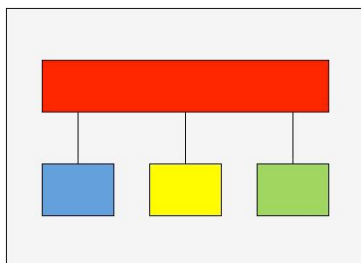


# CON4COORD

## WP1 Management - Final Report

Jan H. van Schuppen and  
Marios M. Polycarpou

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## Abstract

In the deliverable D-WP1-3 the coordinator Jan H. van Schuppen and the deputy coordinator Marios M. Polycarpou report on the management of the CON4COORD project (INFSO-ICT-223844 Grant Agreement number). The shortened acronym C4C for CON4COORD is also used. The leader of Workpackage WP1 is Jan H. van Schuppen. The coordinating organization is the research institute Centrum Wiskunde & Informatica (CWI) in Amsterdam, The Netherlands. The reporting period is the third year of the life time of the project which has run from 1 May 2010 till 1 May 2011.

At the time this deliverable is produced, the project is expected to be extended by four months, from 1 May 2011 to 1 September 2011. The contract for the amendment of the extension period is not yet signed at the date this deliverable is to be submitted.

The structure of the deliverable is that of the Periodic Progress Report as prescribed by the European Commission in the FP7 document *Guidance notes on project reporting* but extended with a section on the teams of the project and a section with research highlights.

A brief description of the contents of the deliverable by section follows. Section 1 provides an introduction to the deliverable. Section 2 recalls for the reader the description of Workpackage 1 from Annex 1 of the Grant Agreement. Section 3 provides a publishable summary of this deliverable. The expertises of the teams are described in Section 4. The project objectives are stated in Section 5. The progress of the consortium on the workpackages is described in Section 6. The research highlights are described in Section 7. It also contains a brief description of the project meetings held. Section 8 provides information on the deliverables and the milestones. Project management is discussed in Section 9. Section 10 provides the names of the junior and the senior researchers active on the project.

The information on the financial resources used in the third year is not yet available on the date that this deliverable must be submitted to the European Commission. The financial information will be listed in the Final Report of the project which report is due late 2011, if the project is extended.

The reader is also referred to the *Report Coordination Control of Distributed Systems* which will become available later in 2011.

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# 1 Introduction

The purpose of this deliverable is to provide information on the management of the project in the third year of the lifetime of the project.

The project *Control for coordination of distributed systems* was selected by the European Commission for financial support in the Spring of 2008. The financial means are provided by the European Commission from *Framework Programme 7 (FP7)* as part of the Work Programme Information and Communication Technology (ICT) in particular from the Theme Challenge 3: Components, Systems, Engineering, Objective ICT-2007.3.7 Networked Embedded and Control Systems, (c) Control of Large-Scale Complex Distributed Systems. The official acronym of the project is *CON4COORD* but the participants use the abbreviated acronym *C4C*. The project with Grant Agreement Number 223844 has started formally on 1 May 2008 and it has a three year life span. The C4C Consortium has asked the European Commission for an extension of the life time of the project by four months, from 1 May 2011 till 1 September 2011. The project officer has in principle agreed with the extension request but the contract for the amendment of the extension remains to be signed at the time this deliverable is submitted. The only major task during the extension period is the organization of the demonstration of the underwater vehicles during the C4C Review Meeting 2011 at the University of Porto in Porto, Portugal.

This deliverable, is entitled *D-WP1-3 Management - Final Report*. The reporting period is the third year of the project which runs from 1 May 2010 until 1 May 2011. The deliverable provides information on:

- the project objectives and the main scientific achievements for the reporting period;
- the management of the project.

The Editors of this deliverable are Jan H. van Schuppen (C4C Project Coordinator) and Marios Polycarpou (C4C Deputy Coordinator). The structure of the deliverable is based on that of the format of the Periodic Progress Report as specified by the European Commission in the *Guidance notes on project reporting*. That guideline has been extended by a section on the teams and a section with research highlights of the full three year of the project.

A summary of the report by section follows. The next section provides the description of Workpackage Management (WP1) as stated in Annex 1 of the contract. A publishable summary of this report is provided in Section 3. The teams are briefly presented in Section 4. Section 5 provides the project objectives as stated in Annex 1 of the Grant Agreement. Section 6 provides a summary of the results of the project structured by workpackages. The management of the project is described in Section 9. Information on the use of the financial resources is provided in Section 10 and this includes lists of the junior and the senior researchers paid by the contract.

## 2 WP1 Description

The following text is identical to that listed in Annex 1 of the Grant Agreement of the project for Workpackage 1.

Work package number	WP1	MNG	Start date		0									
Work package title	Project Management													
Activity type	MGT													
Participant number	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	
Participant short name	CWI	TUD	TUE	UCY	UGE	UPO	CER	UVE	HNN	MST	OCE	RWS	TRI	
Person months	2	1	1			1		1		1			1	

### Objectives

- (1) *European Commission*. Maintaining effective relations with the European Commission.
- (2) *Consortium*. Good governance of the project in all respects in smooth cooperation with all partners.
- (3) *External contacts*. To establish and maintain effective relations with other projects and organizations not involved in the project.

### Description of work

#### Task WP1.1 EU relations (1-36, P1).

To maintain relations with the European Commission about the project including the execution of the contract and the submission of reports.

#### Task WP1.2 Project Coordination Committee (1-36, P1, (All partners)).

To organize the Project Coordination Committee for the governance of the project.

