24th, 2006 Innsbruck, Austria. It was co-located with the industrial conference Modellierung 2006

The agenda of the meeting can be found at the above URL, as well as the detailed minutes and slides. There were 52 registered participants, among which 15 from industry.

Here we summarize the most important conclusions from this meeting.

A first ½ day was devoted to the *interaction between control and embedded electronics* in automotive industry. This was mainly an academic meeting, although experiences and cooperations with automotive industry were reported by some speakers. This part of the meeting was co-organized by the Hart Real-Time, Adaptive Real-Time and Control network activity led by the Control for Embedded Systems cluster.

- Stefan Kowalewski (Aachen Uni.) reported on his experience while being at Bosch on *the relation between software development and control function development in automobile embedded systems*. Here are some quotes from his presentation.

  When I entered industry, my background was in control, discrete event systems, and formal verification. Main work topics I worked on then were different: SW engineering, SW architecture design and analysis, SW reuse and variability management. There was clearly a mismatch of background. The reason is that soft topics were more perceived by the management as being critical at that time. Most problems had been caused by SW mastering problems. Automotive supplier industry felt it was well experienced at developing new functionalities; problems arrived when additional customers call for variants. “Hard” methods were not in the focus at that time (control, verification). Control design was considered mastered, formal verification was not of interest. Many software architecture analysis workshops were organised. Their basis was: architecture trade-off analysis method (ATAM), delivered by the SW engineering institute, Pittsburgh. Participants were: marketing, architects, SW developers, testers, and, whenever possible, management. My overall experience is that there is a permanent misunderstanding between control & software engineers.

  Control engineers think that system structure (the trivial part) and algorithms (the difficult part) follow from control requirements $\Rightarrow$ they think that the system should be designed by control engineers; remaining tasks would be for SW engineers. SW engineers in research departments think that control engineers make it wrong in the architecture phase ⇒ they think that the system should be designed by SW engineers; on the other hand, algorithm design is trivial (there are tools for that!); they think that computer aided control engineering tools are used to escape from architecture considerations via code generation.

- Karl-Erik Arzen (Lund) reported on: *Time, events and components in automotive embedded control systems*.

  The core of his presentation focused on "controller timing". Classical control assumes deterministic sampling. In most cases sampling is assumed periodic (although not for engine control). In practice, too long sampling interval or too much jitter cause poor closed loop performance. Classical control assumes constant or negligible latencies. A debate among automotive architects currently exists on the relative merits of Event Triggered (ET) versus Time-Triggered (TT) architectures. While software/hardware systems aspects of this issue have been deeply investigated in the academic and industrial communities, little has been done to consider its control aspects. What is the influence on control feedback loop performance, of going for one or the other alternative? A perhaps surprising outcome of the extensive experimental study performed at Lund University group is that maximizing temporal determinism (the TT solution) may degrade control performance since it amounts to sample at maximum bounds for latency (experiments show that this is worse than random latency for closed loop control performance); it is also inflexible.

- Carlos Canudas-de-Wit (LAG, Grenoble) reported on: *Control design for X-by-wire components: steering by wire*.

  (This presentation reported on a 4-year experience in cooperating with Renault.) More applications are coming in which control specifications are subjective, as they involve not only the mechanics, but also the driver. What is "comfort" as a control objective? How to reproduce (or possibly improve) feelings provided by classical all-mechanical solutions when moving to electronics alternatives is a difficult issue.

  Complexity limits are reached in terms of control. It is unclear that engineers still really master what is happening inside the loops. This complexity in design results from the product design history. An important adcance in SW engineering has been the concept of component. Now, what is a component for control? *Model following control* might be a good approach: the desired behaviour is taken as the *interface model* and every other component that fits the same desired behaviour can be put instead. Also, wireless communications start being considered for embedded electronics by some car makers (mostly in the US). Feasibility is addressed at this moment.

The second day was devoted to *AUTOSAR, the industrial perspective.* Two industrial speakers gave detailed presentations followed by in-depth discussions and exchanges. Then, a panel session was organized in the afternoon. We report here the main findings of these contributions:

- Christian Salzmann (BMW car IT), reported on: *AUTOSAR, first experiences and the migration strategy of BMW group*.

  BMW car IT is a subsidiary of BMW, member of BMW group. Christian Salzmann is responsible for the assembly of SW system. He was involved in the specification of the AUTOSAR run time.

