Title page

INFORMATION SOCIETY TECHNOLOGIES
(IST)
PROGRAMME

Contract for: *(select as appropriate)*

Shared-cost RTD
Demonstration project
Combined RTD & Demonstration project
Accompanying Measure
Concerted Action/Thematic Network
Trial
First User Action
Best Practice Action
Access Action
Assessment Action

Annex 1 - "Description of Work"

Project acronym: ARTIST
Project full title: Advanced Real-Time Systems
Proposal/Contract no.: IST-2001-34820
Related to other Contract no.: *(to be completed by Commission)*

Date of preparation of Annex 1:

Operative commencement date of contract: *(to be completed by Commission)*

1. Project summary

Project Acronym (2)	ARTIST	Project No (3)	IST-2001-34820

A2.	Project Summary (20)

Objectives (maximum 1000 characters)

The aim of the Initiative is to co-ordinate the R&D effort in the area of Advanced Real-time Systems so as to
* Improve awareness of academics and industry in the area especially about existing innovative results and technologies, standards and regulations
* Define innovative and relevant work directions, identify obstacles to scientific and technological progress and propose adequate strategies for circumventing them

Description of work (maximum 2000 characters)

The Initiative will focus on three relevant work directions
* Hard Real-Time Systems
* Component based Design and Development
* Adaptive Real-Time Systems for QoS Management

The work directions comprise:
* Establishing a roadmap mapping future directions in advanced real-time systems
* Proposing curricula for Education and Training in advanced real-time systems
* Dissemination and International Collaboration
* Creating strong two-way ties with industry

Milestones and expected results (maximum 500 characters)

Reviews are planned at times T0+12, T0+24 and T0+36.

Deliverables are reports on work performed in the work directions mentioned above.

2. Project objective(s)

2.1 Advanced Real-Time Systems

The evolution of information sciences and technologies is characterized by the extensive integration of embedded components in systems used in various application areas, from telecommunications to automotive, manufacturing, medical applications, e-commerce etc. In most cases, embedded components are real-time systems that continuously interact with other systems and the physical world. Integration and continuous interaction of software and hardware components makes the assurance of global quality of service requirements a major issue in system design. The failure of a component may have catastrophic consequences on systems performance, security, safety, availability etc.

Building embedded real-time systems of guaranteed quality in a cost-effective manner raises challenging scientific and technological problems. Existing theory, techniques and technology are of little help as they fail to provide a global framework relating various design parameters to system dynamics and its properties. Contrary to conventional real-time systems, the development of advanced real-time systems, must take into account a variety of requirements concerning:

- Fast evolving, strongly constrained environments with rich dynamics e.g. in multimedia and telecommunication systems.

- Combination of hard and soft real-time activities which implies the possibility to apply dynamic scheduling policies respecting optimality criteria. Soft real-time is indeed harder than hard real-time as it requires that when necessary, some timing constraints are relaxed in some optimal manner.

- Behaviour which is dynamically adaptive, reconfigurable, reflexive, intelligent and "any fashionable buzzword used to qualify properties meaning that systems behave less stupidly than they actually do". Building systems meeting such properties is essential for quality assurance if we want to increase system interactivity and autonomy. Inventing new buzzwords does not help solving problems which are intrinsically hard. In fact, it is easy to understand that building systems enjoying such desirable properties amounts to synthesizing controllers and thus, advanced control techniques for complex and heterogeneous systems are needed.

- Dependability covering in particular security, safety and availability. The dynamic nature and heterogeneity of advanced real-time systems makes most dependability evaluation techniques partial or obsolete.

- Cost-effectiveness and time to market. These requirements are certainly the most important for advanced real-time systems which are embedded in mass market products. If they are relaxed, it is possible to satisfy quality requirements and this has been the case for conventional real-time applications. For example, the cost of the control equipment in a commercial aircraft is (still) a small percentage of the cost of the whole. On the contrary, for cellular phones even minimal optimisations of resources such as memory and energy or of time to market is of paramount importance.

Advanced real-time system developers lack theoretical and practical tools and enabling technology for dependable and affordable products and services. The emergence of such enabling technology requires tight and long term cooperation between research, industry and various authorities (regulation, funding). From a theoretical point of view, it raises foundational problems about systems modeling, analysis and control which appears to be a key concept in advanced real-time systems engineering.

On the other hand, enabling technology should follow the evolution of the various standards – ad hoc or institutional - used to enhance system integration, interoperability and to assure systems quality. Enabling technology integrates from research and standards the elements that appear to be practically effective and relevant. In this process, industrial users, tool developers, research and standardization bodies should be strongly and harmoniously cooperating.

The strategic importance of advanced real-time systems has been recognized in the US where several ambitious integrated projects with long term aims have been launched each in the range of 60-100 million USD e.g. Path, Mobies, Nest.

2.2 ARTIST objectives

The aim of the Project is to co-ordinate the R&D effort in the area of Advanced Real-time Systems so as to

- Improve awareness of academics and industry in the area, especially about existing innovative results and technologies, standards and regulations
- Define innovative and relevant work directions, identify obstacles to scientific and technological progress and propose adequate strategies for circumventing them.

- Achieving the aim requires mobilization and tight collaboration of research teams, system developers and technology providers. For the Project to be successful it is necessary to

- Get the best teams involved, by offering an attractive and appropriate framework for collaboration which improves in many respects the current situation concerning the level of funding, project evaluation and monitoring, flexibility in the use of resources in particular, by simplification of administrative procedures.
This is a necessary condition for achieving both quality and critical mass, given the diversity of sources of funding and the relative abundance of uncoordinated offers and opportunities to get support at national, European and international level.

- Define a global, realistic, ambitious and mobilizing roadmap in collaboration with associated industrial partners covering all the needs from theory, to methods, tools, standards and technology. To achieve the roadmap objectives, a cluster of coordinated projects should be set up. The existence of a roadmap with clearly defined objectives and steps should guarantee continuity of the effort and overall coherence – which is missing today. The roadmap objectives should be periodically revised to take into account evolving requirements.

The Project will focus on system-centric approaches by adapting or further extending them to real-time software and hardware technology. It will consider generic approaches and will not privilege particular application areas. This is currently feasible due to the increasing adoption of standards and the use of a limited number of languages in systems engineering. Nevertheless, the Project will use a diverse selection of suitable applications to evaluate and further specialize the approaches, whenever appropriate.
The Project should establish good contact and interaction with application specific projects for essential technologies and infrastructure as well as relevant projects on control theory and dynamic systems.

It is anticipated that the Project will bring the following benefits:
- Avoid fragmentation of the effort in the area by grouping together activities, by increasing awareness and added value through cooperation.

- Mobilize to achieve challenging objectives of the elaborated roadmap
- Treat in depth some well identified hard problems which are the main impediments to state-of-the-art progress today and develop strategies for reaching effective solutions in specific application contexts.

To achieve these aims ARTIST gathers together outstanding European teams interested in Advanced Real-time Systems and coming from different areas such as,

- Design and implementation of embedded software,
- Operating systems and middleware,
- Programming languages and compilers,
- Modeling and validation,
- Software engineering and programming methodologies,
- Scheduling and execution time analysis,
- Networking and fault tolerance.

Such a variety of competence and skills is indeed necessary to tackle the hard scientific and technological problems addressed by ARTIST.

The project is implemented as a set of 3 coordinated actions. Actions scopes do not uniformly cover the area. We preferred to concentrate the effort on the most promising and challenging work directions corresponding to actual needs.

Action1 deals with ***Hard Real-time*** and aims at consolidating and further improving a strong European competence and know-how that is strategic for industry developing safety or mission critical applications such as avionics, automobile, railroad, space, energy distribution etc. In this area Europe has strong advantages with results and technologies such as Synchronous Languages widely used in avionics (Scade, Esterel, Signal) and Time Triggered Architectures at the basis of fault-tolerant safety critical architectures used in automobile industry.

Action2 deals with ***Component based Design and Development***. It which gathers together on the one hand teams having expertise in Formal Methods and especially in semantics and compositionality/composability problems and on the other hand teams working on Systems and Software Engineering.

Action3 is on ***Adaptive Real-Time Systems for QoS Management*** used in telecommunications, large open systems and networks where the hard real-time requirements are replaced by general QoS requirements. It gathers teams with expertise in real-time operating systems and middleware.

The three actions will cooperate and produce results in their respective areas in order to contribute in the following four directions: Roadmap, Education and training, Dissemination, Industrial liaison

3. List of Particpants

List of Participants

Partic. Role*	Partic. no.	Participant name	Participant short name	Country	Date enter project**	Date exit project**
C	1	Université Joseph Fourier Grenoble 1 / VERIMAG	UJF/VERIMAG	France	01/04/02	31/03/05
P	2	Institut National de Recherche en Informatique et en Automatique	INRIA	France	01/04/02	31/03/05
P	3	Technische Universitaet Wien	TU Vienna	Austria	01/04/02	31/03/05
P	4	Uppsala University	UU	Sweden	01/04/02	31/03/05
P	5	Universitaet des Saarlandes	UdS	Germany	01/04/02	31/03/05
P	6	Project on Advanced Research of Architecture and Design of Electronic System	PARADES	Italy	01/04/02	31/03/05
P	7	Kuratorium OFFIS e.V.	OFFIS	Germany	01/04/02	31/03/05
P	8	Aalborg University	AAU	Denmark	01/04/02	31/03/05
P	9	Technische Universiteit Eindhoven	TU/e	Netherlands	01/04/02	31/03/05
P	10	University of York	YORK	United Kingdom	01/04/02	31/03/05
P	11	Commissariat à l'Energie Atomique	CEA	France	01/04/02	31/03/05
P	12	University of Lancaster	ULANC	United Kingdom	01/04/02	31/03/05
P	13	Ecole Normal Supérieure de Cachan	ENS Cachan	France	01/04/02	31/03/05
P	14	University of Twente	UT	Netherlands	01/04/02	31/03/05
P	15	Maelardalen University	MDH	Sweden	01/04/02	31/03/05
P	16	University of Pavia	UNIPV	Italy	01/04/02	31/03/05

P	17	Scuola Superiore S. Anna of Pisa	SSSA	Italy	01/04/02	31/03/05
P	18	Universidad de Cantabria	UNICAN	Spain	01/04/02	31/03/05
P	19	Universidade de Aveiro	UAVR	Portugal	01/04/02	31/03/05
P	20	Universitat politecnica de Catalunya	UPC	Spain	01/04/02	31/03/05
P	21	Fundação da Faculdade de Ciências da Universidade de Lisboa	FFCUL	Portugal	01/04/02	31/03/05
P	22	Universidad Carlos III de Madrid	UC3M	Spain	01/04/02	31/03/05
P	23	Centre National de la Recherche Scientifique / VERIMAG	CNRS/ VERIMAG	France	01/04/02	31/03/05
P	24	Institut National Polytechnique de Grenoble / VERIMAG	INPG/ VERIMAG	France	01/04/02	31/03/05

4. Contribution to programme/key action objectives

One of the key elements of the Information Society is the existence of a vital and competitive systems and software development industry. The European systems and software development industry needs technologies and methodologies to improve its competitiveness in face of the dominance of big uS companies. A key element in this strategy is the early adoption of innovative software and systems technologies.
ARTIST addresses the Information Society Programme, key action IV – Essential Technologies and Infrastructures. Its scope is transversal to several action lines. We give below the most relevant action lines that intersect with ARTIST's work plan.

IV1.1 Design of networked embedded systems whose objectives are "To integrate and validate concurrent design and validation tool frameworks for resource constrained hardware/software systems embedded in intelligent devices and their networking". It is expected "multidisciplinary work on :
(i) Fast prototyping, hardware/software co-design, architecture simulation, software engineering supporting …"
(ii) Innovative hardware/software architectures pushing the of computing efficiency "
(iii) Run-time embedded software components ….

Clearly, ARTIST addresses foundational aspects of these topics. Concurrent design and validation problems are addressed by actions 1 and 2 while action 3 deals with aspects of hardware/software architectures and run-time embedded software components

IV1.2 Multi-service networks – middleware for seamless access to services with focus on "the middleware adaptation layer architectures and technologies allowing to secure delivery and portability …".
This is central to action 3 on "Adaptive Real-time systems for QoS management".

IV.2 Computing, communications and networks where work addresses "distributed systems operating under real-time conditions". The objectives of action line IV2.1 "Real-time distributed systems" are central for ARTIST.
(i) "To develop and assess models, technologies and tools for sharing and interactive use in real-time applications" is clearly in the scope of action 1.
(ii) "To focus on adaptive systems, real-time platforms " is in the scope of action3.
(iii) "To support the development of high performance, distributed control systems that are composable and meet stringent real-time requirements" is clearly in the scope of action 2 dealing with component based development and where composability is a very important issue.

IV.3 Technologies and engineering for software systems and services largely intersects ARTIST's workplan as its is specified in its general objective: "The work addresses generic technologies and engineering for the development, deployment, operation and evolution of software intensive systems embedded in goods and services as well as facilitating production and enterprise processes. The focus is on software architecture and adaptive …." ARTIST deals with all the foundational and technological aspects of these topics. In particular, action line IV3.1 focuses "on models and notations for describing systems architectures and being able to reason about them. The main concern is to guarantee required quality attributes of systems" Action 4 addresses all the aspects of modelling systems architectures by addressing both theoretical and practical (e.g standardization) issues.
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5. Relations to Programme

We provide below the list of the European project in which ARTIST partners are involved per action. This long list shows that the ARTIST consortium is involved in a large number of R&D projects covering the area of real-time. We believe that this should ease coordination of the effort, direct access through partners to project results and exploration of additional linkages and synergies.

5.1 Hard Real-time Systems

Sacres (1996-1999)

Solutions for SAfety Critical Real-time embedded Systems. See http://www.tni.fr/sacres/.
The central ideas of SACRES are : 1/ Do as much validation as possible at the specification level. 2/ Allow combinations of data-flow and state-based specification styles, using respectively state-of-the-art specification tools SILDEX and STATEMATE. 3/ Use formal specification of safety-critical properties at the specification level for maximal rigor. 4/ Automatically generate efficient distributed code from the specification, entirely replacing the manual coding phase. 5/ Use automated correctness proofs for the generated code as additional independent checks. Partners are British Aerospace (UK) , i-Logix (UK) , INRIA (F) , OFFIS (D) , Siemens (D, project leader), SNECMA (F) , TNI (F), Weizmann Institute (ISR) .