#### Task WP1.3 Legal and financial affairs (1-36, P1, (All partners)).

To take care of all legal and financial matters of the project including the contract of association or the consortium agreement between all partners.

#### Task WP1.4 Project meetings. (1-36, P1, (All partners)).

To organize the project meetings in cooperation with the local organizers, the partners.

#### Task WP1.5 Reporting (1-36, P1, (All partners)).

#### Task WP1.6 External relations (1-36, P1, (P1, and selected partners as appropriate)).

To maintain all other external contacts on the project.

### Deliverables

Number	Description	WP	type	Dissem.	Month due
D-WP1-2	MNG Initial report	WP1	R	PP	12
D-WP1-2	MNG Progress report	WP1	R	PP	24
D-WP1-3	MNG Final report	WP1	R	PP	36

There follows information on the relation of the above tasks with the sections of this deliverable. The report on Task WP1.1 EU Relations is treated in Subsection 9.6. The report on Task WP1.2 on the Project Coordination Committee is presented in Subsection 9.4. The report on Task WP1.3 Legal and financial affairs is presented in Sections 9 and 10. The report on Task WP1.4 the Project meetings is presented in Subsection 9.3. The report on Task WP1.5 Reporting is presented in Section 6. The report on Task WP1.6 External relations is presented in Subsection 9.8.

### 3 Publishable summary

#### Project Control for coordination of distributed systems

(acronym CON4COORD, abbreviated acronym C4C; INFSO-223844 Grant Agreement Number). The life time of the project is 1 May 2008 - 1 May 2011.

Financial Support by the European Commission via the Seventh Framework Programme (FP7) by Theme Challenge 3: Components, Systems, Engineering, Objective ICT-2007.3.7 Networked Embedded and Control Systems (c) Control of Large-Scale Complex Distributed Systems.

The reporting period of this publishable summary is the third year of the life time of the project, 1 May 2010 till 1 May 2011.

The project encompasses five case studies and four theoretical workpackages, besides two management workpackages. Seventeen deliverables are to be submitted to the European Commission in the reporting period. Below the research progress is presented per workpackage.

*WP2.* The control synthesis and the control design for control of single autonomous underwater vehicles and for coordination control of multiple vehicles is a major contribution of this workpackage.

*WP3.* The communication between two or more aerial vehicles for control during a search mission is a major contribution of this workpackage.

*WP4.* The further development of the hierarchical road network infrastructure, the scenario analysis of the Amsterdam ring network, and the partial test of the traffic control measures for the Amsterdam ring network are major contributions of this workpackage.

*WP5.* The modeling, control design, and the analysis of algorithms for the automatic operation of straddle carriers (automated guided vehicles) on a container terminal is a major contribution of this workpackage.

*WP6.* The modeling, control design, and the control synthesis for high-speed printers of the Océ company is a major contribution of this workpackage.

*WP7.* The theory for coordination control of coordinated linear systems and their application to formation flying of underwater vehicles and aerial vehicles is a major contribution of this workpackage.

*WP8.* The theoretical framework for directed information and for communication in noisy channels with feedback is a major contribution of this workpackage.

*WP9.* The informatics modeling formalism for distributed hybrid systems is a major contribution. The development of teleoperations is another contribution. Finally the modeling and the performance evaluation of communication channels is another major contribution of this workpackage.

*WP10.* The development of the mathematical rigorous software package *Ariadne* for computations with nonlinear and hybrid systems is a major contribution of this workpackage.

The progress towards the project objectives in the third year of the C4C Project is summarized by:

- There is significant research innovation of five technologically advance case studies and on four theoretical workpackages.
- Research training has taken place of 14 Ph.D. students and of 9 post-doctoral researchers. In addition, 13 senior researchers were paid by the project and at least 9 researchers were active for the project but not paid by the project.
- The academic research groups have interacted with the companies involved in the project. The results of the project have been presented to the research communities at various conferences.

## 4 Teams and their expertise

There follows a brief description of the teams of the C4C Consortium. The format of the description of a team is: the acronym, the legal name of the team, the name of team leader, and the expertise of the team.