  In premium cars 200-300 MBytes of codes are deployed on over 60 ECUs (This amount is not going to increase for the next 8 years), which are connected by 6 types of buses. It is expected that having 1GByte code in the car will be reached within 5 years. This will yield a very complex computing system. 5 years ago, the most complex communication concept was a global variable. This is why there is a strong pressure toward model based development techniques and system architectures allowing new ways to develop SW, adapted to the specific needs from automotive domain. This is the aim of the AUTOSAR standard.

The more interesting part within this AUTOSAR architecture is its component model: the *application component.* Also important is the *AUTOSAR run time environment (RTE)*. This aims at decoupling application layer from infrastructure, allowing for possibly orthogonal architectures. This plays a role like CORBA.

Each component must indicate a large number of features regarding communication interfaces (port types, type of communication blocking / nonblocking, queued, how the other extremity handles the communications, etc…). There is thus fine typing regarding communications. If two components want to communicate, they express this in terms of the virtual bus, without knowing the actual localization of each other, nor the type of actual bus technology being used. This is not completely plug-and-play, for reasons of scheduling.

Voices back 2002: AUTOSAR will never work; the overhead of RTE will be huge; it will double RAM/ROM needs… In 2005, the powertrain pilot trial has been developed in cooperation between BMW, BMW Car IT, and Siemens VDO. The overhead is very low and performance is satisfactory; because everything on the RTE is generated off-line.

- Kai Richter (Symtavision) reported on: *the AUTOSAR timing model – status and challenges*.

Symtavision is a young spinoff of TU Braunschweig, founded in 2005 by R. Ernst. The company develops timing and scheduling analysis tool suite.

Regarding timing effects: control functions impose timing requirements; this results in high-level specs on SW components; the AUTOSAR approach regarding this is to break down the SW structure into manageable blocks, enhanced with timing aspects.

Some information on the code inside is needed to perform subsequent scheduling, timing dependencies, and tasking organization. *The breaking of SW components into finer grain tasks results in a breaking of the original SW architecture*: how can this be traced? How can this be scheduled? You cannot decide how it will perform on a purely local basis, without some abstract model of the environment or other subsystems it interacts with.

Conclusions are summarized now. AUTOSAR aims at being a vehicle for modularity, portability, reuse, adaptability. Unfortunately, timing is not as modular as the SW itself. SW architecture does not reflect timing dependencies. Timing is mapping dependent, not modular. Many approaches for timing exist. No one has been chosen for AUTOSAR. This happened just because corresponding issues are new to suppliers both technically and from business viewpoint. It is the responsibility of suppliers that they match the OEM's networking characteristics. Regarding OEMs, networking effects are out of the suppliers' responsibility; there is a need to deal with contracts including QoS aspects to address this. Overall, it is too bad that the research community has not been asked for assistance for a long time on this large set of problems.

The rest of the day was devoted to a panel session with the morning speakers. Additional panelists were: Alberto Ferrari (PARADES), Rolf Ernst (TU Braunschweig), Martin Törngren (KTH), Julio Medina (Uni. Cantabria), Werner Damm (Offis), Rolf Johansson (Mentor Graphics), Heiko Dörr (Daimler-Chrysler), François Terrier (CEA), Stefan Kowalewski (RTWH Aachen), Susanne Graf (VERIMAG). Minutes are recorded. I like to quote one particular illuminating statement by Christian Salzmann:

> *The development process is very distributed with different roles. Having an AUTOSAR model that allows modeling the entire car with a component aspect, the question would be:* ***How can we slice this information in such pieces that we can allocate the adequate pieces to the different roles, and without harming IPs and without knowing in advance some pieces of information that are coming later in the process?***

A text is in preparation where all findings made during this meeting will be organized. The objective is to make this become a publication.

Summary of conclusions of the meeting *Beyond AUTOSAR*

Here we summarize what we think are the main conclusions of this meeting:

- Regarding the interaction *contro/embedded software*:
  - There is a permanent misunderstanding between control & software engineers
  - Regarding the relative merits of ET/TT, control design aspects provide complementary views, not considered before
  - There is a need for a notion of *component for control*, that would enable incremental development of control systems.
- Regarding AUTOSAR:
  - The AUTOSAR design flow for distributed embedded electronics is not completely plug-and-play, neither it is compositional, for reasons of scheduling: scheduling is, today, based on global systems models. Component-based techniques for real-time are needed. (*This is an ongoing research activity at some ARTIST2 teams participating to RTC and Executions Platforms clusters.*)
  - Turning the AUTOSAR approach into an effective tool for dispatching the work efficiently among suppliers is still seen as a challenge.