SafeAir (IST-1999-10913 , 2000-2002)

Advanced design tool for aircraft systems and airborne software. See http://www.safeair.org/ . The major result of Safair will be a validated Avionics Systems Development Environment (ASDE) for system and software development. This environment supports system and software specification, on the basis of formal, readable notations both at the analysis and design phase, and integrate de-facto standard modelling tools for avionics applications. Partners are Aerospatiale-Matra-Airbus, Daimler-Chrysler Aerospace Airbus, Israel Aircraft Industries, i-Logix, INRIA, OFFIS, Siemens, Snecma moteurs (project leader), TNI, Verilog-Telelogic, Weizmann Institute.

ESACS (Enhanced Safety Assessment for Complex Systems, GRD1-2000-25060,)

The objectives of ESACS (http://www.cert.fr/esacs/) are to define a methodology to improve the safety analysis practice for complex systems development, to set up a shared environment based on tools supporting the methodology, to validate the methodology through its application to case studies. The environment between design and safety will consist of tools to generate parts of the safety analysis using information extracted directly from the system model and of a repository including all the safety information related to the complex system under development. (Partners: Alenia, Airbus France, BAe Systems, Airbus Deutschland, SAAB, SIA, ITC-irst, ONERA, OFFIS, Prover)

CC (Control and Computation 2002-2004)

Its goal is to study and improve hybrid system methods in computerised control. Shared partners with HaRT: Parades, Verimag. Other partners : CWI, EDF, Lund Universitet, ETHZ, ABB, Universtà di Siena.

FIT - Fault Injection for TTA (IST-1999-10748), 2000-2002:

It is the objective of the project to experimentally validate the system concepts of the TTA, taking a prototype TTP/C controller chip, developed within the ESPRIT project TTA, as the basis. The experiments determine the error-detection coverage of the TTA in a realistic application by using different hardware and software based fault-injection methods. www.cti.ac.at/fit

Partners: Carinthia Tech Institute; TU Vienna - Institut fuer Technische Informatik; TTTech Computertechnik AG; Czech Technical University in Prague; Universidad Politecnica de Valencia; Chalmers University of Technology; Motorola GmbH; AB Volvo;

PAMELA - Prospective Analysis For Modular Electronic Integration In Airborne Systems (G4RD-CT-1999-00086), 2000-2001:

PAMELA is a Critical Technology project, aimed at selecting and preparing the underlying technologies, concepts and standards for future implementation of Integrated Modular Aircraft Electronics, which covers
Cockpit avionics and Utilities, Crew and Passenger services and Communications. http://spd-web.terma.com/Projects/pamela

Partners: Thales Avionics SA; Diehl Avionik Systeme GmbH; EADS Airbus GmbH; EADS Airbus SA; Airbus UK Ltd; Smiths Aerospace Ltd; BAE Systems Avionics Ltd; Gesellschaft fur Angewandte Informatik und Mikroelektronik mbH; Sinters; Westland Helicopters Ltd; University of York; Liebherr Aerospace Lindenberg GmbH; TU Vienna - Institut fur Technische Informatik; TERMA Elektronik AS;

DSoS - Dependable Systems of Systems (IST-1999-11585), 2000-2003:

The overall objective of the DSoS project is to develop significantly improved means for composing a dependable "system of systems" (SoS) from a set of largely autonomous component computer systems. The focus of the project will be on the design, placement and properties of the linking interfaces (LIFs) that form the common boundaries between component systems. http://www.newcastle.research.ec.org/dsos

Partners: University of Newcastle upon Tyne; Qinetiq Limited; Institut National de Recherche en Informatique et en Automatique; Centre National de la Recherche Scientifique (Delegation Midi-Pyrenees); TU Vienna – Institut fur Technische Informatik; Universitaet Ulm; Universite Paris Sud;

SETTA - Systems Engineering for Time-Triggered Architectures (IST-1999-10043), 2000-2001;

The overall goal of the SETTA consortium is to push the time-triggered architecture - an innovative European-funded technology for safety-critical, distributed, real-time applications such as fly-by-wire or drive-by-wire - into future vehicles, aircraft, and train systems. To achieve this goal, SETTA focuses on the systems engineering of time-triggered-architectures. http://www.setta.org

Partners: DaimlerChrysler AG; Regienov Renault Recherche Innovation on behalf of its members Renault and Renault Vehicule Industriels; Siemens AG; DaimlerChrysler Aerospace Airbus GmbH; Alcatel Austria; TTTech Computertechnik AG; Fuchs, Sprachmann & Partner Dependable Computer Systems
KEG; TU Vienna - Institut fur Technische Informatik; University of York;

NEXT TTA - High-Confidence Architecture for Distributed Control Applications (Proposal No. IST-2001-32111):

The NEXT TTA project enhances the structure, functionality and dependability of the time-triggered architecture (TTA) to meet the austere cost structure of the automotive industry, while satisfying the rigourous safety requirements of the aerospace industry.

Partners: Austria Mikro Systeme International AG is a partner of the project not yet listed up; IONA is NOT part of the project; SRI is only subcontractor;

EAST-EEA project from the ITEA program (EUREKA)

The goal of the project is to enable a proper electronic integration through definition of an open architecture mostly hardware distributed enabling hardware and software interoperability. This will be achieved by defining a layered software architecture based on a middleware concept, which provides interfaces and services to support portability of embedded software modules on a high quality level. The architecture will be built on top of existing solutions (e.g. OSEK/VDX)... Partners are AB VOLVO, AUDI, BMW, DC, OPEL, ETAS, SIEMENS VDO, ZF, SBS C-lab, VECTOR, MAGNETI MARELLI, RENAULT, PSA, VALEO, SIEMENS AUTOMOTIVE, UNIVERSITY of PADERBORN, LORIA, IRCCYN, INRIA.

5.2 Component based design and development

IST-1999-20608 CARTS project.
Its aim is to develop a Computer Aided Architectural Analysis tool environment supporting a particular architectural style for real-time component-based design and to demonstrate that it can be profitably used by equipment manufacturers that embed in them real-time software for reducing development time and costs, while maintaining the quality and performances. CARTS does not address the whole development process but proposes tool support at a very early stage of system development.

IST-1999-11557 INTERVAL.

Its aim is to take into account real-time requirements during the whole development cycle of real-time systems. It focuses on:

- the definition of timed extensions of the languages SDL, MSC and TTCN which are used for Telecom applications and standardized by ITU-T and ETSI, and

- tool support for specification, simulation, validation and testing of real-time systems using the extended languages.

IST-1999-10069 AIT-WOODDES:
The AIT-WOODDES project (Workshop for Object Oriented Design and Development of Embedded Systems,IST-1999-10069, http://wooddes.intranet.gr/) will focus on the high level specification of embedded real time systems allowing evolving design of product applications so as to quickly and easily adapt the product to the market evolution and to master increasing complexity of such products. The project will deliver an environment for the design of embedded systems using, where possible, existing standards, techniques and products. This environment will offer system description and development tools providing a homogeneous and continuous support for the development process of embedded systems.
(Partners: PSA, MECEL, CEA, I-Logix, Intracom, Uppsala Univ., OFFIS, Aalborg Univ.)

IST-2001-33522 OMEGA.
OMEGA (Correct Development of Real-Time Embedded Systems in UML, IST-2001-33522) aims at the definition of a development methodology in UML for embedded and real-time systems

based on formal techniques and used to improve commercially available UML tools. For this purpose it will (1.) identify reasonable and effective subsets of UML for real-time, as well as necessary extensions, (2.) provide formal foundations, methods and tools for compositional verification of real-time systems within UML, and (3.) construct a development methodology based on the UML modelling and specification capabilities and the verification methods and tools developed in the project. (Partners: VERIMAG, EADS Launch Vehicles, IAI, Univ. Nijmegen, NAL, OFFIS, Univ. Kiel, Weizmann Inst., France Telecom, CWI)

5.3 Adaptive Real-Time Systems for QoS Management

FIRST - EC (IST-2001-32467) Flexible Integrated Real-Time Systems Technology

The proposed research aims at providing a real-time scheduling framework to enforce timing constraints with some flexibility, achieving a trade off between predictability in the performance and efficiency in the resource utilisation. Viewing the schedulers as component building blocks enables temporal encapsulation of subsystems to support composability and reusability. The framework enables users to select the best-suited service for individual activities, rather than the prevalent monolithic approaches enforcing single regimes. ARTIST participants: University of Malardalen, Scuola Superiore S. Anna, University of York, University of Cantabria

CORTEX - EC (IST-2000-26031) CO-operating Real-time senTient objects: architecture and EXperimental evaluation
http://www.navigators.di.fc.ul.pt/projects/projects.html#CORTEX

The key objective of CORTEX is to explore the fundamental theoretical and engineering issues necessary to support the use of sentient objects to construct large-scale proactive applications and thereby to validate the use of sentient objects as a viable approach to the construction of such applications.

GLOBDATA - Esprit (IST-1999-20997)
http://www.navigators.di.fc.ul.pt/projects/projects.html#GLOBDATA

The overall objective of the project is to design an efficient software development tool and support system to provide application developers with a global view of an object database repository with transactional access to geographically distributed persistent objects independent of their location.

COMITY (Esprit Project No. 23015) Co-design Method and Integrated Tools for Advanced Embedded Systems http://www.it.uc3m.es/~comity

The main goal of the COMITY project is to improve and promote and engineering methodology with an associated toolset for the entire design cycle of complex embedded systems. COMITY will provide system engineers and SW and HW designers with modelling techniques at multiple levels of abstraction, and by using a common framework based on virtual prototyping to explore architectural solutions and trade-offs before SW or HW being fabricated. ARTSTIST participant: Universidad Carlos III de Madrid

MaRTE Minimal Real-Time Operating System for Embedded Applications
http://ctrpc17.ctr.unican.es/.

The aim of the project is to develop a real-time kernel for embedded applications that follows the Minimal Real-Time POSIX.13 subset. Most of its code is written in Ada with some C and assembler parts. It allows software cross-development of Ada and C applications using the GNU compilers Gnat and Gcc. In particular in the case of Gnat the Run-Time Library GNARL has been adapted to run on our kernel. Remote debugging of applications is also possible using the GNU debugger gdb.
ARTSTIST participant: University of Cantabria

6. Community added value and contribution to EU policies.

Today's real-time systems are increasingly complex, often operating within multi-layer, multi-platform, distributed environments. These systems are being created in rapid development environments that drive them toward the marketplace at breakneck speed. In an age of rapid development in increasingly complex environments, automation is the only hope for producing high quality real-time systems at competitive costs and within the critical marketing windows of opportunity. Yet, the overwhelming amount of development is still done without sufficient tool support for the whole development cycle starting from high level specifications down to on target implementation, resulting in labour intensive, tedious, time-consuming, and error-prone processes. ARTIST aims to address these issues.

6.1Trans-national collaboration

The need of rigorous development methods is largely independent of the specific development processes used within the EU Member States. Furthermore, the study and development of system centric approaches mobilizes an important number of teams in the US within large projects covering a wide spectrum of competence in methods, software and systems. ARTIST needs an extensive range of skills and expertise that are not easily available in any one of the Member States. Moreover, the collaboration among organizations from various countries, characterized by different development environments and application domains, guarantees that the solutions adopted will be applicable to a variety of situations.
ARTIST provides critical mass and collaboration required.

Through trans-national collaboration among a number of key players, the following can be achieved:

- Contribute to the transfer of research results to industrials producing embedded real-time software and systems. This high growth area is a strategic application domain for European industry.
- Help tool and technology providers adapting and improving existing technology.

6.2 Real-time systems development improvement

In large systems engineering projects, a large variety of techniques are used for description, programming, validation and finally for implementation. The consistency of the overall development process is problematic and in general not guaranteed. The resulting impact on quality assurance is however seen as a major bottleneck in systems development. ARTIST will co-ordinate the effort for relating, comparing and evaluating the different techniques. More importantly, the project will identify missing and promising links between existing techniques and enhance compatibility of techniques by promotion of standards.

ARTIST gathers together the most important academic research teams in the area of advanced real-time systems. It has a focused work programme with 3 actions corresponding to well identified technological needs: one on “traditional” hard real-time for safety critical systems used in the sector of transport and two dealing with needs resulting from softer real-time practice in areas such as telecommunications and multimedia.

ARTIST academic research teams have tight connections with the main industrials and technology providers in the area.

Finally, ARTIST will co-ordinate and reinforce already established connections between European and US teams.

7. Contribution to Community social objectives.

7.1 Improving quality of life

The main vehicle for improving the quality of life for the Union's citizens is the change of the society and its economic basis from an industrial to an information-based society. It is this change that justifies the Information Society Technologies (IST) Program. The objective of the Information Society is to enable individuals and organizations to innovate and be more effective in their work, thereby providing the basis for sustainable growth and high added value employment, while improving the quality of working life.

The establishment of the Information Society is a key objective of the EU in improving the quality of life for its citizens. The main enabler of the Information Society is the use of embedded systems in products used in various application areas including transports, energy distribution, integrated manufacturing, health, banking and services. Its successful realization is greatly dependent upon the quality of these products.

ARTIST will contribute enabling European industry deliver guaranteed quality systems. This will greatly assist in the establishment of the Information Society, with its promise of improved quality of life for European citizens.

7.2 Improving employment

As the EU moves from an industrial to an information society, employment moves to the skills of the information society. Quality software/hardware products are the basis of these key skills.

Employment levels in Europe will be positively influenced by ARTIST, because the project helps the European computing community develop high quality products, which will, in turn, bring their benefits to all EU employees. The labour forces that will be freed by the shortened development cycle of the next generation of products will accelerate the establishment of the Information Society, together with its foreseen benefits to the EU employment.

Finally, cross-fertilization of ideas through close collaboration between the EU and affiliated states will improve the competitiveness of European companies, fuel their growth and increase their capacity to create new jobs.