- *CWI*. The Centrum Wiskunde & Informatica (CWI), a research institute financed by the Ministry of Education and Research of the Government of The Netherlands established in Amsterdam, The Netherlands. The team leader is Jan H. van Schuppen. Other members of the team are Luc C.G.J.M. Habets and André C.M. Ran, and Pia L. Kempker (Ph.D. student). The expertise of the team is in control and system theory, in particular control of stochastic systems, of discrete-event systems, of hybrid systems, of distributed control systems, and of dynamic games. In addition, there is expertise in dynamical system theory including complexity of control problems.
- *CER*. The research institute CEnter for REsearch and TEchnology - Thessaly (CERETETH) is a legal, non-profit entity organized under the auspices of the General Secretariat for Research and Technology of the Greek Ministry of Development, established in the town of Volos in Greece. The team leader is Leandros Tassioulas. The expertise of the team is in information theory, in particular in the information theory of communication networks.
- *TUD*. The Delft University of Technology (TUD, Dutch acronym) in particular the Faculty of Technology, Policy, and Management in Delft, The Netherlands. The team leader is Dr. J. Vrancken. The expertise of the team is in control and communication networks, in particular for the traffic control centers of The Netherlands.
- *TUE*. The Eindhoven University of Technology (TUE), in particular the Department of Mechanical Engineering, established in Eindhoven, The Netherlands. The team leader was Koos (J.E.) Rooda from the start of the project till 27 April 2010. As of 27 April 2010 Prof. Jos C.M. Baeten is the leader of the TUE team. The expertise of the team is modeling and control of manufacturing systems, in particular modeling using automata and process algebras, and the application of supervisory control.
- *UCY*. The University of Cyprus (UCY), in particular the Department of Electrical and Computer Engineering, established in Nicosia, Cyprus. The team leader is Charalambos D. Charalambous. The expertise of the team is in: control of stochastic systems, information theory for control; fault detection and safety issues of computer systems; adaptive control and monitoring of control systems, control of aerial vehicles.
- *UGE*. The Universiteit Gent (UGE), in particular the Institute for Sustainable Mobility and the SYSTeMS Research Group in Gent, Belgium. The team leader is René K. Boel. The expertise of the team is: control of stochastic systems, control of Petri nets, control of hybrid systems, information theory, modeling and control of electric machines and power networks.
- *UPO*. The University of Porto (UPO), in particular the Department of Electrical Engineering (FEUP) in Porto, Portugal. The team leader is Fernando Lobo Pereira. The expertise of the team is in: optimal control of discontinuous systems, control of hybrid systems, modeling and control of autonomous underwater vehicles.
- *UVR*. The University of Verona (UVR), in particular the Department of Computer Science (Dipartimento d'Informatica) in Verona, Italy. The team leader is Tiziano Villa. The expertise of the team is in: optimization, circuit design, modeling and control of hybrid systems, software for hybrid systems, communication networks, design and verification of distributed computer systems.

- *HNN*. The company PSA Hessen Noord Natie (HNN) established in the town of Antwerp in Belgium. The leader of the team is Jan Tijmen Udding. As of 1 September the team leader is Johnny Vandendriessche. If the project is extended then the team leader for the extension period will be Mr. Vandewalle. The company operates a large container terminal in the Port of Antwerp. The expertise of the team is the operation of the terminal activities and the computer systems for these operations.
- *MST*. The company Ocean Scan - Marine Systems Technology (MST). The team leader is Alexandre Sousa who is also the director of the company. The company produces equipment for marine systems, in particular underwater vehicles and surface water vehicles including the software for control and for communication. The company cooperates closely with the team UPO from which it is a spin off. The expertise of the team is in mechanical construction and in the construction of dedicated computers and software.
- *OCE*. The company Océ with headquarters in the town of Venlo, The Netherlands. The leader of the team is Lou Somers. The company produces copy machines and high-speed printers. The expertise of the team is the modeling and the control of printers using tools of automata and of hybrid systems.
- *TRI*. The company Trinité Automatisering B.V. (TRI). The team leader is Frank Ottenhof who is also the director of the company. The company is a software house for traffic control centers in The Netherlands. The expertise of the team is the design of software for control and communication networks, in particular real-time software.



## 5 Project objectives for the period

The project objectives are:

1. To carry out research on control for coordination of distributed systems for five case studies and for four theoretical workpackages.
2. To educate several junior researchers, Ph.D. students and post-docs, to become researchers with knowledge and experience in control for coordination of distributed systems.
3. To increase the cooperation of the teams involved in the project on the research topic of control of distributed systems.

The *aim* of the project is to design and to evaluate controllers for the five case studies and to formulate theory for the coordination of distributed systems in regard to control, communication, informatics, and tools.

The strength of the project is in: (1) the five case studies of control of distributed systems with end users; (2) the theoretical knowledge of the consortium in the area of control of distributed systems, in particular the large number of principal investigators with a Ph.D. degree from major universities in the U.S.A. or Europe; and (3) the combination of theoretical expertises of the consortium necessary for the project.

The *particular research objectives* are:

1. *Case study. Control of underwater vehicles.* Control for coordination of three or more underwater vehicles for surveillance or environmental monitoring missions.
2. *Case study. Control of aerial vehicles.* Control for coordination of several aerial vehicles for missions of environmental monitoring.
3. *Case study. Control of road networks.* Control of traffic on a road network with information from many vehicles in a hierarchically structured control and communication network to meet objectives of network efficiency, traffic safety and the environment. Scenario analysis of the Amsterdam ring network and the partial test of integrated control measures.
4. *Case study. Control for coordination of automatic guided vehicles.* Control design and control synthesis for automated guided vehicles, straddle carriers, which are transporting containers to or from the quai to a yard.
5. *Case study. Control of complex machines.* Control design for complex machines such as high-speed printers which use distributed control and information processing to achieve an optimum between performance and cost.
6. *Control.* Control synthesis and control design for coordination of distributed systems by a global coordinator which achieves a trade-off between the control objectives and the total cost.
7. *Communication for control of distributed systems.* Synthesis and performance analysis of protocols for communication networks used for control including dynamically changing networks.
8. *Informatics for control of distributed systems.* Modeling, synthesis, and design of distributed algorithms for control and failure detection of distributed systems.
9. *Tools.* Computer programs to compute control laws with guaranteed performance bounds for hybrid systems by methods of mathematics and of computer science.

## 6 Work progress and achievements for the period

The work progress is described per workpackage.