Difficulties in organizing and planning other activities

So far the meeting *Beyond AUTOSAR* was a full success. Other meetings were initially planned that could not be held during this period. We briefly indicate these and the reasons for failure.

At the RTC working meeting held during the Innsbruck meeting on AUTOSAR, some other meetings were planed. One of them was planed in this framework of this activity, namely a *Meeting on predictability of hardware in automotive/avionics and semiconductor industry*. This meeting was planed jointly by partners from the RTC and Execution Platform clusters, to be held June 2006. Early preparation of this meeting showed a risk of insufficient success, so this meeting was postponed to end of 2006 and is described in the progress report of activity *Seeding new work directions.*.

These failures indicate that the needed effort to bring to success a workshop such as *Beyond AUTOSAR* should not be underestimated.

2.2.2 Publications Resulting from these Achievements

Group publications involving several ARTIST2 partners

We list here joint work from teams involved in this activity:

RISE project papers

Ch. Kossentini and P. Caspi: Approximation, Sampling and Voting in Hybrid Computing Systems. In HSCC06, Sta Barbara, March 2006.

[ECRTS`04] N. Scaife and P. Caspi. "Integrating Model-Based Design and Preemptive Scheduling in Mixed Time- and Event-Triggered Systems", Proceedings of the 16th Euromicro Conference on Real-Time Systems (ECRTS'04), IEEE Computer Society, pp. 119-126, 2004.

[EMSOFT`05a] S. Tripakis , C. Sofronis , N. Scaife , P. Caspi. "Semantics-preserving and memory-efficient implementation of inter-task communication on static-priority or EDF schedulers", Proceedings of the 5th ACM international conference on Embedded software, pp. 353-360, September 18-22, 2005, Jersey City, NJ, USA.

SPEEDS project papers (in preparation)

SPEEDS/HRC partners: Heterogeneous Rich Components meta-model semantics. (This document defines the semantics of the SPEEDS heterogenous component model, allowing to formally combine different aspects of a component, functional and non-functional.)

SPEEDS/HRC partners: Heterogeneous Rich Components meta-model syntax.

Other

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Thomas A. Henzinger and Joseph Sifakis, "The embedded systems design challenge, Proceedings of the 14th International Symposium on Formal Methods (FM), Lecture Notes in Computer Science, Springer, 2006.

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Individual partners publications

D. Potop-Butucaru, B. Caillaud, A. Benveniste. Concurrency in Synchronous Systems. *Formal Methods in System Design*, to appear, 2005.

Arne Hamann, Razvan Racu, Rolf Ernst. *A formal approach to robustness maximization of complex heterogeneous embedded systems.* To be published International Conference on Hardware - Software Codesign and System Synthesis (CODES), Seoul, Korea, October 2006.

Razvan Racu, Arne Hamann, Rolf Ernst. A Formal Approach to Multi-Dimensional Sensitivity Analysis of Embedded Real-Time Systems. In *In Proc. of the 18th Euromicro Conference on Real-Time Systems (ECRTS)*, Dresden, Germany, July 2006.

Kai Richter, Marek Jersak, Rolf Ernst. How OEMs and suppliers can tackle the network dimensioning problem. *Embedded Real Time Software Congress (ERTS06)*, Toulouse, France, January 25-27, 2006. Workshop participants from industry and academia (50/50). Focus: real-time issues in avionics and automotive systems. http://www.erts2006.org/

Kai Richter, Rolf Ernst. Real-Time Analysis as a Quality Feature: Automotive Use-Cases and Applications, *Embedded World 2006 Fair and Conference*. Nuremberg, Germany - February 14-16, 2006. Major European event for digital embedded systems HW and SW. http://www.embedded-world-2006.de/main/Page.html

Kai Richter, Marek Jersak, Rolf Ernst. How OEMs and suppliers can face the network dimensioning challenges. *Design, Automation and Test in Europe (DATE) Conference,* Special Track Automotive Designer's Forum, Munich, Germany, March, 2006.

Kai Richter, Rolf Ernst. Applying Real-Time Network Research in the Automotive Industry: Lessons Learned and Perspectives, *Euromicro Conference on Real-Time Systems (ECRTS),* satellite workshop on Real Time Networks (RTN)*,* Dresden, Germany, July 2006.