7.3 Improving work process

The unpopularity of the costly and labour intensive enforcement of systems quality by ad hoc and empirical techniques is well known. Quality assurance by labour intensive code inspection and testing techniques is seen as a “necessary evil” in the otherwise exciting software and system development cycle.
ARTIST will enhance awareness and promote innovative development techniques relieving practitioners from low level and tedious validation tasks. It will allow a considerable improvement of the overall systems quality. It also will require more skilled personnel in the quality assurance field, since rigorous development and validation methodologies are based on formal techniques and place an emphasis on modelling and automatic tools.

8. Economic development and S&T prospects

Research and Technology Development in the field of software and systems development, is of course, an integral part of the IST Program. Nevertheless, due to the expected demand for quality embedded software and systems products in the coming information society, there is a need to develop methodologies and tools that will facilitate the development of quality software and make the whole process more efficient and attractive to employees.

The ARTIST project brings together outstanding research teams with complementary skills, and strong connections with industry. They will pool their resources, knowledge and experience to further develop the state of the art in the area of advanced real-time systems. None of the partners separately has direct access to all required resources to address the full range of user needs and technology.

Research is essential for economic development but difficult for industry because of its need to focus on daily operational activities to meet current deadlines. Especially, embedded systems and software developers, must adapt to fast technological evolution and market constraints. On the other hand, it is crucial that research follows the evolution of industrial needs. The latter trigger the emergence of new problems and new research areas e.g. research on flexible real-time systems.

ARTIST will act as a catalyser by providing the appropriate structure and opportunities for interaction between researchers and also between researchers and industrials and by creating the conditions for critical mass and cross-fertilization.
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9. Workplan

9.1 General description

9.1.1 Action1

9.1.1.1 Action1 - Rationale and challenges

This action focuses on the design of distributed safety critical hard real-time embedded systems. Such systems gain increasing importance and constitute a driving force for the EU overall industry. Hard real-time embedded systems tend to exhibit an exponentially increasing complexity. A typical target industrial sector is transport (aircrafts, trains, automobiles, bikes,...). The following keywords listed in italics are important:

- *"distributed"* is an unavoidable feature of the execution architecture, resulting difficulties need to be considered;
- *"safety critical"* calls for the use of rigorous techniques, and, preferably, formally sound approaches;
- "*hard real-time"* indicates that timing issues are a constraint, and, even more, that time is itself one of the actors;
- *"embedded systems"* means that the final delivery is not the software/hardware per se, but the whole controlled system, plant, or device; the resulting boundary conditions (e.g., sensors/actuators) cannot be ignored.

For hard real-time systems we need to validate behaviours prior to deployment. So we need models and analyses that will allow us to validate the behaviours of interest. This will include in particular formal representations and model checking (for example), resource requirement models and schedulability analysis.

The above needs are already well studied topics today, but handling distributed designs in this context is much less understood, and still remains a challenge.

The industrial needs

This action proposes to take transportation systems in general as its target application area. This does not mean, however, that the addressed problems are only relevant for this industrial sector. But we feel it appropriate to select it as a target, since strong and demanding needs are expressed, and major difficulties are encountered in designing the corresponding systems. Considered industries, with corresponding actors having expressed their interest in this action (letters attached), are the following :

- aircraft/aerospace :EADS, Dassault-Aviation, Snecma
- trains : ABB
- automobile : Daimler-Chrysler, BMW, PSA, Renault, Magneti-Marelli
- tool vendors : Telelogic, Esterel Technologies, TNI-Valiosys, TTP-Tech, Cadence
- power distribution/process control : ABB, Schneider

The central need of these industries is to have a smooth system development process, starting from the early phases of system engineering, down to the deployment of the overall software (both infrastructure and application) on the actual embedded architecture.

A careful analysis of these industrial sectors reveals the following :

- The early phase of system engineering mainly involves scientific engineering, which consists of the overall high level requirements, physical plant or system modelling, control - command - supervision design, the design of intelligent sensoring system, and related rapid prototyping. A typical toolset for this stage is Matlab/Simulink/Stateflow. It is extremely important that the paradigm which is used by the engineers at this first stage is kept as an entry point of the software system design phase. This is the very basic condition for ensuring a smooth transition from, say, control system engineering, down to software system engineering.

- On the other hand, embedded control systems for the above listed industries already are distributed hard real-time systems. They will remain so, and will become more and more complex. A hard reason for this is the move toward component engineering. Here, by component we mean an intelligent sensor or sensor subsystem, a device with its actuator and controller, a

supervision/protection subsystem, and the like. Thus components are hybrid objects blending hardware devices, local computer system, communication means, and software. Therefore, deployment architectures involve components and communication media, organized into a complex, distributed, real-time system. Here tools and methods used are diverse, they typically involve the direct
programming of tasks and the use of RTOS, and/or the use of hardware or HW/SW co-design tools ; quite often, methods are in-house.

Comparing these two items reveals how large the gap between them is. The associated migration is mainly performed today by using a large variety of tools, based on different and sometimes orthogonal paradigms, together with a cautious design process, sometimes itself subject to certification. A number of progresses have been performed the last decade, many of them originating from the teams of the present action, but specific challenges still remain, they are detailed below.

On the other hand, it is generally recognized that no background curriculum exists today, which is targeted to embedded systems design. Unlike systems theory for control science and engineering, and automata/language theory for software science and engineering, no relevant basic scientific corpus is available today. And this fact is likely to have a major impact on the lack of both a comprehensive view and method of embedded systems engineering, and a corresponding educational curriculum.

9.1.1.2 Action1 - Background

The action will improve awareness of academics and industry and define innovative and relevant work directions, in the area of hard real-time systems. It will try to explore possibilities of integration/exploitation of the following results/technologies developed over the last decade.

- **Synchronous languages.** Synchronous languages can be seen as a formalization of the usual way to design systems, for engineers, in the considered industries. This technology can take place, either in the classical design process in systems engineering (where a de facto standard for scientific engineering is Matlab/Simulink), or in the embedded software as well as hardware design areas. It is thus a natural candidate for codesign approaches.

  - The Lustre group at Verimag (Lustre, plus related technologies for validation) http://www-verimag.imag.fr/SYNCHRONE/lustre-english.html

  - The Esterel/SyncCharts and Signal groups at Inria (plus related technologies for validation).
    - **For Signal, see**
      some references : http://www.irisa.fr/sigma2/benveniste/home.html#Computer
      the Signal group : http://www.irisa.fr/ep-atr/index_english.html
      TNI-Valiosys, Sildex/Signal : http://www.tni.fr/tni/offre/sildex/index.eng.html

    - **For Esterel/SyncCharts see**
      Esterel site : http://www.esterel.org
      INRIA Esterel Tick team : http://www.inria.fr/recherche/equipes/tick.en.html
      I3S SPORTS SyncCharts team : http://www.i3s.unice.fr/~map/WEBSPORTS/
      Esterel Technologies : http://www.esterel-technologies.com/

  - The group of Alberto San Giovanni Vincentelli, with connections to the work on VCC and ECL, which includes synchronous technologies. Refs and links see, http://www.cadence.com/products/vcc.html

- Work at University of Oldenburg and OFFIS on semantic integration of various specification formalisms, including Statemate, Stateflow, Scade, Ascet. See http://ca.informatik.uni-oldenburg.de/publications/publications.html

- **Abstract Interpretation and other abstraction techniques**. Abstract Interpretation well-founded and effective way of extracting reliable information about the run-time behaviour of programs. In addition, we believe that abstracting models in various ways is central, for many purposes, e.g., for evaluating code, for verification, for code generation. Abstract Interpretation has recently emerged as a systematic way to performing this.
The group of the university of Saarland at Saarbrücken (Reinhard Wilhelm) has established skills in abstract interpretation for worst case execution time of embedded programs. See http://rw4.cs.uni-sb.de/research.html and http://rw4.cs.uni-sb.de/bib2html/tfb.html

- **Timed automata and related models for timed behavioural aspects**. This involves models to evaluate designs, given the functional specification, schedulability constraints and resource requirements. When time is an important parameter in control,more powerful models must be considered. This includes variations around timed automata and efficient techniques for model checking, schedulability analysis, schedule and controller synthesis, and generation of code guaranteeing hard time constraints.

  - The work on timed systems and UPPAAL at Uppsala and Aalborg: http://www.docs.uu.se/docs/rtmv/uppaal/andhttp://www.docs.uu.se/astec/ and http://www.cs.auc.dk/research/FS/

  - The technical University of Eindhoven has developed equational techniques to deal with the infinite state aspects of these systems http://www.cwi.nl/~mcrl/mutool.html

  - The Verimag group with the Kronos tool. http://www-verimag.imag.fr/TEMPORISE/kronos/

- **Time-triggered (TT) systems & architectures.** The TT approach puts time in forefront for hard real-time systems design. It states as a credo that the date of a data may be more important than its actual value (the latter may be only "approximate" in some sense). To some extend, TT infrastructures implement the abstract model of synchronous languages, but, in addition, it makes time a distinguished actor, for which special primitives should be considered (unlike in synchronous languages). Today, TT has mainly progressed at the architecture level, with a significant success in the area of field busses and automobile. But work is underway to extend this approach at higher levels of the design process.
The group of Hermann Kopetz, in Wien. http://www.ttpforum.org and http://www.vmars.tuwien.ac.at

- **Fixed Priority Scheduling (FPS) and other scheduling techniques.** While synchronous languages focus on control, and timed automata put emphasis on the combination of control and time, there exists a huge background in the area of scheduling techniques. Among the scheduling techniques, the ones based on fixed priorities are most suited to hard real-time. According to this technology, tasks are viewed as black-boxes (unlike in the previous models) and the quantitative aspects of their interleaved/concurrent/pre-emptive execution is its focus. One can view the previous approaches and models as providing, from functional and architectural information, architectural and scheduling constraints for tasks, which can then be used to design appropriate scheduling. There is a need for the use of scheduling in combination with other models, in the way sketched before.
The group of Alan Burns and Andy Evans at the University of York has an established position in the area of FPS. See http://www.cs.york.ac.uk/rts

- **Real-Time oriented distributed infrastructures, RTOS.** For the deployment phase, some kind of model is required for the execution infrastructure. As stated before, the case of interest for this action is when the infrastructure is distributed. Besides the TT infrastructures which we have highlighted, many infrastructures used in real-time systems are not TT ones, but yet are distributed. Of course, RTOS sometimes belong to this class, and for this reason they are frequently difficult to model and handle formally. But, besides the OS layer, the hardware architecture itself is frequently distributed, just because the underlying plant requires so : sensors/actuators together with their computer systems, may constitute a distributed system per se, regardless of any OS on the top of them. This is what we could call the unavoidable distributed aspects of real-time systems. How to migrate from a specification which abstracts away from this execution infrastructure, to the actual implementation, is a big challenge for real-time systems today (with the exception of the TT approach, in which the conformance of the deployment is guaranteed by the conformance of the execution architecture to the specification model; this has a cost, and therefore alternative approaches are also of interest). Hence handling this as part of our formal comprehensive approach is a major focus of this action. Related studies are quite novel, but some teams of the action have this in their objectives.

  - The groups already invited possess the desired expertise to tackle this aspect too. See in particular http://www.cs.york.ac.uk/rts

  - The Syndex group at Inria (Yves Sorel), who is developing a tool mapping a data-flow synchronous specification or Simulink-like diagram to a distributed DSP type architecture, with involvement in automobiles. See http://www-rocq.inria.fr/syndex/welcome.html

- **Hybrid systems.** This is a hybrid research area, blending people and ideas from control and computer sciences. Its subject is the study of systems that are mixed continuous/discrete, in both time and space. Hybrid systems will not be a central technology within this research action, but we feel that it will be very useful : after all, the plant together with its control and supervision system is in general hybrid, when considered at the early stage of control system engineering. On the other hand, the fine study of how a real-time software behaves when deployed on a distributed, real-time architecture, naturally leads to handling hybrid systems.

  - The Verimag group is a central actor, worldwide, in this area.
    http://www-verimag.imag.fr/VHS/ and http://www-verimag.imag.fr/~tdang/ddt.html

  - The PARADES group of CNR (Sangiovanni-Vincentelli) has established skills in this area.

9.1.1.3 Action1 - Objectives

Most of the above listed technologies have reached a certain degree of maturity today. Tools and methods exist for the more mature ones. However, the entire design process for real-time embedded systems requires the integration of these different technologies. And this seems to be currently a bottleneck. Developing a comprehensive understanding of these different technologies in order to facilitate their integration, is the overall focus of this action. From this, a roadmap for research efforts in this area will be proposed. Also, this will allow us to draw preliminary propositions for what an educational curriculum on embedded systems could be. Confronting ideas with engineers from the target industries will allow this study to remain relevant. From this analysis, the following objectives can be formulated for Action 1, regarding Work Packages 1 (roadmap), 2 (Education), and 4 (Industrial liaison):

- Concerning WP 1, Roadmap, Action 1 will focus on the integration of the different technologies that are used today in the different phases of the design. Effort will be devoted to identifying where the bottlenecks are, and what research should be done to overcome them. Some focused technical work will also support this study.

- Concerning WP 2, Education, Action 1 will assess, together with other actions, the need for a curriculum on real-time embedded systems design, and will contribute to its definition and experimentation.

- Finally, Action 1 will contribute to WP 4, Industrial Liaison, by inquiring at major and representative industries from the sector, about the current bottlenecks and needs in the design of real-time embedded systems.

9.1.2 Action2

9.1.2.1 Action2 - Rationale and challenges

Component based design is perceived to be a key technology for developing advanced real-time systems in a both cost- and time effective manner. Already today, component based design is seen to increase software productivity, by reducing the amount of effort needed to update and maintain systems, by packaging solutions for re-use, and easing distribution. Ideally, application development could follow a "drop & glue" approach, picking components from a library incorporating the intellectual property of the system house as well as standardized components, giving to the system developer a range of re-usable components supporting all layers of a system architecture, with only little "glue" e.g. in the form of wrappers and specialization required to combine the "dropped" components to a system implementation. Re-use across multiple implementation platforms is further enhanced by separating functional modeling from deployment architectures, as suggested by the OMG´s Model-Driven Architecture approach.

A key motivation for this action is to enhance component technology to fully support the life cycle of advanced real-time systems, striving to reach the same level of maturity as engineering disciplines in building systems from components. Given the perceived range of advanced real-time systems as outlined in the introduction, the step from today's component technology to reach the key objective of this action is immense. Let us look into particular application domains to highlight the challenges.