### 6.1 WP1

During the third year of the life time of the project, the following management activities were organized. Three project meetings were held: (1) The seventh project meeting was held 12 July - 14 July 2010 at the team TUD in Delft, The Netherlands and was organized by the TUD and the CWI Team. (2) The eight project meeting was held 2x-2x October 2010 in Gent, Belgium and was organized by the UGE Team. (3) The ninth project meeting was held 2-1-23 March 2011 at the University of Verona in Verona, Italy, and was organized by Tiziano Villa and his UVR team. The tenth project meeting is scheduled for 4-5 July 2011 and will be held in Porto, Portugal and organized by the UPO and MST Teams. The coordinator has stimulated contacts between the researchers of the teams. The production of the deliverables was stimulated and supervised, and finally the deliverables were submitted to the European Commission. The coordinator is in the process of organizing the third C4C Review Meeting scheduled for 6 and 7 July 2011.

During the second year of the project, the coordinator has been in frequent contact with the project officer Dr. Alkis Konstantellos as in the previous two years of the project. The coordinator has attended an EU Concertation Meeting on Control held on 2 June 2010.

### 6.2 WP2

The control synthesis, the control design, for control of single autonomous underwater vehicles and for coordination control of multiple vehicles is a major research highlight. The demonstration scheduled for July 2011 during the C4C Review Meeting 2011 is a major event requiring major work of the team UPO. The contributions are due to the teams UPO and MST, of which we mention only its leaders: Fernando Lobo Pereira, João Sousa, and Alexandre Sousa.

### 6.3 WP3

The aim of deliverable D-WP3-3 is to provide a research progress report on the design and evaluation of cooperative control methods for uninhabited aerial vehicles operating autonomously in an uncertain, dynamic environment. During this period, the emphasis has been on: (i) the design and evaluation of algorithms that achieve cooperation within a team of uninhabited aerial vehicles; (ii) the development of a methodology and algorithms for multi-vehicle coordinated control of UAVs; (iii) the investigation of issues related to limited communication and limited information sharing among the vehicles and (iv) the evaluation and demonstration of the performance of the developed algorithms.

### 6.4 WP4

Workpackage 4 on Road Network control has made the following progress in year 3 (May 2010 through April 2011)

**The Scenario Coordination Module (SCM)** A network control system has successfully been installed in the Amsterdam area, and is now being used by two traffic management authorities in close cooperation, the one for the motorways and the municipality of Amsterdam. A first evaluation of the system has been carried out both by measuring improvements on traffic (outside C4C) and by interviewing operators. Both evaluations are quite positive.

**The Hierarchical Model** The Hierarchical Model has been further elaborated and applied to control principles that have the potential to prevent regularly occurring congestion. Partially, this has been implemented in the SCM system.

**Standardization** Considerable progress has been made in the necessary standardization of interaction between traffic control units, both local and coordinating. A first draft of the standard has been drawn up and no less than four parties are involved in the development of this standard.

**Lagrangian State Estimation** Traffic state estimation in Lagrangian coordinates, which means: as seen from a driving car, has been further developed and compared with the more traditional Eulerian methods of state estimation. The combination of Lagrangian and Eulerian methods offers a substantial improvement over each of these methods alone.

**Platoon Based Traffic Modeling** For urban networks, progress has been made in platoon based traffic models for both traffic state estimation and network control for urban networks. Hybrid models, combining different models for motorways and for urban traffic, seem to have the best prospects to model traffic in mixed networks.

**Fuzzy Control** Experiments have been conducted in which various methods of fuzzy control have been applied to the network control problem, especially multi-criteria control. Multi-criteria control is an important aspect of traffic control, in which nowadays no longer congestion is the main goal, but in which safety and environmental concerns play an increasing role.

**BlueTrack Experiments** For the purpose of measuring network effects, such as travel times, a Bluetooth based monitoring device has been developed (called BlueTrack), but the installation is currently delayed due to the necessary permissions from the authorities. On the other hand, successful experiments have been carried out in Belgium, which have demonstrated the usefulness of this relatively cheap monitoring device.

## 6.5 WP5

This deliverable provides various solutions strategies to the Autonomous Guided Vehicles (AGV) problems that were formulated in the earlier deliverable D-WP5-2. Different solution methodologies were developed depending on the underlying topology (free movement or movement on a grid).

## 6.6 WP6

The first use case was finished already in the second reporting period, see previous deliverable D-WP6-2, instead of at the anticipated end of the third reporting period. This was the result of applying supervisory control theory, which facilitated automatic synthesis of the controller based on the formally defined plant model and control requirements of the first use case. This allowed us to introduce a second use case, which has been fully evaluated in the third reporting period. The case deals with specification of output power to the toner module of an Oce high-end printer with respect to the input type of the paper. The toner transfuse belt and the paper should both be preheated so that the temperatures of both components are within specified bounds when the paper reaches the fuse drums. The toner transfuser belt has a fixed heat capacity, but the paper heat capacity depends on the paper weight, and on whether it has already undergone a printing operation on the other side of the paper. The control problem is to distribute the limited available power to ensure proper image transfer to the paper, at the highest speeds possible. The problem is formally specified by modeling the plant and the control requirements using state-based supervisory control theory. Subsequently, the controller has been automatically synthesized. The result are presented in deliverable D-WP-3.

Deliverable D-WP6-4 reports on the implementation and industrial evaluation of the solutions for the two use cases of work package 6. By applying automatic code generation based upon formal, behavioral models in the context of the model-based engineering paradigm, we aimed to (1) shift the focus of software engineers from writing and debugging code to modeling plant and control requirements, (2) shorten the define-validate-redefine loop, and (3) reuse models to improve reusability. These aspects are discussed in detail with respect to the implementation of the two solved cases reported upon in the previous deliverables.