Richard Anthony, Alexander Leonhardi, Cecilia Ekelin, Dejiu Chen, Martin Törngren, Gerrit de Boer, Isabell Jahnich, Simon Burton, Ola Redell, Alexander Weber, Vasco Vollmer: A Future Dynamically Reconfigurable Automotive Software System, to appear at Elektronik im Kraftfahrzeug, Dresden, Germany, June 27-28 2006

A. Metzner und C. Herde. RTSAT - Scheduling Tasks in Distributed Real-Time Systems by Enhanced Satisifiability Checking. In: Proceedings of the IEEE Real-Time Systems Symposium, Work in Progress Session. December 5-8, 2005 Miami, Florida, USA

A. Metzner, M. Fränzle, C. Herde und I. Stierand. An Optimal Approach to the Task Allocation Problem on Hierarchical Architectures. In: Proceedings of the 20th IEEE International Parallel and Distributed Processing Symposium. IEEE Computer Society, April 25-29 ,2006 Rhodes Island, Greece

G. Pinto, W. Damm und S. Ratschan. Guaranteed termination in the verification of LTL properties of non-linear robust hybrid systems. In: In ATVA Automated Technology for Verification and Analysis 2005. Taipei, Taiwan, October 4-7, 2005, LNCS 3707

W. Damm, H. Hungar und E. Olderog. Verification of cooperating traffic agents. International Journal of Control 79 (5). 2006.

W. Damm. Component based design of embedded automotive systems. In: Proceedings, AAET 2006, Automatisierungs-, Assistenzsysteme und eingebettete Systeme für Transportmittel 2006.

From control loops to real-time programs P. Caspi and O. Maler in *Handbook of Networked and Embedded Control Systems,* Birkhäuser, 2005

2.2.3 Keynotes, Workshops, Tutorials

ARTIST2 Workshop: Design Issues in Distributed, Communication-Centric Systems

DATE Conference, Munich, Germany, 10.3.2006

Organiser: Bruno Bouyssounouse, Rolf Ernst, Lothar Thiele

Objective: The workshop presented relevant, innovative, and holistic topics in communication-centric systems, sensor networks, dynamic real-time architecture, distributed computing, minimal operating systems, and self-organisation.

URL: http://date.eda-online.co.uk/2006/prog/index.php?id=42

ARTIST2 Workshop: Distributed Embedded Systems

Leiden, Netherlands, 21.11. - 24.11.2005

Organiser: Lothar Thiele

Objective: Benchmarking and comparison of different formal analysis approaches

URL: http://www.tik.ee.ethz.ch/~leiden05/

Keynote address by Tom Henzinger and Joseph Sifakis: The embedded systems design challenge

14th International Symposium on Formal Methods (FM)

August 2006

We summarize some current trends in embedded systems design and point out some of their characteristics, such as the chasm between analytical and computational models, and the gap between safety-critical and best-effort engineering practices. We call for a coherent scientific foundation for embedded systems design, and we discuss a few key demands on such a foundation: the need for encompassing several manifestations of heterogeneity, and the need for constructivity in design. We believe that the development of a satisfactory Embedded Systems Design Science provides a timely challenge and opportunity for reinvigorating computer science.

Tutorial: Supporting predictable design using formal analysis techniques

ARTES Summer School, Stockholm Schweden, August 21-25 2006.

Speaker: Arne Hamann and Razvan Racu, Technical University of Braunschweig.

URL: http://www.artes.uu.se/events/summer06/

Talk: Scheduling Analysis in Practice - Early Lessons Learned

ARTIST2 Workshop: Distributed Embedded Systems, Leiden, Netherlands - November 21-24th, 2005.

Speaker: Kai Richter

URL: http://www.tik.ee.ethz.ch/~leiden05/

Talk (in german): Zuverlässige und effiziente Integration eingebetteter Systeme - ein Widerspruch?

Annual Meeting IEEE Computer Society, Wolfsburg Germany, July 2006.

Speaker: Rolf Ernst, Technical University of Braunschweig.

Invited Lecture by Martin Törngren: "Automotive Embedded Systems – research challenges", Aug. 24, 2006, ARTES summer school (www.artes.uu.se)

Invited Lecture by Martin Törngren at Mecel (a Swedish subsidiary of Delphi): **"Cost-efficient and systematic verification of embedded control systems"**, June 14, 2006 Performed at the occasion of starting a new national project between Mecel and KTH.