Within **automotive industry**, the recent mergers have further multiplied the number of platforms to be supported by car manufacturers. A vision for system development is that key functional "ingredients" of electronic control units (ECUs), sometimes called atoms or features, will be kept and maintained in a proprietary design repository, allowing model- and platform based variations to be constructed from such atoms using the above mentioned "drop & glue" approach. To support such a vision, component models must carry information for all system development processes: the system- design and possibly safety analysis process, for production and for maintenance. Let us consider concrete examples. To support power-management, component models must explicate operation modes which allow the system to be deactivated. To transition from an application independent model to deployment on a concrete network of ECUs, memory/CPU/bandwidth requirements of components must be known. Interfaces for diagnostic processes both integration testing, manufacturing, and maintenance must be visible. To support safety- analysis, component failure modes and failure rates must be accessible. These sample question highlight the need to maintain with each component an (application-specific) range of viewpoints, which jointly cover the life cycle of automotive applications. The elaboration of such an approach is further complicated by the need to support not only distributed development across multiple sites, but also various forms of interplay between manufactures and supplier companies, in particular allowing the integration of "atoms" from multiple sources (e.g. multiple suppliers) while protecting their IP. The need to ensure non-interference of such atoms when coming from multiple suppliers is obvious, taking into account legal issues such as liability. Hence strong encapsulation and rigid measures to assure this are a must in supporting component based design in this domain. It should be pointed that current industrial practice is far from this vision. We only begin to see today deployment of model-based development processes, and current methods and tool support are available for single ECU based implementations only. However, already the next generation development tools supporting distributed applications are in the pipeline, and companies are analysing library based approaches.

The challenge for the **telecommunication domain** for the future is to enable the ubiquitous "anything, anytime, anywhere" concept. It means that a service should be seen for an end user as a black box respecting functional and non functional (Quality of Service)
properties (or goals) independently of the underlying architecture. For that, we need innovative and consistent development methodology from high level specification towards design. Telecommunication applications, and similarly, new concepts such as VHE (Virtual Home Environment), are built from a set of service or service features (high level component), which could be new features but also existing features. Formal validation is necessary to obtain a consistent composition of such distributed components respecting their interface specification but also their properties as specified on the system view (user view for example). Real time aspects (performances for example) is also a critical problem, in particular, for the next mobile generation (UMTS), where quality of service is the subject of negotiation between the user terminal and the core network.

In **factory automation** the process of transformation from building monolith proprietary systems to component-based systems is already active several years. The process started from componentisation of applications in common platforms and additional components using software product-line approach. The second step, ongoing today, is decomposition of basic platform and further decomposition of different applications, using new component-based technologies, and mixing in-house developed components with COTS. These trends come from market requirements (reduced time-to-market, flexibility, lower development costs, and in the same time increase of Quality of Services, managing much larger amount of information, and finally integration with information and application from other domains). To be able to meet these requirements the automation industry is focusing on core-business, outsourcing, the reuse of components and buying COTS. However, there are many problems related to this approach that still remain to be solved, valid for component-based development in general and in particular in process automation (component technology, development processes, understanding system complexity, reliability of COTS and component-based systems, maintainability, flexibility, ability for integration, predictability of integration, trusted components etc.). A typical challenge of industrial process automation is integration. We can distinguish between vertical integration in which data and processes at different process levels are integrated, and horizontal integration in which similar types of data and processes from different domains are integrated. Typical examples of vertical and horizontal integration can be found in industrial process automation. At the lowest levels of management (Field Management), data collected from the process and controlled directly, is integrated on the plant level (Process Management), then is further processed for analysis and combination with data provided from the market and finally published on the Web (Business Management). To successfully obtain integration of different type of data and different type of application the integration process, as a part of the development process, must be seamless, reliable and predictive. Predictive integration is a challenge for itself. The main question of a predictive integration is if it is possible to predict the behaviour of component compositions from known behaviour of components (is. known functional and non-functional attributes). Automation industry is very well aware of advantages of component-based development approach, but also about the disadvantages. In many cases industry does not have solutions and is interested in finding them in collaboration with research.

There is a range of technical problems and issues that must be resolved in order to address the application challenges outline in the previous section. Technical problem areas the need to be addressed include:

- *Life-cycle-complete component models*

The identification and characterization of a set of component viewpoints supporting the full life cycle of components, and covering different viewpoints such as timing, use of resources, interface specifications, failure models. It also includes demonstrators of such component models for selected application domains, including automotive and telecom.

- *Verification and Validation*

Verification and validation of viewpoints across design steps against requirements. The challenge here is for component based V&V.

- *Component integration technology*

Technology to (automatically) propagate the impact across a component configuration across all viewpoints. To check consistency of viewpoints of a component configuration, analysing potential interferences between conflicting viewpoints.

- *Intelligent middleware*

Encapsulating target architecture, providing services supporting all viewpoints in making intelligent decisions for deployment architectures;
Optimising the various cost-functions related to viewpoints;
Providing strong encapsulation between safety- and non-safety related parts of the system; Supporting mix of soft- and hard real-time constraints.

- *Synthesis and Deployment*

Such as knowledge based component retrieval based on requirement specifications. Automatic "glue" synthesis. Automatic construction of deployment architectures. Architectural patterns.

9.1.2.2 Action2- Objectives

Current technology and standards for component based development, such as COM, CORBA, etc, give **syntactic** support for component based development, e.g., by specifying calling conventions for procedures. However, success of the component based development paradigm for real time systems will require technology that extends this support to the **semantic** level, handling aspects such as services, interfaces, protocols, timing, resource utilization, failure models, etc., in particular for real time systems. Developing a comprehensive understanding of the state-of-the-art of the area, current and future needs, and potential of candidate technologies is the overall focus of this action. From this, a roadmap for research efforts in this area will be proposed. Also, this will allow us to contribute to the development of a candidate educational curriculum by material that is specific to component based development of real time systems, an other issues that arise in the effort. Finally, for the industrial impact of the action, it is instrumental to establish close interaction with the work on emerging and new standards, such as promoted by the OMG.

From this analysis, the following objectives can be formulated for Action 2, regarding Work Packages 1 (roadmap), 2 (Education), and 4 (Industrial liaison):

Concerning WP 1, Roadmap, Action 2 will integrate assessment of the state-of-the-art on component-based development for real-time systems, findings about industrial practice and needs, and evaluation of candidate technologies, in order to define a roadmap for future research efforts in the area.

Concerning WP 2, Education, Action 2 will assess, together with other actions, contribute to its definition and experimentation, and also contribute material specific to component based development

Finally, Action 2 will contribute to WP 4, Industrial Liaison, by assessing relevant ongoing work on standardization concerning component technology for real time systems, with the aim to influence future standardization work.

9.1.3 Action3

9.1.3.1 Action3 - Rationale and challenges

An increasing number of real-time applications, related to multimedia and adaptive control systems, require greater flexibility than classical real-time theory usually permits.

For critical control applications (i.e., those whose failure may cause catastrophic consequences), the feasibility of the schedule has to be guaranteed a priori and no parameter can be changed on line, while the system is running. Although this is a reasonable assumption for hard real-time control systems, it can be too restrictive for other applications, limiting flexibility and efficiency in exploiting the available computational resources.

For example, in multimedia systems timing constraints can be more flexible and dynamic than control theory usually permits. Activities such as voice sampling, image acquisition, sound generation, data compression, and video playing, are performed periodically, but their execution rates are not as rigid as in control applications. Missing a deadline while displaying an MPEG video may decrease the quality of service (QoS), but does not cause critical system faults. Depending on the requested QoS, tasks may increase or decrease their execution rate to accommodate the requirements of other concurrent activities.

If a multimedia task manages compressed frames, the time for coding/decoding each frame can vary significantly, hence the worst-case execution time (WCET) of the task can be much bigger than its mean execution time. Since hard real-time tasks are guaranteed based on their WCET (and not based on mean execution times), multimedia activities can cause a waste of the CPU resource, if treated as ``rigid'' hard real-time tasks.

In other situations, varying tasks' parameters gives the possibility of handling overload conditions, providing a more general admission control mechanism. For example, whenever a new task cannot be guaranteed by the system instead of rejecting the task, the system can try to reduce the utilizations of the other tasks (by increasing their periods in a controlled fashion) to decrease the total load and accommodate the new request.

The challenging problem: Unfortunately, there is no uniform approach in the current real-time literature for dealing with the situations illustrated above. For such a reason, the objective of this action is to identify the key features for developing flexible real-time kernels that can exhibit adaptability, predictability and efficiency in supporting soft real-time applications with Quality-of-Service requirements. Several domains will benefit from the results of this action, including multimedia systems, soft real-time control applications, virtual reality and graphic applications.

9.1.3.2 Action3 - Objectives

In order to support such applications, the following key issues will be addressed during the proposed initiative.

- "Flexibility". This means having the possibility to specify different types of timing constraints or task models, and select different algorithms for task scheduling and resource management. Flexibility also means capability to deal with not fully specified activities (e.g., aperiodic tasks with unknown arrival time and/or computation time).

- "QoS control". This means identifying task models to describe QoS requirements and kernel mechanisms able to provide guarantee for the specified requirements.

- "Adaptability". This is crucial to support applications with unknown and variable computational load. This will address methods for estimating the current load in order to change operating system policies to conform with a given situation.

- "Efficiency". This feature is important for greedy or optimal exploitation of the available resources in applications with high computational requirements, as well as for reducing the cost in the case of embedded systems.

- "Composability". This issue will investigate methods for achieving modular and composable kernels. This is useful for configuring a system based on application requirements and for developing applications independently from kernel mechanisms.

To receive feedback from a different environment, a number of industrial and university groups have been identified as external consultant and will be invited to the meetings whenever possible. They are identified as associated members in the partner description part. Their contribution is important to discover new research directions and focus on specific problems closer to the industrial world.

From this analysis, the following objectives can be formulated for Action 3, regarding Work Packages 1 (roadmap), 2 (Education), and 4 (Industrial liaison):

- Concerning WP 1, Roadmap, Action 3 will focus on the integration of the different technologies that are used today in the different phases of the design. Effort will be devoted to identifying where the bottlenecks are, and what research should be done to overcome them. Some focused technical work will also support this study.

- Concerning WP 2, Education, Action 3 will assess, together with the other actions, the need for a curriculum on real-time embedded systems design, and will contribute to its definition and experimentation.
- Concerning WP3, Dissemination, Action 3 will present the results of the project to leading conferences and journals on real-time systems. Moreover, it will establish collaborations with US teams and projects related to the field of soft real-time computing.
- Finally, Action 3 will contribute to WP 4, Industrial Liaison, by interacting with a set of representative industries working in the field, about the current bottlenecks and needs in the development of soft real-time applications operating in highly dynamic environments.

9.2 Workpackage list

The workplan will be structured in the following workpackages:

WP0: Management
WP1: Roadmap
WP2: Education and training
WP3: Dissemination
WP4: Industrial liaison

Each action will contribute to the workpackages 1,2,3 and 4.

Work-package No	Workpackage title	Lead contractor No	Person-months	Start months	End month	Phase	Deliverable No
WP0	Management	1	31.6	0	36		W0.A0.Y1 W0.A0.Y2 W0.A0.Y3
WP1	Roadmap	2	157.2	0	36		W1.A1.N1.Y1 W1.A1.N1.Y2 W1.A1.N2.Y2 W1.A1.N1.Y3 W1.A1.N2.Y3 W1.A2.N1.Y1 W1.A2.Y2 W1.A2.Y3 W1.A3.N1.Y1 W1.A3.N1.Y2 W1.A3.N2.Y3
WP2	Education and training	1	78.6	0	36		W2.All.Y1 W2.All.Y2 W2.All.Y3
WP3	Dissemination	16	27.6	0	36		W3.All.N1Y1 W3.All.N2Y1 W3.All.N1Y2 W3.All.N2Y2 W3.All.N1Y3 W3.All.N2Y3
WP4	Industrial liaison	4	78.6	0	36		W4.A1.Y1 W4.A1.Y2 W4.A1.Y3 W4.A2.Y1 W4.A2.Y2 W4.A2.Y3 W4.A3.N1.Y1 W4.A3.N2.Y2 W4.A3.N3.Y3
	TOTAL		373.6				

A more detailed breakdown of the effort per workpackage and partner is given in the table below:

	Total n° of person months	WP 0	WP 1	WP 2	WP 3	WP 4
CO 1 UJF / VERIMAG	20,8		10,4	5,2		5,2
CO 1 Co-ordination	40,5	31,6			8,9	
CR 2 INRIA	28,1		12,2	6,1	3,7	6,1
CR 3 TU Vienna	11,3		5,6	2,8		2,8
CR 4 UU	27,0		10,7	5,4	5,6	5,4
CR 5 UdS	11,3		5,6	2,8		2,8
CR 6 PARADES	6,8		3,4	1,7		1,7
CR 7 OFFIS	21,8		10,9	5,4		5,4
CR 8 AAU	27,0		13,5	6,7		6,7
CR 9 TU/e	15,8		7,9	3,9		3,9
CR 10 YORK	13,4		6,7	3,4		3,4
CR 11 CEA	7,0		3,5	1,8		1,8
CR 12 ULANC	5,1		2,6	1,3		1,3
CR 13 ENS Cachan	18,0		9,0	4,5		4,5
CR 14 UT	9,8		4,9	2,4		2,4
CR 15 MDH	10,0		5,0	2,5		2,5
CR 16 UNIPV	10,3		0,5	0,2	9,4	0,2
CR 17 SSSA	9,8		4,9	2,4		2,4
CR 18 UNICAN	12,0		6,0	3,0		3,0
CR 19 UAVR	21,0		10,5	5,3		5,3
CR 20 UPC	10,2		5,1	2,6		2,6
CR 21 FFCUL	5,0		2,5	1,3		1,3
CR 22 UC3M	31,7		15,8	7,9		7,9
CR 23 CNRS / VERIMAG	0,0					
CR 24 INPG / VERIMAG	0,0					

TOTALS	WP 0	WP 1	WP 2	WP 3	WP 4	
	31,6	157,2	78,6	27,6	78,6	**373,6**

9.3 Workpackage descriptions

Below we describe the contribution of Actions to the different WP's. The following coding is applied to denote tasks: TaskWx.Ay represents a task of Workpackage x performed by Action y. If the TaskWx.Ay has many subtasks they are denoted by their Number z : TaskWx.Ay.Nz.