## 6.7 WP7

The research progress is in: *WP7.1 Control Synthesis*. Coordination control of linear systems has advanced in regard to control synthesis, the decompositions of coordinated linear systems, and controllability and observability concepts of such systems.

*WP7.2 Control design for the case studies*. Control of autonomous underwater vehicles has advanced in the formulation of a control law for reference tracking of multiple vehicles. In addition, adaptive prediction of the traffic flow into a motorway network was shown to operate very satisfactory. Control of manufacturing networks was advanced in regard to decentralized control and the establishment of properties of the closed-loop system.

*WP7.3 Control via a communication network*. Control of when to request information of another subsystem was advanced in regard to synthesis of a control law. From a case study it seems that periodic control is optimal. A communication law was designed in a distributed control with communication setting for state estimation for Kalman filtering. The communication laws of fixed dimension may not have an unique solution.

*WP7.4 Overall coordination control of distributed systems*. The reader is referred to the *Report on Coordination Control of Distributed Systems* for essays of most of the results of Workpackage 7. In the appendix of this deliverable the reader will find a tutorial paper on distributed control of Gaussian systems.

## 6.8 WP8

This deliverable presents the progress report of the partners of project CON4COORD on the research of Workpackage 8 communication for control during the reporting period, 1 May 2010 till 1 May 2011. The Teams involved in the Workpackage 8 are: UCY, UGE, UPO, CER, UVR, TUE, MST.

*WP8.2 Control via communication network*. Several problems are formulated, while control theoretic and information tools are employed to provide solutions when causal feedback is available to the encoder, decoder and controller. The rate distortion function for a class of sources is investigated. The rate distortion function for causal encoding and/or decoding is investigated and a new tight lower bound, reminiscent of the Shannon lower bound for classical rate distortion function is derived. Lossless codes with limited codeword length are developed. Trade-offs between control and communication objectives subject to optimality of the control strategies and that of the encoder/decoder that achieve capacity are obtained.

Moreover, network problems are formulated via information theory for sources which are outputs of stochastic controlled differential and discrete equations. The notion of available information to each block of the communication and control blocks is captured via side information, conditional independence, and the concept of sufficient statistic (conditional distributions). Several of the analytical tools described under WP8.1 are employed using decentralized control and communication strategies.

*WP8.3: Simulation of a scenario of network control*. A Network Control Systems (NCS) simulator is created to investigate control over communication networks with finite data rates. Performances which are evaluated via the NCS simulators are its fidelity with respect to the theoretical results, such as the

trade-offs between communication and control objectives. This part will be further developed in the rest of the duration of the project.

The report includes short essays on research completed (methodology, results) and some research highlights for the duration of the project related to activities under WP8 Communication for Control.

## **6.9 WP9**

This deliverable presents the final report of the partners of project CON4COORD on the research of Work Package 9 (Informatics for Control of Distributed Systems) during the third year of the project. The reporting period is May 1, 2010 until April 30, 2011 and the teams active for WP9 during this period are: the Center for R&D Hellas (CER) at Volos, Greece; Eindhoven University of Technology (TUE) at Eindhoven, The Netherlands; the University of Cyprus (UCY) at Nicosia, Cyprus; the University of Gent (UGE) at Gent, Belgium; and the University of Verona (UVR) at Verona, Italy.

## **6.10 WP10**

Analysis and control of distributed systems

- We developed a framework for the composition of hybrid automata, and extended Ariadne to provide support for composition of individual components to build complex hybrid systems.
- We implemented in Ariadne verification strategies for distributed hybrid systems based on assume-guarantee reasoning.
- We developed a parametric analysis routine for hybrid systems inside Ariadne. This routine can determine the range of values for a given set of parameters defined over intervals for which the system respects a given safety property.

Input languages and user interface

- We studied interval temporal logic as a specification and query language for hybrid systems.
- We improved the user interface of Ariadne by providing input support for the Compositional Interchange Format modeling language.

Testing and application

- We developed an automatic tuning policy for the accuracy parameters of Ariadne, which improves both the design and verification times.
- We analysed a collection of industrial problems provided by the modeling and control design activity of the other work packages and also by the EU projects SPEEDS and COCONUT.

## **6.11 WP11**

The dissemination has advanced in regard to the C4C website, publications, and communications to end users.

## **6.12 Overall assessment**

The coordinator concludes that the project objectives for the third year are almost fully met.

1. There is considerable research progress on all of the workpackages. The investigations of the case studies proceed well but the progress varies by case study. The case studies are all technologically advanced and even limited progress will be beneficially to the organizations involved.
2. There is significant research training of the 14 Ph.D. students and the 8 post-docs.
3. The teams have intensified their cooperation in the third year of the project.

### 6.13 Research innovation

There follows a summary by the coordinator of the major research innovation provided developed by the research teams during the life time of the C4C Project. The summary differs slightly from the research highlights.

WP2 Autonomous Underwater Vehicles. The development of the control and the operation of a single vehicle and the coordination of multiple vehicles is a major innovation. The interaction of this workpackage with those of WP7 Control and WP9 Informatics for Control, has been very fruitful.

WP3 Uninhabited Aerial Vehicles. Control algorithms for the search process of moveable sensors and the communication between vehicles during the search process is a major innovation. The interaction of this workpackage with that of WP7 Control and of WP8 Communication for Control has been beneficial.

WP4 Road Networks. The further development of hierarchical road networks in particular for the architecture, control, communication, and computation, is a major development. The scenario analysis for the Amsterdam Ring Network and adaptive prediction of the inflows are major innovations. The control synthesis of controllers for an urban road network is a major innovation. The interaction of this workpackage with those of WP7 Control have been very beneficial.