Invited Lecture by Martin Törngren at ENEA: "Automotive Embedded Systems; characteristics, trends and challenges", May 17, 2006

Invited Lecture by Martin Törngren at PLM Forum 2006: "Challenges for PLM of Mechatronic Systems", Stockholm, May 10, 2006 A forum arranged by Technia AB.

Martin Törngren invited panelist for the ARTIST2 workshop: Beyond Autosar, Innsbruck, March 24, 2006.

General Keynote : "Quo Vadis, EDA? Reasoning about the Trends and Challenges of Engineering Design Automation" Alberto Sangiovanni-Vincentelli

EDA Forum

Hanover, Germany – November 16-18, 2005; Wolfganf Rosenstiel, Chair

Forum Preface: EDA is facing a complicated situation these days. Shorter product life cycles, higher flexibility and new technological challenges require more and better EDA tools. Additionally, the new application areas towards ubiquitous computing and ambient intelligence demand for a new kind of EDA. On the other hand investment in EDA has a very slow growth, which is surprising, since it was proven recently that design capabilities of enterprises are a decisive factor for a leading position in competitiveness and sustainable profit.

Therefore, it is the top priority of edaForum05 – and this is the fourth in a sequence of very successful events – to discuss and to find solutions for this contradiction. edaForum always brings together the EDA decision makers with some of the best speakers from all over the world. Like in the past years, edaForum is unique in combining technical and business EDA aspects in one single event. This year's technical highlights will include ultra low power design for ubiquitous computing and ambient intelligence as well as robust and predictable design under uncertain conditions in nanoscale technology. In the more business oriented sessions we will discuss questions like:

- How to measure ROI of EDA?
- What roles have chips in the value chain?
- Do fabs still pay off?
- Are fabs the only way to make money in the nanoelectronics era?
- Is it all about cost and risk management, reliability and yield or about new creative product ideas fast implemented in silicon directly from system level?
- Is a new application specific design solution more important than managing the chip production process or is it the other way around?

Abstract of the presentation:

EDA has played a pivotal role in the past 25 years in making it possible to develop a new generation of electronic systems and circuits. However, innovation in design methodologies has slowed down significantly as we approach a limit in the complexity of systems we can design satisfying increasing constraints on time-to-market and correctness. There is a general trend for the electronics industry to focus on system issues, as software becomes a fundamental component and as the supply chains are destabilized because of the quest for additional value-added in presence of increasing costs and investments. At the same time, manufacturing issues are populating the nightmares of circuit engineers as they try to cope with an implementation fabric that becomes unreliable and difficult to characterize. These trends are at the same time creating severe problems to companies that are based on a business model that is showing stress and opportunities for new enterprises that come into the play with new vistas. There are many open issues to resolve to move towards the new world of technology as world-wide economic developments add complexity to the forecasts. In this presentation, we will look at the issues facing the electronic companies supply chains, the technical challenges, possible solutions and scenarios.

http://edacentrum.de/edaforum/

Keynote : "Automotive Electronics: Steady Growth for Years to Come" Alberto Sangiovanni-Vincentelli

ASP-DAC Conference, Yokohama, Japan, Jan. 24-27, 2006

Conference Chair: F, Hirose

Presentation of the Conference (part of): On behalf of the Organizing Committee, I would like to welcome you to the Asia and South Pacific Design Automation Conference 2006 (ASP-DAC 2006). ASP-DAC is a sister conference of DAC, DATE and ICCAD, and it is the 11th event of this conference series. ASP DAC 2006 will be held at Pacifico Yokohama, Japan, from January 24 through 27, 2006, jointly with the Electronic Design and Solution Fair 2006.

ASP-DAC is the meeting place where researchers and engineers come together to learn and discuss state of the art technologies of system/SoC design, EDA and design methodologies. In 2006, we put special effort into attracting designers and design industries to produce Designers' Forum.

We have three keynote speakers from academia, the semiconductor industry and the systems industry. Professor Alberto Sangiovanni-Vincentelli, University of California at Berkeley, will explore future system design perspectives in automotive electronics. Satoru Ito, President & CEO of RENESAS Technology Corp. will discuss challenges of device innovation. Yukichi Niwa, Senior Advisory Director of CANON INC. will present the company's key concept of architecting platform based design.