The values of x and y can range from 0 to 4 where A0 denotes the action of the Coordinator. We write Task.Wx.All to denote a task performed by all partners.

9.3.0 WP0: Management

This workpackage consists of TaskW0.A0 performed by the Project Coordinator (see 9.7 Management):

The purpose of this task is the coordination of the actions so as to ensure the overall coherency of the project and make the synthesis of the results and findings. This will be achieved by:

- Continuous monitoring, interaction with action coordinators and participation in meetings organized by the actions.

- Organization of the annual ARTIST gathering (see 9.7 Management):.

Project reviews will take place at T0+12, T0+24, T0+36 months . A workshop is organized with invited participants for dissemination and evaluation purposes. The workshop could be a part of the review (reviewers attend the workshop) which can be completed with a closed review meeting.

Exceptionally, the first workshop will be organized October 10-11, 2001 right after the EMSOFT meeting in Grenoble. The workshop will be an opportunity to refine objectives and bring modifications to the Technical Annex, if necessary.

9.3.1 WP1: Roadmap

Measures of success

The following criteria will be applied to measure success of this work package:

- Publication of reports in journals, magazines and conference proceedings presenting assessment of the state of the art in Europe or worldwide and dissemination of roadmap work

- Definition and launching of new and innovative projects contributing to work directions identified by the published roadmap work

- Adoption by industry of the recommended technological solutions, techniques and standards

Action1 – TaskW1.A1

The contribution of Action 1 to WP1 will be twofold.

Task W1.A1.N1

Action 1 will assess the state-of-the-art in Hard Real-Time Systems. Since the area is very broad, it will be worth focusing on one particular aspect, which has been recognized to be a bottleneck, namely*: the difficulties related to the combination of different notations, formalisms, and methods, throughout the different phases of the design*. This contribution will rely on the following other activities of Action 1:

- Knowledge from Action 1 partners will help us with identifying more precisely where the bottlenecks are, in order to achieve integration of different notations, formalisms, and methods,.

- The work of WP4 on industrial liaison will help establish a firmer basis for effective, realistic and coherent streamlining.

- Finally, to avoid proposing ad hoc solutions, it will be important to start some technical joint research, in order to explore what integration and/or streamlining are feasible and interesting from a practical point of view.

The coordinator of this task is Albert Benveniste.

Task W1.A1.N2

Action 1 will make inroads to more technical work in support of the preceding task. This will consist of joint and coordinated research on the development of a comprehensive mathematical approach to establish foundations of this area, i.e., a ``Uniform Mathematical Language'' for the embedded systems area, with emphasis on hard real-time aspects.

The coordinator of this task will be Alberto Sangiovanni-Vincentelli (PARADES).

To substantiate this objective, let us mention some existing efforts and results toward this direction, from several teams of this action:

- The group of Paul Caspi, at Verimag has developed a new theory of so-called quasi-synchronous approach, to analyze how synchronous programs can be distributed on a real-time, loosely synchronous architecture, without the need for any explicit synchronization.

- The group of Paul Le Guernic and Albert Benveniste, at Irisa, has developed a new paradigm of de-synchronisation, to study the preservation of the synchronous semantics under asynchronous, distributed deployment.

- The group of Alberto Sangiovanni-Vincentelli, in connection with the University of California at Berkeley, participates to the globalisation efforts of the Ptolemy group, see http://www.ptolemy.eecs.berkeley.edu/.

Action2 – TaskW1.A2

TaskW1.A 2. N1. Component Models

Component modelling is a key ingredient in development processes, deployment technology, tool support, etc. and must be considered from a variety of points of view. This task will assess the state-of-the-art with respect to component models in Real Time systems. The assessment will cover needs, existing technology and usage from a variety of points of view, to form a roadmap for future research efforts. Aspects that will be considered include the following.

- Requirements and desiderata on life-cycle complete component models that arise or will arise in component-based development processes in selected application domains. Input will be obtained from Task W4.A1. (interviews with industrials) and from the associated industrialists that are invited at ARTIST meetings. Application areas that will be considered include automotive applications, telecommunications applications, and factory automation.

- The current state-of-the-art on component models with respect to different relevant viewpoints, including functional, interface and timing aspects, Quality of Service, reliability, and resource utilization. Candidate formalisms and technology for formalization of these viewpoints will be assessed.

- Relevant characteristics of component technology that is successfully employed in other technological areas, such as ASIC design.

- Input from WP 4.2, which will review the current efforts of relevant standardisation efforts within OMG and industry.

Coordinator of Task W1.A 2. N1: Jean-Marc Jezequel, IRISA

Task W1.A2. N2. Component Integration, together with Verification and Validation

This task deals with issues guaranteeing correct functioning of an assembly of components. This involves checking that components behave as expected, interact properly, and that once assembled important properties are preserved. This task will assess the state-of-the-art, taking into account results of Task W1.A2.N1. Aspects under consideration are.

- Impact from selected application-specific architectural patterns, on the requirements on inter-working between components.

- Assessment of needs and candidate technology for verification of a component against its specification, across the viewpoints mentioned in the description of Task W1.A2.N1. Technology that will be considered includes testing and formal verification.

- Assessment of needs, candidate technology, and tool support for checking consistency of particular component assemblies. This includes compositional verification and testing of components assemblies, checking consistency between component interfaces, and analysing potential interferences between conflicting requirements.

- Assessment of needs and candidate technology for predicting non-functional properties of component assemblies, such as resource and timing properties.

Coordinator of W1.A2. N2: Ed Brinksma, U. of Twente

Task W1.A2. N3. Soft Real Time

This task will investigate the problem of specifying and reasoning about flexible timing constraints in the framework of component-based development. Such constraints are important in a variety of applications, including telecom, multimedia, and control applications. The task will strongly use the activities of Task W1.A1.N2 on finding a framework for the modelling hard real time properties, and the activities of TaskW1.A3.N1 on "Flexible timing models for QoS specification".

Issues that will be considered include

- Assessment of needs and candidate technology for formulation of soft real time properties of components, and their use for reasoning about QoS properties of component assemblies.

- Assessment of needs and candidate technology for combination of hard and soft real-time requirements.

Coordinator of TaskW1.A2.N3: Gordon Blair, Lancaster U.

Action 3 – TaskW1.A3

The contribution of action 3 in WP1 consists of two phases. In the first phase, a number of soft real-time applications will be characterized to identify the open problems that need to be addressed at the kernel level to achieve a proper QoS management. In the second phase, a set of kernel mechanisms and algorithms will be selected among those proposed in the real-time literature which can provide efficient support to the considered applications.

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Task W1.A3.N1 Flexible timing models for QoS specification

This task will investigate the problem of specifying flexible timing constraints to support different types of soft real-time applications with quality of service requirements. In particular, the task will focus on computational activities with dynamic behaviour, variable computation time and unknown arrival patterns.
Another important objective of this task is to define a computational timing model based on user-level specifications for quality of service issues, applicable to multimedia and control systems.

A number of real-time applications with soft real-time requirements will be considered as examples to identify the open problems that need to be addressed at kernel level to achieve a proper QoS management. Each application task will be characterized in terms of criticality, computational demand, activation constraints, resource requirements, and performance requirements. Application domains will include multimedia computing, robotics, and wireless distributed systems.

A tight interaction with all the partners is essential in this phase to identify the parameters to be included in the computational model in order to capture the most important timing requirements and QoS characteristics of the applications.

To receive feedback from a different environment, a number of industrial companies and leading university groups from the United States have been identified as external consultants (see the associated members in the partner description part) and will be invited to the meetings whenever possible. Their contribution is important to discover new research directions, identify possible bottlenecks and focus on specific problems closer to the industrial world.

The expertise among the partners participating to the workpackage is balanced and well distributed to cover the most relevant aspects of the problem. In fact, the group of Alan Burns at University of York has a long experience in fixed priority systems, while the group of Giuseppe Lipari at the

Scuola S. Anna of Pisa leads the research on dynamic and flexible scheduling algorithms. The group of Gerhard Fohler at Malardalen University is already investigating new flexible timing models and the group Josep Fuertes in Catalonia is studying real-time control techniques for QoS management.

TaskW1.A3.N1 will be coordinated by Giuseppe Lipari from the RETIS Laboratory of the Scuola Superiore S. Anna of Pisa, Italy. An important contribution for the modelling activity will also come from Malardalen University, who developed flexible timing models for real-time applications, the group at University of Aveiro and the University of Pavia, which are both involved in soft real-time robotic applications. The group in Aveiro has also great expertise in distribute systems and field bus networks for industrial environment. Finally, the group of Paulo Verissimo, expert in dependable distributed systems, will contribute to this task to take fault-tolerant features into account.

Task W1.A3N.2 Adaptive kernel mechanisms

This task will select among the existing literature those mechanisms and algorithms suitable for supporting flexible computational activities with QoS specifications. In particular, the following issues will be considered:

- **Efficient aperiodic service**. This is motivated by the observation that many modern real-time applications run in dynamic environments where several external events may generate significant aperiodic load that must be handled efficiently but without jeopardizing the QoS guarantee performed on the periodic task set.

  Partners involved include University of York, University of Pavia, Malardalen University, and University of Aveiro.

- **Resource reservation**. Whenever a minimum level of performance has to be guaranteed off-line, the system should allow computational resources to be partitioned among tasks, so that each task can get a fraction of the available resources based on their requirements.

  Partners involved include Scuola Superiore S. Anna, University of York, Univ. of Pavia.

- **Temporal isolation**. When task computation times and arrival times may vary from instance to instance and cannot be predicted in advance, the system should guarantee that a misbehaving task with high priority do not steal time and resources allocated to other tasks.

  Partners involved: Scuola Superiore S. Anna.

- **Resource reclaiming**. Whenever a reserved resource is not fully used by a computational activity, a reclaiming mechanism should make the resource available to the other activities to increase average resource usage. This is especially important when dealing with tasks with highly variable computation times.

  Partners involved: Scuola Superiore S. Anna, University of York, Univ. of Pavia.

- **Overload and QoS management**. To increase efficiency in resources usage, soft real-time systems are not designed to work under worst-case scenarios, hence a transient overload can easily occur and must be managed properly to control the QoS in a predictable fashion.

  Partners involved: University of Catalonia, University of York.

- **Adaptation**. If environmental conditions change significantly or the system was designed based on wrong parameter estimates, the system should be able to adapt to the new conditions using some feedback signal constructed by monitoring task execution or other appropriate variables.

Partners involved: University of York, University of Lisboa, Scuola Superiore S. Anna, Univ. of Aveiro.

- **Composability**. This issue will focus on methods for achieving modular and composable kernels that can be configured dynamically, based on the actual application requirements.

  Partners involved: University of Cantabria, INRIA, Univ. of Madrid, Scuola S. Anna of Pisa.

Task W1.A3.N2 will be coordinated by Giorgio Buttazzo from University of Pavia, Italy.
Important contributions to this task will come from the group of Giuseppe Lipari at the Scuola S. Anna of Pisa, who already developed a number of modular real-time kernels for embedded and multimedia applications (see http://gandalf.sssup.it/).

Other essential contributions will come from the group of Michael Harbour at University of Cantabria, who already developed a modular embedded real-time kernel, called MARTE (see http://ctrpc17.ctr.unican.es/), from Jean-Bernard Stefani at INRIA, expert in component-based distributed OS technology, and the group of Carlos Delgado Kloos at Univ. of Madrid, expert on QoS control and middleware.

9.3.2 WP2: Education and training

This workpackage consists of TaskW2.All performed by all the partners.

Measures of success WP2

Success will be assessed by means of the following:

- Acceptance of the proposed curricula on embedded systems in European Universities or Technical Schools, by the end of the project.
- Positive reviews on the adequacy of the curricula to meet industrial needs, from European companies.

TaskW2.All

Embedded systems are a key area in Information Technology, for the future of Europe.
There is exists no educational curriculum today, which has embedded systems in its core focus. This fact has also been recognized in the USA. However, the EECS (Electrical Engineering and Computer Science) department of the University of California at Berkeley (US partner of ARTIST project) is currently launching such a curriculum.

The WP Educational Programme of ARTIST aims:

- to assess the need for such an educational programme, on a European basis,
- to prepare a draft proposal for such a curriculum, in case it is recognized useful.

To achieve the above aims, the following approach will be used. Based on knowledge and experience internal to the ARTIST project, and on educational programmes emerging elsewhere, a first proposal for such a curriculum will be drafted. This draft proposal will be used as an annex to a questionnaire, to be sent to a sample of people from representative industries, having significant influence on the definition of the profile of newly hired persons. Feedback from this questionnaire will be then analysed. Based on this analysis,

- the usefulness of a curriculum devoted to embedded systems will be assessed,

- the (order of magnitude of the) number of needed graduated students, for Europe, will be estimated, and

- updates of the curriculum itself will be made.

A major difficulty will consist in finding a representative list of qualified persons to respond to the questionnaire. We need to make sure that answers will not be biased. To facilitate this part of the work, *we will ask the commission for a letter expressing support for the questionnaire.*

Each action will contribute to the definition of the Curriculum in its respective area and has appointed the responsibles for the coordination of work:

Action1: Florence Maraninchi and Paul Caspi, Verimag
Action2: Ivica Crnkovic, MdH
Action3: Giuseppe Lipari , Scuola Superiore S. Anna of Pisa

Verimag is responsible for this task. The list of the other contributors is:

- INRIA: Robert de Simone Robert.De_Simone@sophia.inria.fr, Partice Quinton Patrice.Quinton@irisa.fr
- Technische Universitat Wien: Gunther Bauer, bauer@vmars.tuwien.ac.at
- Department of Computer Systems at Uppsala University: Wang Yi
- Fachrichtung Informatik, Universität des Saarlandes Im Stadtwald: Joern Schneider
- PARADES: Alberto Sangiovanni-Vincentelli, and Luciano Lavagno
- OFFIS R&D Division of Embedded Systems: Ernst Ruediger Olderog
- Department of Computer Science, Aalborg University: Anders P. Ravn, Arne Skou
- Eindhoven University of Technology: Jos C. M. Baeten
- Department of Computer Science, University of York: Alan Burns (burns@cs.york.ac.uk)

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9.3.3 WP3: Dissemination and International Collaboration

The workpackage is composed of two tasks: TaskW3.All.N1 on Dissemination and TaskW3.All.N2 on International Collaboration. All the partners contribute by participation to dissemination events. Nevertheless, the tasks are mainly performed by action coordinators and the project coordinator that have extra resources for this purpose (see Costs).