WP5 Automated Guided Vehicles. The modeling of the automatic operation of the vehicles on a container terminal, the control algorithms, the nonblockingness of the closed-loop system, and the overall optimization of the closed-loop system are major innovations. The interaction of this workpackage with those of WP7 Control has been very beneficial.

WP6 Complex Machines. The modeling and the control design for complex machines by a hierarchical system and the advance in the software design process from software writing to modeling and to control synthesis is a major research innovation. The interaction of this workpackage with WP7 Control and with WP9 Informatics for Control has been very beneficial.

WP7 Control. Coordination control has been proposed and developed during the life time of the project with emphasis on modeling, decompositions, and control synthesis and the application to formation flying of AUVs and UAVs and to ramp-metering on motorways, has been a major research innovation. Distributed control with communication between local controllers has been advanced and this is a research innovation but more needs to be investigated. This workpackage has benefitted from all case studies and from the workpackages WP8, WP9, and WP10.

WP8 Communication and Control. The development of concepts, theory, and algorithms for communication over noisy channels with feedback is a major innovation of this workpackage. Control via networks has also been advanced. This workpackage has interacted with those of WP2, WP3, WP7, and WP9.

WP9 Informatics and Control. Modeling of distributed systems as understood in theoretical computer science and for verification of safety and performance evaluation is a major innovation of the project. The evaluation of teleoperations of engineering systems is a major innovation. The workpackage has benefitted from the case studies and from interaction with the workpackages WP7 and WP10.

WP10 Tools. The further development of the software package Ariadne and its use for computations of industrial case studies is a major innovation of the project. The computer programs developed by the academic researchers for all other workpackages are very beneficial for the end users and for the research teams and as such are a major innovation of the project.

## 7 C4C Research highlights

The research highlights are distinguished per workpackage.

- *WP2*. The control synthesis, the control design, for control of single autonomous underwater vehicles and for coordination control of multiple vehicles is a major research highlight. The demonstration scheduled for July 2011 during the C4C Review Meeting 2011 is a major event requiring major work of the team UPO. The contributions are due to the teams UPO and MST, of which we mention only its leaders: Fernando Lobo Pereira, João Sousa, and Alexandre Sousa.
- *WP3*. The communication between two or more aerial vehicles for control during a search mission is a major research highlight. The contribution is due to the UCY Team with Marios Polycarpou, Christos Panayiotou, and Theofanis Lambrou as its researchers.
- *WP4*. The further development of the hierarchical road network infrastructure, the scenario analysis of the Amsterdam ring network, and the partial test of the traffic control measures for the Amsterdam ring network are major research highlights of WP4. The contribution is due to the teams TUD and TRI of which we mention the main leaders: Jos Vrancken, Frank Ottenhof, and Marcel Valé.
- *WP5*. The modeling, control design, and the analysis of algorithms for the automatic operation of straddle carriers (automated guided vehicles) on a container terminal is a major research highlight. The contribution is due to the teams HNN, UCY, and UGE of which we mention the main researchers involved: Jan Tijmen Udding, Qin Li, Christos Panayiotou, Theofanis Lambrou, René K. Boel, Nicolai E. Marinica, and Jonathan Rogge.
- *WP6*. The modeling, control design, and the control synthesis for high-speed printers of the Océ company is a major research highlight. The contribution is primarily due to the teams OCE and TUE of which we mention the researchers Lou Somers, Bert van Beek, Jos Baeten, Jasen Markovski, and Koos Rooda.
- *WP7*. The control and theory for coordination control of coordinated linear systems and their application to formation flying of underwater vehicles and aerial vehicles is a major research highlight of the C4C Project. The contributions are due to Pia L. Kempker and her advisors.
- *WP8*. The theoretical framework for directed information and for communication in noisy channels with feedback is a major research highlight of the C4C Project. The contributions are due to the UCY team, in particular to the researchers Christos Kourtellaris, Photis Stavrou, and Charalambos D. Charalambous.
- *WP9*. The informatics modeling formalism for distributed hybrid systems is a major research highlight. The development of teleoperations is another research highlight. The modeling and analysis of particular communication networks is another research highlight. The contribution is due to the UVR team in particular to the researchers Marta Capiluppi, Roberto Segala, Paolo Fiorini, Davide Quaglia, Riccardo Muradore, Tiziano Villa.
- *WP10*. The development of a mathematical rigorous software package for computations with nonlinear and hybrid systems is a major research highlight. The contributions are due to the teams UVR and CWI with as researchers Davide Quaglia, Tiziano Villa, Pieter Collins, and Sanja Živanovič.



## 8 Deliverables and milestones tables

### 8.1 Deliverables

There follows a list of deliverables which were due in the reporting period. The list is structured by the workpackage numbers and by the number of the deliverable.

All deliverables submitted to the European Commission are also available on the C4C website, except that the Final Management Report D-WP1-3 is only available to the consortium members. In the table below, the expression PP denotes private to the participants and PU denotes public availability.