Abstract of the talk: The world of electronics is witnessing a revolution in the way products are conceived, designed and implemented. The ever growing importance of the web, the advent of microprocessors of great computational power, the explosion of wireless communication, the development of new generations of integrated sensors and actuators are changing the world in which we live and work. The new key words are:

- Disappearing electronics, i.e., electronics has to be invisible to the user, it has to help unobtrusively.
- Pervasive computing, i.e., electronics is everywhere, all common use objects will have an electronic dimension.
- Ambient intelligence, i.e., the environment will react to us with the use of electronic components. They will recognize who we are and what we like.
- Wearable computing, i.e., the new devices will be worn as a watch or a hat. They will become part of our clothes. Some of these devices will be tags that will contain all important information about us.

- Know more, carry less, i.e., the environment will know more about us so that we will not need to carry all the paraphernalia of keys, credit cards, personal I.D.s, access cards, access codes.

The car as a self-contained microcosm is experiencing a similar revolution: all the key words listed above are going to have a great impact on the automotive world. We need to rethink what a car really is and the role of electronics in it. Electronics is now essential to control the movements of a car, of the chemical and electrical processes taking place in it, to entertain the passengers, to establish connectivity with the rest of the world, to ensure safety. What will an automobile manufacturer's core competence become in the next few years? Will electronics be the essential element in car manufacturing and design? The challenges and opportunities are related to

- how to integrate the mechanical and the electronics worlds, i.e., how to make mechatronics a reality in the automotive world,
- how to integrate the different motion control and power-train control functions so that important synergies can be exploited,
- how to combine entertainment, communication and navigation subsystems,
- how to couple the world of electronics where the life time of a product is around 2 years and shrinking, with the automotive world, where the product life time is 10 years and possibly growing,
- how to develop new services based on electronics technology,
- how to exploit communication among cars and between cars and infrastructure such as Global Positioning Systems and cellular networks,
- how are the markets evolving (for example, what will be the size of the after-market sales for automotive electronics, if any?).

We will pose these questions while reviewing some of the most important technology and product developments of the past few years. We will also present new trends on how the design of electronics of the car should be carried out. We will finally analyze the dynamics of the automotive electronics industry that is bound to produce a major shake-up in the structure of the design chain with particular emphasis on the AUTOSAR consortium.

http://www.aspdac.com/aspdac2006

Keynote : "Innovazione a 360 gradi: l' Elettronica del Futuro" Alberto Sangiovanni-Vincentelli

II Giornata della Innovazione, Confindustria, Roma March 3, 2006, Pasquale Pistorio Organizer

The goal of the meeting was to discuss the role of innovation in industry with particular emphasis on embedded and networked systems. The audience was about 4,000 industrialists in all sectors in Italy. Outcome was a series of new interactions with white goods industry such as Indesit, the largest company in the domain in Europe.

Invited Talk and Organization of a Special Session on Networks: Is "Network" the Next "Big Idea" in Design? Network Paradigms in Systems, Sensors, & Silicon. Alberto Sangiovanni-Vincentelli

Date 2006, Munich, Germany, March 6-10, 2006

In the last decade, we started to design blocks with millions of atomic elements transistors, gates, lines of code. As complexity continues to grow, we are moving away from creating each element from scratch, toward methodologies that emphasize connecting the right elements, in the right communication patterns, to achieve the right functionality. This view of design is being called the network paradigm. Complex component interactions can create a range of amazing behaviors, some useful, some unwanted, some even dangerous. To manage these, a "science" for network design is evolving, applicable in some surprising areas. In this session, we survey three application domains, and discus the modeling, analysis, and design challenges involved. From large-scale hardware/software systems, to dynamically adaptive sensor networks, to network-on-chip architectures, these ideas are finding wide application. Is the "network" the next "big idea" for our community?

Focus and Relevance:

This is, by design, intended as a "gee whiz!" technical session, in which some very new ideas are aired for the Design Automation community, in the form of a range of "exciting" applications. We hope to impart at least some of the essence of the theoretical foundations, design implications and appropriate design methods for using the network paradigm to solve some real problems. But to make this interesting, we focus on the applications themselves, and let the speakers use these to illustrate the critical points of communication-centric design. Particular emphasis will be placed on presenting the properties and design metrics that are relevant to understanding the various networks that characterize the component interactions in these engineered systems. Attendees will learn what the communication-centric approach is, how it works, why it is important, and perhaps where it might actually apply to a system-level design scenario in their own areas.