Measures of success WP3

For the general dissemination work the success criteria are listed below, in TaskW3.All.N1. For International Collaboration, success will be assessed by means of the following:

- Increase of awareness of the state of the art in Europe in the area of real-time software and systems as attested to by visits of outstanding experts from the US and their participation in project meetings.

- Participation of project partners in joint technical meetings with US teams or US funding agencies for the definition of strategic work directions in real-time R&D

- Definition and launching of coordinated and if possible, joint projects with US teams.

Dissemination - TaskW3.All.N1

Dissemination will be addressed through:

- Broad based publicity through the ARTIST WWW site, through links from the Home Pages of the partners involved, and through contacts with other major web sites dedicated to the subject.

- Targeted efforts will be made to link with similar projects that are already endorsed by the EC or are currently in the planning stages.

- Continuous interaction with standardization consortia at OMG, ITU or elsewhere in Europe.

- Advertising inserts in related publications, presentation of results at international fairs and conferences on UML and embedded systems

- Publication of professional and scientific papers in the appropriate journals.

- Participation at and organization of international conferences, of the domain: ARTIST will be actively involved in the organization of the EMSOFT workshops. The first EMSOFT workshop took place in October 2001 in Tahoe City. It has been sponsored by DARPA and NSF. It has been a very important event in the area as it gathered together for the first time more than 100 specialists. EMSOFT will be organized in October 2002 by VERIMAG in Grenoble.

Events for disseminating and advertising ARTIST results can be co-located with the following conferences: Emsoft, FemSys, FTRTFT, Workshop on Synchronous Languages, IEEE Real-Time Systems Symposium, IEEE Real-Time Applications Symposium, Euromicro Conference on Real-Time Systems, Real-Time Computing Systems and Applications, Concur.

International Collaboration - TaskW3.All.N2

An important activity is International collaboration with outstanding US teams in the area. We plan to organize joint workshops, such as EMSOFT, and technical meetings. A part of the Management budget (see Costs) will be used for the organization of such events and also for the invitation of US experts in ARTIST meetings.

The ARTIST partners have already well established collaborations with the most outstanding US teams and projects in the area of real-time. The collaboration will be established by organizing joint meetings between ARTIST actions and US projects or teams and/or by inviting US academic or industrial experts to ARTIST meetings.
The result with the collaboration will be awareness of the state-of-the-art and the emergence of joint projects whenever it is feasible and appropriate.

This is an indicative list of projects and teams with which collaboration is sought.

University of California at Berkeley
Team its director and senior researchers: Embedded Systems Laboratory, professors Tom Henzinger, Edward Lee, Shankar Sastry
Topic of interest : Development of embedded real-time systems, involved in the Mobies DARPA project http://www.rl.af.mil/tech/programs/MoBIES/.

Carnegie Mellon Software Engineering Institute
Predictable Assembly from Certifiable Components (PACC),
Dr. Kurt Wallnau, http://www.sei.cmu.edu/pacc/.

University of California Irvine, Dept. of Information and Computer Science
Prof. André van der Hoek, http://www1.ics.uci.edu/~andre/
Topics of interest: Software Architectures, Components, Configuration Management
DARPA & NSF projects:
- DASADA (DARPA) http://www.if.afrl.af.mil/tech/programs/dasada/.
- CAREER (NSF) http://www.nsf.gov/home/crssprgm/career/start.htm

University of Virginia, Dept. of Computer Science, Laboratory for Next Generation Real-Time Computing
Prof. John Stankovic, http://www.cs.virginia.edu/~stankovic/rts.html
Topic of interest: Component Based Embedded Systems: Design and Analysis

University of Illinois
Expertize: Software fault-tolerance
Contact: Lui Sha
Email: lrs@uiuc.edu
URL: http://www.cs.uiuc.edu/contacts/faculty/sha.html

University of North Carolina at Chapel Hill
Expertize: QoS control in multimedia systems
Contact: Kevin Jeffay
Email: jeffay@cs.unc.edu
URL:http://www.cs.unc.edu/~jeffay/

Computer Science Department of Columbia University at New York city
Stephen Edwards, http://www.cs.columbia.edu/~sedwards/

9.3.4 WP4: Industrial liaison

Measures of success

For this workpackage the following measures of success will be applied:

- Acceptance for publication of the overviews about the strengths and weaknesses of European industry in real-time technologies
- The influence and impact of our work on the definition of evolving standards
- Adoption by industry of project recommendations and conclusions, specifically concerning appropriateness of solutions for improving quality and cost effectiveness. This can be measured by the use of recommended new techniques and technologies as well as the increase in awareness about them.

- The emergence of innovative projects to overcome identified difficulties and obstacles or to improve existing technology, as recommended.

Action1 – TaskW4.A1

The aim is to analyse the industrial needs and the current bottlenecks in the industrial development of real-time embedded systems. Analysis will be performed on data collected by inquiring at major and representative industries using real-time systems technologies in order to,

- identify strengths/weaknesses of systems developers industries, in the technical areas considered in project, identify bottlenecks and missing items;
- identify strengths/weaknesses of R&D and tool/methods vendors, with respect to the above recognised bottlenecks and missing items;
- integrate findings and conclusions of this analysis in the ARTIST roadmap.

To achieve this goal, we will establish a questionnaire in collaboration with the associated industrial partners and other selected representatives from industry. The questionnaire will then be analysed and the analysis results will be published.
Given the inherent methodological and other difficulties to achieve the goal, the task will go on three years. We will take a pragmatic approach. Starting from an initial questionnaire addressed to a sample of industrialists we will refine and target the polling process as fast as our knowledge is enriched. In this process, we plan to interview selected representatives from industry who have operational responsibilities. Such interview work has already been carried out by Albert Benveniste in the early nineties, in the framework of the IFAC Committee on Theory. Results of and conclusions from these interviews have been published in:

K.J. Aström, A. Benveniste, P.E. Caines, G. Cohen, L. Ljung, and P. Varaiya. Facing the challenge of computer science in the industrial applications of control. IEEE Control Systems Magazine, II(4), 86-94, Jun 1991, see http://www.irisa.fr/sigma2/benveniste/ARTIST/industry_meetings_1991_Benveniste.pdf for a subset of these reports.

Each action will contribute to the task in its respective area . The responsible for the task is Jan Tretmans, University of Twente. The contributors are:

Responsible: Jan Tretmans, from University of Twente

- INRIA: Albert Benveniste
- VERIMAG: Bruno Bouyssounouse Bruno.Bouyssounouse@imag.fr
- Technische Universitat Wien: Hermann Kopetz
- Department of Computer Systems at Uppsala University: Wang Yi
- Fachrichtung Informatik, Universität des Saarlandes Im Stadtwald: Joern Schneider
- PARADES: Luciano Lavagno and Alberto Sangiovanni-Vincentelli
- OFFIS R&D Division of Embedded Systems: Bernhard Josko
- Deparment of Computer Science, Aalborg University: Kim Guldstrand Larsen, Brian Nielsen
- Eindhoven University of Technology: Jos C. M. Baeten
- Department of Computer Science, University of York: Andy Evans

Action2 – TaskW4.A2

This task will assess relevant ongoing work on standardization concerning component technology for real time systems, with the aim to influence future standardization work. The activities of the task include.

- Attending working groups on components and real-time systems at the OMG and at ITU in order to gain detailed information on the current status of relevant standardisation efforts.

- Assessment of the work being carried out on the semantics of these standards and contribution to the debate about their future. In particular, we will relate the work by various groups to define a precise semantics for version 2.0 of UML. The definition of UML 2.0 will provide an important baseline from which to define the semantics of future UML profiles relating to components.

- Input will be considered from Task W1.A2 concerning application needs in component based development, and candidate technologies.

Coordinator of TaskW4.A2: Andy Evans, York.

Action3 – TaskW4.A3

To provide a contribution of industrial relevance, a number of companies and external consultants have been identified, which operate in the field of real-time embedded systems, multimedia applications and wireless distributed computing. The set of industrial affiliates may also be enlarged during the project depending on the specific needs. Representatives from these groups will be invited to participate at the meetings organized for Action 3 based on their knowledge and experience. In the case in which a company is not able to attend the meeting, we evaluate the possibility to send one or two members of the consortium to the company for an interview. The industrial cooperation should help in achieving the following objectives:

- identifying strengths and weaknesses of existing real-time kernels used for the implementation of soft real-time applications in highly dynamic environments and with variable execution times;

- identifying strengths and weaknesses of existing real-time tools used in the development of soft real-time applications;

- taking advantage of the previous analysis for affecting (i.e., extending and/or modifying) existing standards for defining the operating system interface (e.g. RT-POSIX).

Task W4.A3.N1

A specific questionnaire will be produced to interview the industrial affiliates in order to identify the problems existing today, at the operating system level, in the implementation of real-time applications with soft real-time constraints and variable execution times.

Task W4.A3.N2

Interaction with the companies will be carried out by inviting the industrial representatives at the meetings organized for Action 3 and collect the required information through the questionnaire and through direct interaction.

In the case in which a company is not able to attend the meeting, we evaluate the possibility to send one or two members of the consortium to the company for an interview. The set of industrial affiliates may also be enlarged during the project depending on the specific needs.

Task W4.A3.N3

An important activity of this workpakage will be to assess and provide contributions to the current definition of the real-time extensions of operating system standards, such as Real-Time Posix.

Based on the interaction with the industrial affiliates, the consortium will attempt to identify possible real-time features, programming interfaces, and kernel mechanisms that could affect and improve the current RT-Posix standard. Moreover, it is expected that the results from this workpackage will have impact on the developing methodology of the partners, as well as on vendors and operating systems standards.

This task will be coordinated by Michael Gonzalez Harbour from University of Cantabria, who is currently involved in the international committee for the definition of the RT-Posix standard. Moreover, the task will certainly benefit from the different expertises of all the partners involved in this workpackage.

9.3.5 Distribution of effort per task

The following tables provide a breakdown of relative effort par task and per partner for the three actions. Effort is estimated as a percentage of each partner's total labour. We chose relative efforts to better illustrate each partner's contribution, without distortion due to different labour costs.
For workpackages 0 and 3, figures are given in the detailed workpackage list (9.3).

Distribution of effort per task in action 1

Partners for **ACTION 1**	**W1A1N1**	**W1A1N2**	**W2**	**W4A1**
1 UJF/VERIMAG	25%	25%	25%	25%
2 INRIA	25%	25%	25%	25%
3 TU Vienna	50%	0%	25%	25%
4 UU	50%	0%	25%	25%
5 UdS	50%	0%	25%	25%
6 PARADES	25%	25%	25%	25%
7 OFFIS	50%	0%	25%	25%
8 AAU	50%	0%	25%	25%
9 TU/e	50%	0%	25%	25%
	50%	0%	25%	25%

Distribution of effort per task and year in action 2

Partners for **ACTION 2**	**W1.A2.N1**		
1 Verimag	75%	0%	25%
2 Inria	75%	25%	25%
4 UU	75%	25%	25%
7 OFFIS	75%	25%	25%
8 Aalborg	75%	0%	25%
10 York	25%	0%	0%
11 CEA	25%	0%	0%
12 Lancaster	75%	0%	25%
13 LSV	75%	0%	25%
14 Twente	50%	0%	0%
15 MDH	25%	0%	0%

	W1.A2.N2		
1 Verimag	0%	75%	50%
2 Inria	0%	25%	25%
4 UU	0%	25%	25%
7 OFFIS	0%	50%	25%
8 Aalborg	0%	50%	25%
10 York	0%	0%	0%
11 CEA	0%	25%	25%
12 Lancaster	0%	25%	25%
13 LSV	0%	50%	25%

14 Twente	0%	50%	25%
15 MDH	0%	25%	25%

	W1.A2.N3		
1 Verimag	0%	0%	0%
2 Inria	0%	25%	25%
4 UU	0%	25%	25%
7 OFFIS	0%	25%	25%
8 Aalborg	0%	25%	25%
10 York	0%	50%	25%
11 CEA	0%	0%	0%
12 Lancaster	0%	50%	25%
13 LSV	0%	25%	25%
14 Twente	0%	25%	25%
15 MDH	0%	0%	0%

	W2.All		
1 Verimag	0%	0%	0%
2 Inria	0%	0%	0%
4 UU	0%	0%	0%
7 OFFIS	0%	0%	0%
8 Aalborg	0%	0%	0%
10 York	0%	0%	0%
11 CEA	25%	25%	25%
12 Lancaster	25%	25%	25%
13 LSV	25%	25%	25%
14 Twente	25%	25%	25%
15 MDH	50%	50%	50%

	W4.A2		
1 Verimag	25%	25%	25%
2 Inria	25%	25%	25%
4 UU	25%	25%	25%
7 OFFIS	25%	0%	25%
8 Aalborg	25%	25%	25%
10 York	75%	50%	75%
11 CEA	50%	50%	50%
12 Lancaster	0%	0%	0%
13 LSV	0%	0%	0%
14 Twente	25%	0%	25%
15 MDH	25%	25%	25%

Distribution of effort per task in action 3

Partners for **ACTION 3**	**WP1 T3.1**	**WP1 T3.2**	**WP2**	**WP4 T3.1**	**WP4 T3.2**	**WP4 T3.3**
2 INRIA	25%	25%	25%	8%	8%	10%
10 University of York	25%	25%	25%	8%	8%	10%
15 Malardalen University	25%	25%	25%	8%	8%	10%
16 University of Pavia	20%	30%	25%	8%	8%	10%

17 Scuola S. Anna	35%	15%	25%	8%	8%	10%
18 University of Cantabria	25%	25%	25%	5%	5%	15%
19 University of Aveiro	25%	25%	25%	8%	8%	10%
20 University of Catalonia	25%	25%	25%	8%	8%	10%
21 University of Lisboa	25%	25%	25%	8%	8%	10%
22 Universidad Carlos III	25%	25%	25%	8%	8%	10%

9.4 Deliverables list

We denote by Del TOTO.Yn the deliverable of Task TOTO for year n.