Deliv. number	Deliverable name	WPn.	Lead participant	Nature	Dissim. level	Month due
D-WP1-3	MNG Final report	WP1	CWI	M	PP	36
D-WP2-4	MAR Multiple-vehicle coordination	WP2	UPO	R	PU	30
D-WP2-5	MAR Final report	WP2	UPO	R	PU	36
D-WP3-3	AER Final Report	WP3	UCY	R	PU	36
D-WP4-4	RON Report n measured data analysis	WP4	TUD	R	PU	30
D-WP4-5	RON Report on the tuning effort for HARS	WP4	TUD	R	PU	36
D-WP5-3	GUV Solution of the control problems	WP5	TUE	R	PU	30
D-WP5-4	GUV Industrial evaluation	WP5	TUE	R	PU	36
D-WP6-3	CMA Solution of the control problem	WP6	TUE	R	PU	30
D-WP6-4	CMA Industrial evaluation	WP6	TUE	R	PU	36
D-WP7-3	CON Final report	WP7	CWI	R	PU	36
D-WP8-3	COM Final report	WP8	UCY	R	PU	36
D-WP9-3	INF Final report	WP9	UCY	R	PU	36
D-WP10-3	TLS Final report	WP10	UVR	R	PU	36
D-WP11-3	DIS Final report	WP11	UPO+CWI	R	PU	36
D-WP11-4	DIS Final plan	WP11	UPO+CWI	R	PU	36

Deliv. number	Due date Annex 1	Delivered Yes/no	Date delivery Email	Date delivery Print sent	Date EU.Com. Acknowledge
D-WP1-3	30 April 2011		6 May 2011	6 May 2011	
D-WP2-4	31 October 2010				
D-WP2-5	30 April 2011				
D-WP3-3	30 April 2011	Yes	4 May 2011	4 May 2011	
D-WP4-4	31 October 2010				
D-WP4-5	31 October 2010				
D-WP4-6	30 April 2011	Yes	4 May 2011	4 May 2011	
D-WP5-3	31 October 2010	Yes	2 May 2011	4 May 2011	
D-WP5-4	30 April 2011	Yes	4 May 2011	4 May 2011	
D-WP6-3	31 October 2010	Yes	2 May 2011	4 May 2011	
D-WP6-4	30 April 2011	Yes	2 May 2011	4 May 2011	
D-WP7-3	30 April 2011	Yes	4 May 2011	4 May 2011	
D-WP8-3	30 April 2011	Yes	2 May 2011	4 May 2011	
D-WP9-3	30 April 2011	Yes	2 May 2011	4 May 2011	
D-WP10-3	30 April 2011	Yes	2 May 2011	4 May 2011	
D-WP11-3	30 April 2011	Yes	4 May 2011	4 May 2011	
D-WP11-4	30 April 2011	Yes	4 May 2011	4 May 2011	

The coordinator apologizes for the late submission of the deliverables due by month 30. Due to intensive research activities, the C4C Teams involved in those deliverables have take more time to complete those deliverables. A communication was made with the project officer about this issue in November 2010.

## 8.2 Milestones

Milestone number	Milestone name	Workpackage involved	Annex 1 due date	Achieved Yes/No	Actual date	Comments
30	Milestone 30	D-WP2-4	month 30			
30	Milestone 30	D-WP4-4	month 30			
30	Milestone 30	D-WP4-5	month 30			
30	Milestone 30	D-WP5-3	month 30	yes	30 April 2011	
30	Milestone 30	D-WP6-3	month 30	yes	30 April 2011	
36	Milestone 36	D-WP1-3	month 36	yes	6 May 2011	
36	Milestone 36	D-WP2-5	month 36			
36	Milestone 36	D-WP3-3	month 36	yes	4 May 2011	
36	Milestone 36	D-WP4-6	month 36	yes	29 April 2011	
36	Milestone 36	D-WP5-4	month 36	yes	4 May 2011	
36	Milestone 36	D-WP6-4	month 36	yes	30 April 2011	
36	Milestone 36	D-WP7-3	month 36	yes	4 May 2011	
36	Milestone 36	D-WP8-3	month 36	yes	30 April 2011	
36	Milestone 36	D-WP9-3	month 36	yes	1 May 2011	
36	Milestone 36	D-WP10-3	month 36	yes	29 April 2011	
36	Milestone 36	D-WP11-3	month 36	yes	4 May 2011	
36	Milestone 36	D-WP11-4	month 36	yes	4 May 2011	

The team leaders and the workpackage leaders have taken note of the milestones and of the progress of the project with respect to the milestones.

The deliverables due at the end of Month 36, thus on 30 April 2010, have not yet been read by the team leaders and the workpackage leaders, formally the members of the C4C General Assembly. These deliverables will be discussed at the next C4C Project Meeting.

## 9 Project management

In this section the C4C Consortium reports on the management of the project.

### 9.1 Management structure

The project *Control for coordination of distributed systems* is financed by the European Commission. The *coordinating organization* is the *Centrum Wiskunde & Informatica (CWI)* in Amsterdam, The Netherlands. The Director of CWI has asked Jan H. van Schuppen to act at the *coordinator* of the project. Jan H. van Schuppen is a senior researcher of CWI. In addition, he has an appointment as Full Professor at the Department of Mathematics of the Delft University of Technology. Jan H. van Schuppen was coordinator of three other projects financed by the European Commission in the period 1992 - 2003. In addition, he was involved in six other projects financed by the European Commission.

Jan H. van Schuppen has asked Marios Polycarpou of the Department of Electrical and Computer Engineering of the University of Cyprus (UCY team) to act as deputy coordinator. The reason for this request is that the project is rather large and that assistance to the coordinator is therefore welcome.

During the third year of the project Ms. Pia L. Kempker (CWI), a Ph.D. student working with Jan H. van Schuppen, has assisted the coordinator with producing reports of the C4C General Assembly meetings and with various small tasks of the coordinator.