Since this is a rather aggressive set of "forward looking" applications, we have taken great pains to make sure we have the best speakers. Thus, we have a set of very experienced presenters, most of whom have done talks of this type at prior Design Automation or similar conferences: Alberto Sangiovanni-Vincentelli will discuss the refinement process for networks from top to bottom; Jan Rabaey will discuss the design of wireless sensor networks; Radu Marculescu will discuss the interplay between static and dynamic properties of silicon networks. All are experienced conference speakers. The moderator, John Cohn, is a uniquely broad individual, who has successfully run many successful Design Automation panels and sessions.

http://www.date-conference.com/

Key Note: Challenges and Opportunities for System Theory in Embedded Controller Design, Alberto Sangiovanni-Vincentelli

2nd IFAC Conference on Analysis and Design of Hybrid Systems, Alghero, Sardinia, Italy – June 7-9, 2006

Abstract: Embedded controllers are essential in today electronic systems to assure that the behaviour of complex systems as cars, airplanes, trains, building security management systems, is compliant to strict safety constraints. I will review the evolution of embedded systems and the challenges that must be faced in their design. I will also present methodologies aimed at simplifying and speeding the design process. The role of hybrid systems in the development of embedded controllers will be outlined. Future applications such as wireless sensor networks in an industrial plant will also be presented.

http://www.diee.unica.it/adhs06/program.html

TUTORIAL AND PANEL – Communication Methods and Networking in Automotive Systems, Alberto Sangiovanni Vincentelli

Date 2006, Munich, Germany, March 6-10, 2006

The purpose of this special session is to evaluate bottlenecks and drawbacks of today's automotive electronic and car network systems, as well as to discuss and envisage new concepts for future system design in automotive electronics and their networks. Both aspects, hardware design and tool-integration into existing development tools will be discussed. The main emphasis is on architectures, design-flow, tool-development, applications and system design.

The special session is addressed to hardware and system engineers as well as to researchers. In a panel, selected world-wide specialists in the field of automotive electronics will discuss the demands and interests of industry on novel technologies and system and research activities for future automotive systems.

http://www.date-conference.com/

Tutorial: Tools for Hybrid Embedded Systems: Modeling, Verification, and Design

Alberto Sangiovanni-Vincentelli

Design Automation Conference, July 24-28, San Francisco, USA

This tutorial gives a detailed overview of the current landscape of tools for the specification, design, and validation of hybrid embedded systems.

The basic principles of hybrid systems (systems that feature both continuous and discrete time components) modeling will be presented as the common theoretical underpinning for all the tools. The core of the tutorial will be live demonstrations of about a dozen tools that have been developed in the industry and academia.

For each tool, a brief presentation of its syntactic and semantic characteristics will be followed by a practical exposition of how to use it to model and design some simple, but challenging "running examples", thereby showing its advantages and limitations. This will provide a sound mechanism to compare the tools by illustrating their differences in terms of expressiveness, usability, power, and performance. Some industrial examples will be modeled, presented, and discussed.

http://www.dac.com/43rd/pindex.html

3. Future Work and Evolution

3.1 *Problem to be Tackled over the next 18 months (Sept 2006 – Feb 2008)*

For the next 18 months, the work will concentrate on 1/ exploiting the already organized meetings and 2/ planning and organizing additional meetings.

Further exploiting the already organized meetings

The conclusions of the meeting *Beyond AUTOSAR* will be organized in the form of a paper for submission to a scientific magazine with large audience in the targeted industrial sector. Preparation of this paper already started and is supposed to last for the rest of 2006, and possibly early 2007. This paper will be prepared by a group of academic participants to this meeting, who staid for the following Saturday in Innsbruck to prepare its contents. We hope that, despite the overloading of key authors of this paper from various sources and projects, the paper will be available for the next report.

Planning additional meetings

A meeting is planed on the topic of *Building automation and security of embedded systems.* This will be organized by PARADES and is scheduled for fall 2006, but not firmly planed yet.

The next important meeting of this activity is planed to be held on the aeronautics/avionics sector (see the work plan). The preparation and exploitation of the latter meeting will allow for an analysis of the situation of and challenges raised by Integrated Modular Avionics (IMA). Since the RTC board is currently busy preparing the 1st meeting of the sister activity *Seeding New Research Directions,* this meeting on IMA will be planed year 2007.