9.4.0 Deliverables WP0

Annual Management reports DelW0.A0.Y1, DelW0.A0.Y2, DelW0.A0.Y3 at T0+12, T0+24, T0+36 respectively.

9.4.1 Deliverables WP1

Action1

Year 1

- **DelW1.A1.N1.Y1** : report on obstacles to smooth integration of the different design phases. This report will serve for elaborating the questionnaire in TaskW4.A1.

Year 2

- **Del W1.A1.N1.Y2** : report on *recognized* obstacles to smooth integration of the different design phases. This report will take into account results of TaskW4.A1
- **Del W1.A1.N2.Y2** : intermediate report summarizing the first research results on the technical work.

Year 3

- **Del W1.A1.N1.Y3** : report on the proposed roadmap for research, to overcome recognized obstacles to smooth integration of the different design phases
- **Del W1.A1.N2.Y2** : final report summarizing the research results on the technical work.

Action2

The major technical deliverables are annual technical reports (white papers), which collect and synthesize the experience and findings by partners in the activities outlined above.
The technical reports describe the state of the art, and outline directions for major research efforts.

Year 1:

Del W1.A2.N1Y1 : Technical report summarizing results of Task W1.A2.N1.

Year 2:

Del W1.A2.Y2 Technical report which summarizes results of Tasks W1.A2.N2 and Tasks W1.A2.N3 together with an update of the report on Task W1.A2.N1, as appropriate.

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Year 3:

Del W1.A2.Y3: Technical report which for all the tasks of TaskW1.A2. provides a roadmap, containing an outline of research directions to advance the state of the art towards the vision outlined in the beginning of this document.

Action3

Year1:

Del W1.A3.N1.Y1: Report describing the characteristics of typical soft real-time applications and the open problems that need to be addressed at the kernel level to achieve a proper QoS management. This report will serve for proposing new computational models that can increase flexibility in expressing timing constraints and QoS requirements.

Year 2:

Del W1.A3.N1.Y2: Report describing a flexible computational model which can express the various types of constraints and QoS requirements encountered in soft real-time applications.

Year 3:

Del W1.A3.N2.Y3: Report describing a set of kernel mechanisms and algorithms (selected among those proposed in the real-time literature) which can provide efficient support to the task model identified in the previous phase

9.4.2 Deliverables WP2

Year 1

Del W2.All.Y1 : report containing first draft curriculum, questionnaire ready, list of persons to send the questionnaire available

Year 2

Del W2.All.Y2 : questionnaire collected, short report describing the method used to have this questionnaire properly answered.

Year 3

Del W2.All.Y3 : questionnaire analysed, curriculum improved, white paper.

9.4.3 Deliverables WP3

Annual reports **DelW3.All.N1.Yn** and **DelW3.All.N2.Yn** for n=1,2,3 will be produced for tasks **TaskW3.All.N1** on Dissemination and **TaskW3.All.N2** on International Collaboration, respectively.

9.4.4. Deliverables WP4

Action1

Year 1

DelW4.A1.Y1 : Questionnaire and list of persons to contact.

Year 2

Del W4.A1.Y2 : Report on collected answers to the questionnaire,.

Year 3

Del W4.A1.Y3 : Report on the analysis of the questionnaire and consequences on the ARTIST's roadmap.

Action2

Year 1:

Del W4.A2.Y1 Technical report which provides a synthesis on the following issues.

- Identification of the aspects of standardization that should be considered by ARTIST
- Relevant aspects concerning the ongoing work to define a precise semantics for version 2.0 of UML

Year 2:

Del W4.A2.Y2: Technical report which assesses the opportunities for ARTIST/OMG interaction and proposes directions for future work.

Year 3:

Del W4.A2.Y3: Technical report which outlines a skeleton of a metamodel for components and associated research issues.

Action3

Year1:

Del W4.A3.N1.Y1: Report describing the questionnaire to be used for interacting with the industrial affiliates.

Year 2:

Del W4.A3.N2.Y2 : Report describing the results of the questionnaire in terms of the strengths and weaknesses of existing real-time operating systems and tools used in the development of soft real-time applications with highly dynamic behaviour.

Year 3:

Del W4.A3.N3.Y3: Report describing a proposal for modifying or extending the RT-POSIX standard to offer a suitable support to soft real-time applications.

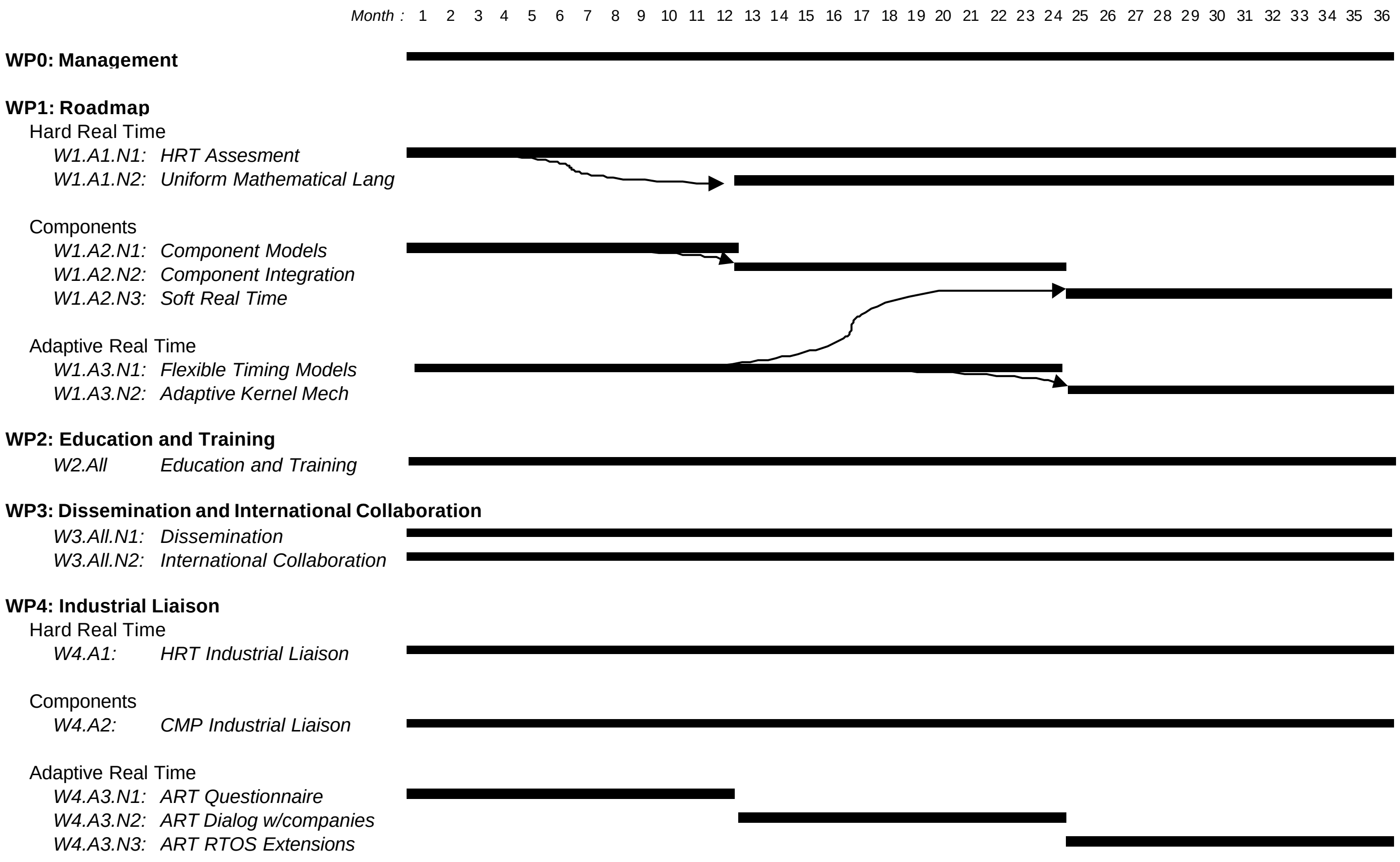
Deliverables list

Del. no.	Deliverable name	WP no.	Lead partic ip-ant	Esti mat ed pers on-mon ths	Deliv ery (proj. mont h)
W0.A0.Y1	Management report	0	Verimag	10,5	12
W0.A0.Y2	Management report	0	Verimag	10,5	24
W0.A0.Y3	Management report	0	Verimag	10,5	36
W1.A1.N1.Y1	HRT- Preliminary Roadmap	1	INRIA	14,4	12
W1.A1.N1.Y2	HRT- Intermediate Roadmap	1	INRIA	14,3	24
W1.A1.N2.Y2	HRT-Preliminary Tech. Report	1	INRIA	3,1	24
W1.A1.N1.Y3	HRT-Final Roadmap	1	INRIA	3,2	36
W1.A1.N2.Y3	HRT- Final Technical report	1	INRIA	14,4	36
W1.A2.N1.Y1	CMP-Preliminary Roadmap	1	UU	31,2	12
W1.A2.Y2	CMP-Intermediate Roadmap	1	UU	23,4	24
W1.A2.Y3	CMP-Final Roadmap	1	UU	14,8	36
W1.A3.N1.Y1	SRT-Preliminary Roadmap	1	UNIPV	14,3	12
W1.A3.N1.Y2	SRT-Intermediate Roadmap	1	UNIPV	14,3	24
W1.A3.N2.Y3	SRT-Final Roadmap	1	UNIPV	26,7	36
W2.All.Y1	Draft Curriculum	2	Verimag	21,6	12
W2.All.Y2	Questionnaire methodology	2	Verimag	21,6	24
W2.All.Y3	Curriculum White Paper	2	Verimag	21,6	36
W3.All.N1Y1	Annual Dissemination report	3	Verimag	9,2	12
W3.All.N2Y1	Annual Intl Collaboration Report	3	Verimag		12
W3.All.N1Y2	Annual Dissemination report	3	Verimag	9,2	24
W3.All.N2Y2	Annual Intl Collaboration Report	3	Verimag		24
W3.All.N1Y3	Annual Dissemination report	3	Verimag	9,2	36
W3.All.N2Y3	Annual Intl Collaboration Report	3	Verimag		36
W4.A1.Y1	Report on Choice of approach	4	INRIA	8,2	12
W4.A1.Y2	Interviews preliminary report	4	INRIA	8,2	24
W4.A1.Y3	Impact on roadmap white paper	4	INRIA	8,2	36
W4.A2.Y1	RT UML standardisation report	4	UU	7,8	12
W4.A2.Y2	ARTIST/OMG interaction report	4	UU	7,8	24

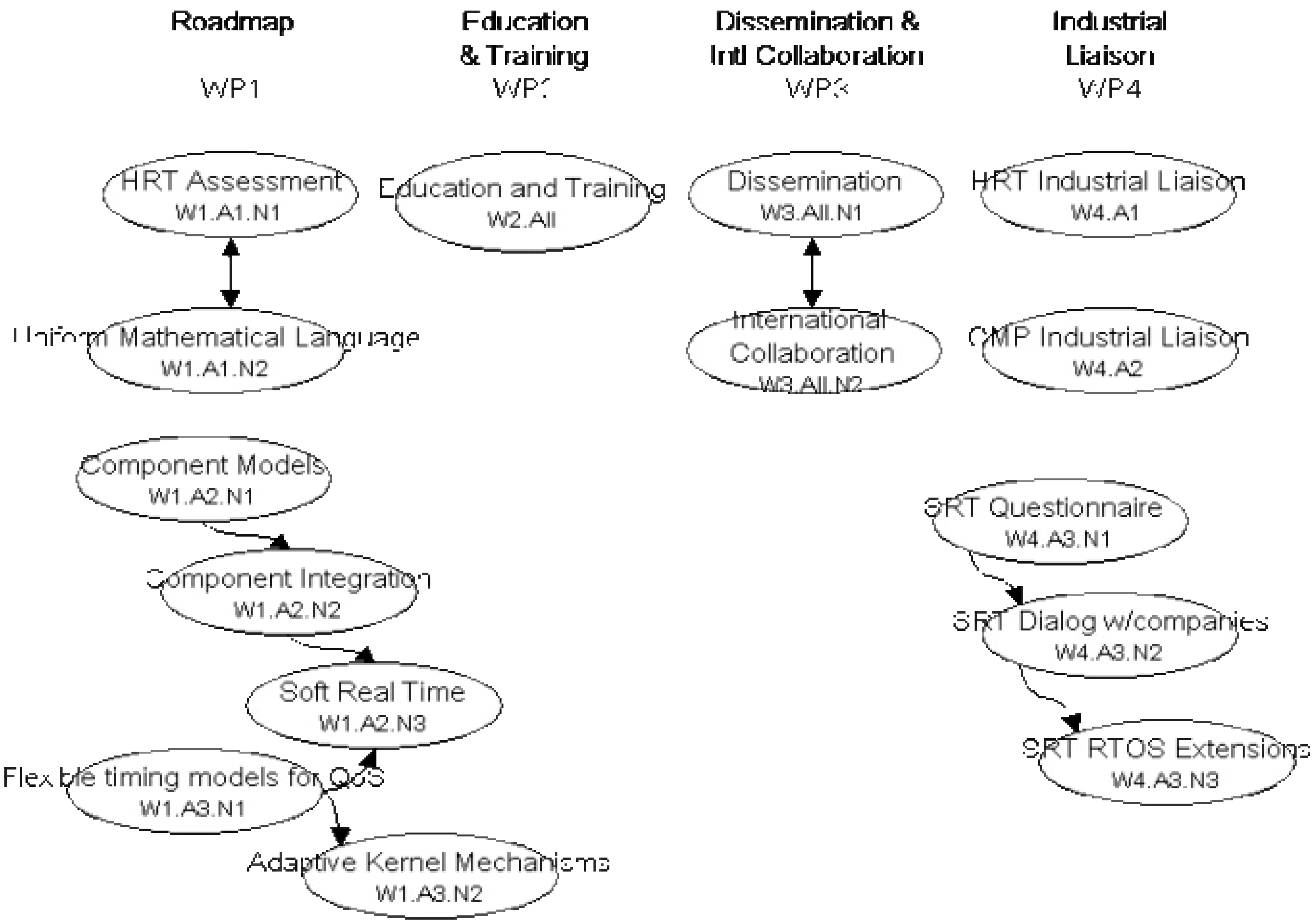
W4.A2.Y3	Components Meta-model report	4	UU	7,8	36
W4.A3.N1.Y1	Industrial affiliates questionnaire	4	UNIPV	8,0	12
W4.A3.N2.Y2	Questionnaire results report	4	UNIPV	8,0	24
W4.A3.N3.Y3	Proposal for RT-POSIX extensions/modifications	4	UNIPV	11,7	36

Please note that all the deliverables are public reports.

9.5 Project planning and timetable



9.6 Graphical presentation of project components



9.7 Project management

We describe the organization principles and then the proposed management structure: the roles of the Executive Board (MB), of the Coordinator and of the Action Coordinators (AC)..

9.7.1 Organization principles

1. The project is a set of coordinated actions.

2. Actions should focus on challenging problems and relevant objectives. No uniform or full coverage of the area is sought. Action objectives may be any combination of the following:

- Industrial objectives: focusing primarily on enhancing the transfer of advanced real-time systems technology, the transfer of user requirements from industry to academia and promoting best practice in advanced real-time systems development

- Research: coordination focusing primarily on the promotion of excellence in European research in the area of Advanced Real-time Systems and defining promising research directions and challenges.

- Education, training and information dissemination: organization of schools and seminars for training of researchers and engineers; dissemination of the state of the art in the area.

3. To avoid passive membership, an action is a lightweight project activity defined by its objectives, its anticipated impact and deliverables, its participants and coordinator. Participants can be academic and/or industrial. Action resources are used essentially for coordination, organization of meetings, seminars and schools, traveling, visits and studentships.
Strongly motivated and highly respected coordinators are instrumental for action success. Participants should have really converging interests and be willing to cooperate. Artificial merging of communities that makes sense theoretically but is not practically effective due to cultural barriers or other incompatibilities, should be avoided.

4. The project organizes a yearly plenary gathering for dissemination, global coordination/management and evaluation purposes. The gathering will be organized around an important scientific meeting (conference, workshop). Furthermore, during the gathering the following events will take place:

- The annual review of the project
- One of the two regular meetings of the actions
- The annual meeting of the Executive Board

5. Each action will establish a Technical Group (TG). The TG has at least 2 regular meetings per year. One of the meetings is organized jointly with the plenary gathering of the project. Technical Group meetings are open to all the partners of the action and invitees as decided by the action coordinator. TG's produce a yearly report (deliverable) that presents all relevant results of the action e.g. important work directions, reports on the state of the art, promotion of results and technologies, standards.

6. Actions can launch other activities such as organization of European Seminars, Schools and Workshops. It is possible also to sponsor existing events provided that they contribute to the aims of the project.

9.7.2 Executive Board (EB)

The project Executive Board (EB), chaired by the project Coordinator, will hold administrative responsibilities. The EB is composed of one management representative from each partner in the consortium, plus the project Coordinator, who is not the representative of any partner. The management representative will have the authority to make decisions on behalf of his institution in terms of overall strategy and resources allocated to the project. The role of the EB will be:

- Provide overall direction of the project. This includes discussing, proposing, and approving major changes in the work plan in response to new problems or situations.
- Produce a consortium agreement
- Execute arbitration policies to resolve conflict of interest

The EB meets once per year, during the ARTIST plenary gathering. Extraordinary meetings can be convened at the request of at least three members. The decisions will be taken by consensus or by simple majority in the case where consensus is not possible. Changes to the work plan in the proposal will require consensus or a qualified majority of all except one. The Project Coordinator will not vote. The Project Coordinator will resolve any tie in the vote.

9.7.3 The Coordinator

The Project Coordinator reports to the EB and to the Commission. The role of the Coordinator is to:

- Co-ordinate all activities and detect deviations. The EB will be involved if necessary.
- Convene the EB, prepare and follow-up EB meetings.
- Draft a quality management plan for approval at the first EB meeting. The quality management plan will include procedures for

-Reporting and communication
-Corrective actions
-Tracking of action items
-Conflict resolution

- Monitor project progress and manpower consumption.
- Keep partners informed about project progress.
- Manage reporting to the Commission and serve as the administrative liaison with the Commission.
- Serve as project secretary and archive.

9.7.4 The Management Board (MB)

The Management Board, composed of the project Coordinator and the Action Coordinators takes care of the day to day management of the project
Action Coordinators are the technical leaders of actions. They are responsible for all technical decisions within the respective actions. The role of the Action Coordinators will be t to:

- Co-ordinate activities in the action and ensure communication among the participants.
- Initiate corrective actions for deviations.
- Ensure the well-timed availability of WP deliverables.
- Report progress to the Project Coordinator, the MB and the EB
- Co-ordinate the interaction and collaboration with other actions.
- Arrange technical reviews as required by the EB or the Commission.

9.7.5 The Advisory Board

A Project Advisory Board will be established by T0+6 months. The Project Advisory Board will be composed of representatives of the main industrial partners and outstanding academics. It meets once per year and its role is to advise and support the project especially concerning the choice of its work directions, dissemination and lobbying.

Appendix A - Consortium description

The Project Coordinator is Joseph Sifakis, VERIMAG, Grenoble, France, e-mail sifakis@imag.fr, url : http://www-verimag.imag.fr/~sifakis/.

The Project consists of three concerted actions. The participants are academic research teams with relevant contribution in the area. The Project has also associated industrial partners who manifested there interest and support. They will participate actively in ARTIST meetings and contribute to the progress of the work.

The lists of the participants par action and of the associated partners are provided below.

Action1: Hard Real-time - Partners and key persons

Coordinator: Albert Benveniste, INRIA/IRISA-Rennes, France

- INRIA, BP 105, 78153 Le Chesnay Cedex, France

-For the Signal group : Albert Benveniste IRISA/INRIA, Campus de Beaulieu, 35042 RENNES Cedex, FRANCE, tel +33 (0)299 84 72 35, fax +33 (0)2 99 84 71 71, email Albert.Benveniste@inria.fr, http://www.irisa.fr/sigma2/benveniste/home.html
-For the Esterel group : Robert De Simone, Robert.De_Simone@inria.fr
-For the SynDex group : Yves Sorel, Yves.Sorel@inria.fr, INRIA, Domaine de Voluceau, Rocquencourt, Phone : (33) 1 39 6352 60, Fax : (33) 1 39 63 57 86 BP 105 - 78153 LE CHESNAY CEDEX, France http://www-rocq.inria.fr/~sorel/workhttp://www-rocq.inria.fr/syndex/welcome.html

- VERIMAG, Centre Equation, 2 avenue de Vignate, F-38610 GIERES, France

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Action2: Component based Design and Development - Partners and key persons

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- Aalborg University (or Brics group)

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Action3: Adaptive Real-Time Systems for QoS Management- Partners and key persons

Coordinator: Giorgio Buttazzo, University of Pavia, Italy

1. University of Pavia, Italy (coordinator)

    Contact: Giorgio Buttazzo
    Email: buttazzo@unipv.it
    URL: http://www.sssup.it/~giorgio

    Expertise: real-time systems and robotics

    Role: This partner coordinates Action 3 and will provide inputs to characterize timing models and kernel mechanisms useful for supporting soft real-time applications in the robotics domain. An important contribution will be also given in the field of aperiodic service mechanisms and overload management policies.

2. University of York, UK

Contact: Alan Burns
Email: burns@cs.york.ac.uk
URL: http://www.cs.york.ac.uk/rts/projects.html

Expertise: fixed priority scheduling and analysis

Role: This partner will contribute to all the activities related to action 3, and will be significantly involved in those concerning aperiodic scheduling, schedulability analysis, processor reclaiming, and QoS management. This partner will also give a significant contribution in the workpackage related to education and training, since it organizes many courses related to real-time systems.

3. Scuola Superiore S. Anna of Pisa, Italy

Contact: Giuseppe Lipari
Email: lipari@sssup.it
URL: http://retis.sssup.it/research.html

Expertise: embedded real-time systems and QoS control

Role: This partner will give an essential contribution for the issues related to resource reservation, temporal isolation, QoS control, feedback-based adaptive policies. Their experience on modular operating systems will be also useful for composable real-time kernels. This partner will also give a significant contribution in the workpackage related to education and training, since it organizes many courses related to real-time systems.

4. University of Cantabria, Spain

Contact: Michael Gonzalez Harbour
Email: mgh@unican.es
URL: http://www.etsiit.unican.es/menupda.htm

Expertise: distributed systems and kernels

Role: This partner is currently involved in the definition of the Posix standard, hence he will coordinate Task 3.3 and will act as an interface with the international committee for the definition of the RT-POSIX standard. The Cantabria group also developed a modular kernel for embedded systems, hence they will contribute on composability and flexible design issues.

5. Malardalen University, Sweden

Contact: Gerhard Fohler
Email: gerhard.fohler@mdh.se
URL: http://www.idt.mdh.se/personal/gfr/research/

Expertise: flexible scheduling algorithms and mode changes

Role: This partner will provide an important contribution for defining a flexible timing model for soft real-time activities and for identifying flexible scheduling algorithms to handle real-time tasks with complex timing constraints. This partner will also have a significant influence in the workpackage related to education and training, since it organizes many courses related to real-time systems.

6. University of Aveiro, Portugal
   Contact: Luis Almeida
   Email: lda@det.ua.pt
   URL: http://sweet.ua.pt/~lda/research.htm

   Expertise: distributed systems and networks

   Role: This partner will contribute in the definition of kernel mechanisms and communication protocols for distributed real-time systems. The Aveiro group will also provide useful inputs for evaluating the performance of aperiodic service mechanisms and bandwidth reservation policies for accessing the network. This partner is involved in organizing undergraduate and graduate courses on real-time systems and, hence, will be involved in education and training.

7. Technical University of Catalonia, Spain
   Contact: Josep M. Fuertes
   Email: pepf@esaii.upc.es
   URL: http://www.ictnet.es/esp/comunidades/automat/

   Expertise: real-time control systems and QoS management

   Role: This partner will provide contributions to characterize timing models and kernel mechanisms useful for supporting soft real-time control applications. In particular, it will investigate on adaptive systems, feedback-based algorithms and QoS management techniques.

8. INRIA, France
   Contact: Jean-Bernard Stefani
   Email: Jean-Bernard.Stefani@inria.fr
   URL: www.inria.fr/rapportsactivite/RA99/reflecs/contr_CTI-CNET.html

   Expertise: component-based distributed OS technology

   Role: This partner will mainly contribute in defining and evaluating the methodologies for achieving a modular and composable kernel that can be configured depending on the application needs.

9. University of Lisboa Faculty of Sciences (FCUL), Portugal
   Contact: Paulo Esteves Veríssimo
   Email: pjv@di.fc.ul.pt
   URL: http://www.navigators.di.fc.ul.pt/people/pjv_e.html

   Expertise: Timeliness and Adaptation in Dependable Systems

   Role: This partner will provide a significant contribution in the field of adaptive real-time systems where a minimum level of dependability is required. Integrating real-time constraints and fault-tolerance issues in the task model will also be a task carried out by this partner.

10. Universidad Carlos III de Madrid, Spain
Contact: Carlos Delgado Kloos
Email: cdk@it.uc3m.es
URL: http://www.it.uc3m.es/~cdk/

Expertise: QoS control and middleware

Role: This partner will provide a contribution in defining and evaluating the methodologies for achieving modularity and composability in soft real-time applications with QoS requirements.

Associated Industrial Partners

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Esterel Technologies, Gerard Berry, Gerard.Berry@esterel-technologies.com

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TTTech, Judith Sattlberger, sattlberger@tttech.com

EADS-Aerospatiale, Mr. Francois Pilarski Francois.PILARSKI@airbus.aeromatra.com>

Dassault-aviation, Emmanuel Ledinot, emmanuel.ledinot@dassault-aviation.fr

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ERICSSON Bjarne Dacker bjarne@erix.ericsson.se

Free2Move - Sweden
Contact: Per-Arne Wiberg
URL: http://www.free2move.se/

Expertise: Wireless technology

Role: Helping in defining new problems for wireless distributed embedded systems and appropriate solutions that can be adopted in such an industrial marked.

Parades - Italy
Contact: Alberto Ferrari
URL: http://www.parades.rm.cnr.it/

Expertise: Embedded systems and system-on-a-chip architectures

Role: Providing an overview of embedded systems for automotive applications which may have impact on kernel mechanisms and operating systems standards.

TimeSys Corporation - USA
Contact: Raj Rajkumar
URL: http://www.timesys.com/

Expertise: real-time operating systems and design tools

Role: Helping in the definition of new features to be incorporated in existing standard for operating systems.

Appendix B - Contract Preparation Forms

BUDGET and COSTS

The following principles were applied to define the budget.

Action members

Each action member is allotted a total of 100 KEuro that can be used for travel or labour costs
Travel resources can be used for

- Attending action meetings
- Visiting project partners
- Attending ARTIST meetings, including the annual gathering, satellite events to Conferences, International Collaboration meetings, meetings of standardisation bodies such as OMG and ITU.
- Attending relevant scientific conferences, if agreement of the IST Management

NB. Action members are research teams. A partner may participate in different action by different teams

Action coordinators

Action coordinators are allotted a total of 100 KEuro that can be used for travel or labour costs.
From this amount 50 KEuro will be used for paying travel to non partners, invited participants of the project, for participation to project meetings. This amount has been put under specific costs.
The rest, 50 KEuro will be used for travel, labour, and for action 3, for small equipment.

Project coordinator

Action coordinators are allotted a total of 500 KEuro decomposed as follows:

- 200 KEuro for International Collaboration as specified in WP3. This amount is put under specific costs

- 300 KEuro decomposed into 25 KEuro for travel and 275 KEuro for paying a full time project assistant and part time administrative personnel for management and accounting.

Other rules

- As requested by the IST Management, 25% of the budget has been set aside under specific costs in the Coordinator's budget. This amount will be used only after written approval by the project officer. It is earmarked for new incoming contractors or other extra tasks that can be defined during the project.

- The travel costs for non partners (200 KEuro in the action coordinators budgets plus 200KEuro for international collaboration) is subject to the following restrictions
  - A ceiling of 750 Euro for travels within Europe
  - A ceiling of 150 E per day for accommodation and living in Europe