3.2 *Current and Future Milestones*

- Meeting on *Embedded electronics in automobile beyond AUTOSAR*: successfully completed March 2006; still under exploitation. End of exploitation (collective paper in preparation) planed for early 2007.
- Meeting on *Fundamental Challenges raised by Integrated Modular Avionics*: not planed yet. Expected in 2007, see below.
- Meeting on *Fundamental Challenges related to Real-Time Components raised by Consumer Electronics and Telecommunications*: not planed yet. Expected year 2008, see below.

3.2.1.1 Meeting: Fundamental Challenges raised by Integrated Modular Avionics

Meeting Title	Fundamental Challenges raised by Integrated Modular Avionics
Approximate Date	This is one of our other candidate meetings planed. We will have it either in fall 2006 or winter 2007. Which partner will organize and host it is still open.

Objectives and expected output	The aim of this 2-3 days meeting is to invite key industrial actors from aeronautics, for extensively discussing the following matters: • What the problems are for them, what the degrees of freedom are. To this end, we shall have somebody from industry deeply explaining the issues; this presentation shall be prepared jointly between some ARTIST person and the industrialist(s). • Each one of ARTIST2 participants would try to relate what she or he's doing, to the above presentation, on-line during the meeting. • Minutes will be carefully recorded and subsequently lifted to the status of an ARTIST2 document and deliverable. These will contain in addition suggestions for further research directions.

There is a totally different category of industrial sector where Real-Time Components and Architectures are important, namely telecommunications and consumer electronics. More generally, we are looking for industrial sectors where the overall performance and service delivery can be achieved by acting on architecture, OS and scheduling, and application, jointly. This is a situation totally different from that in the above discussed industrial sectors. And this raises clearly other fundamental issues. We will probably not have the resources to organize this meeting *in addition to* the previous one. It may however be an interesting backup if we fail identifying high quality invitees for our previous meeting. In case we plan to organize such a meeting, this would be jointly performed with the Adaptive Real-Time and Control clusters.

3.2.1.2 Meeting: Fundamental Challenges related to Real-Time Components raised by Consumer Electronics and Telecommunications

Meeting Title	Fundamental Challenges related to Real-Time Components raised by Consumer Electronics and Telecommunications
Approximate Date	This is one of our other candidate meetings planed. We see it as a backup for our previous mentioned meeting. We may have it either in fall 2006 or winter 2007. Which partner will organize and host it is still open.
Objectives and expected output	The aim of this 2-3 days meeting is to invite key industrial actors from this sector, for extensively discussing the following matters: • What the problems are for them, what the degrees of freedom are. To this end, we shall have somebody from industry deeply explaining the issues; this presentation shall be prepared jointly between some ARTIST person and the industrialist(s). • Each one of ARTIST2 participants would try to relate what she or he's doing, to the above presentation, on-line during the meeting. • Minutes will be carefully recorded and subsequently lifted to the status of an ARTIST2 document and deliverable. These will contain in addition suggestions for further research directions.

3.3 Indicators for Integration

This activity already plays a strong role in integration, as the important events typically involve different topics covered by Artist2 clusters, and thus require the involvement of several clusters. This has been the case for the meeting *Beyond Autosar* and should continue to be so. Hence an obvious indicator for integration with regard to this activity is the list of ARTIST2 clusters as well as non core members of ARTIST2 or external industrial partners who will be involved in the preparation and contents of the main events. The same applies to the post-event exploitation, if any.

3.4 Main Funding

Main sources of funding include:

- the Integrated Projects
    - DECOS https://www.decos.at/
    - ASSERT http://www.assert-online.net/
    - MODELWARE
    - RUNES, http://www.control.lth.se/research/runes.html
- the new Integrated Projects
    - SPEEDS
- the STREPS
    - DYSCAS - www.dyscas.org
    - ATESST - www.atesst.org
    - OMEGA
- FP5 IST Projects
    - RISE http://www.esterel-technologies.com/rise/
- the national funding agencies
    - Swiss National Science Foundation
    - US National Science Foundation
    - French Agence Nationale de la Recherche
    - FLEXCON Swedish program
    - Swedish Research Council
    - AVACS (Automatic Verification and Analysis of Complex Systems, Transregional Collaborative Research Center, http://www.avacs.org)
- Direct industrial contracts
    - Airbus – Verimag CIFRE contract in support of the PhD of Chiheb Kossentini

3.5 Internal reviewers for this deliverable

Alberto Sangiovanni-Vincentelli (PARADES)

Bengt Jonsson (Uppsala University)