The major decisions for the project are taken by the C4C General Assembly of the project. In Annex 1 the C4C General Assembly is called the *Council of Team Leaders* but these decision making organizations are identical. Every team of the C4C has a leader and as such this team leader is a member of the Council of Team Leaders. The tasks of the Council of Team Leaders is to decide on the major activities of the project, such as the location and dates of project meetings, and to monitor the research progress. The list of the team leaders follows.

CWI	Jan H. van Schuppen
CER	Leandros Tassiulas
TUD	Jos Vrancken
TUE	Koos (J.E.) Rooda (till 27 April 2010)
TUE	Jos C.M. Baeten (as of 27 April 2010)
UCY	Charalambos D. Charalambous
UGE	René K. Boel
UPO	Fernando Lobo Pereira
UVR	Tiziano Villa
HNN	Jan Tijmen Udding (till 1 Sep. 2010)
HNN	Johnny Vandendriessch (since 1 Sep. 2010)
MST	Alexander Sousa
OCE	Lou Somers
TRI	Frank Ottenhof/Marcel Valé

The *Workpackage Leaders* are responsible for the coordination of the activities in their workpackage. They are also the editors of the deliverables of the workpackages. The list of workpackage leaders follows.

WP1	Jan H. van Schuppen
WP2	João Borges de Sousa
WP3	Marios M. Polycarpou
WP4	Jos Vrancken
WP5	Jan Tijmen Udding (till 1 Sep. 2010)
WP5	Christos Panayiotou (since 1 Sep. 2010)
WP6	Bert van Beek
WP7	Jan H. van Schuppen
WP8	Charalambos D. Charalambous
WP9	Chris Hadjicostis
WP10	Davide Bresolin
WP11	Tiziano Villa, Jan H. van Schuppen

A *Consortium Agreement* has been signed by the participants.

## 9.2 Management activities in Year 3

The main management activities in Year 3 were: (1) the preparations for the extension of the life time of the project; (2) the change in the leader of the HNN team and of WP5; (3) the production of the deliverables and of the *Report on coordination control of distributed systems*; and (4) the organization of the C4C Review 2011. These items are discussed below.

The coordinator has proposed to extend the life time of the project during the C4C Review Meeting 2010 held in Brussels with the European Commission. The reasons for doing so are: To have more time for the planned demonstration of the underwater vehicles, also to be demonstrated during the C4C Review Meeting 2011; To be able to charge the costs of the travel and the stay for the review meeting to the project; To have more time for the completion of the financial report after the end of the life time of the project, with an extension this is to be done in the Fall of 2011 and otherwise during the summer of 2011. The coordinator formally requested the extension of the project on behalf of all team leaders early January 2011. The Project Officer has communicated to the coordinator that he has a positive attitude to the request. At the time this deliverable is completed, the contract for the extension is still not signed due to various reasons.

As described elsewhere in this deliverable, the leader of the HNN team resigned from HNN as of 1 September 2010. Mr. Johnny Vandendriessche took over as HNN Team Leader.

The coordinator has assisted with the organization of the three project meetings held in the reporting period. The project meetings are described below, see Subsection 9.3 It was decided to keep three project meetings also during the third year of the project to keep the interaction between the teams of the project at a high level. The organization of a project meeting proceeds as follows. The coordinator asks one of the teams whether it is able and willing to locally organize the project meeting. If so, a proposal for three possible sets of dates is formulated. The team leaders are then asked to vote on the sets of dates. The set of dates, always two and a half day, receiving the most votes is selected and the outcome is communicated to the team leaders. Later each workpackage leader contacts the researchers of his workpackage for proposals for lectures during the upcoming project meeting. The workpackage leader then formulates a proposal for the session on the corresponding workpackage. Since the fourth project meeting the coordinator organizes the scientific program of the project meeting as he did for the first two meetings. The last project meeting will be held 4-5 July 2011 at the partner UPO in Porto, Portugal. Its organization is in progress.

The coordinator has organized the production of the deliverables. The editing of the deliverables was the responsibility of the respective workpackage leaders. The deliverables have been discussed in Subsection 8.1. According to Annex II of the Grant Agreement, the coordinator is responsible for the communication of the deliverables to the European Commission.

### 9.3 Project meetings held

In the reporting period three project meetings were held. The reason to have three project meetings rather than two is to keep the interaction within the project at a high level. There follows an overview of the three project meetings held in the reporting period.

1. The seventh project meeting was held at the Delft University of Technology (TUD) in Delft, The Netherlands, 14-16 July 2010. The organization of the project meeting was the responsibility of Jos Vrancken (TUD) and Jan H. van Schuppen (CWI). They were assisted by secretaries of the Department of Mathematics of TUD. Jan H. van Schuppen has a part time appointment at the Department of Mathematics of the Delft University of Technology. The financial support for the visit came exclusively from the TUD Team. The number of participants was about 27. The scientific program consisted of lectures by members of the C4C Teams. There was no work visit to a company during this meeting.

On Monday 14 July there was a meeting held of the General Assembly of the C4C Project in which all partners of the project participated.

2. The eight project meeting was held 18-20 October 2010 in Gent, Belgium and was organized by the UGE Team. The team leader René K. Boel was responsible for the organization. The number of participants was about 25. The scientific program consists of lectures by primarily the junior researchers of the teams. There was no work visit during this project meeting.

On Monday 16 October there was a meeting of the General Assembly of the C4C Project held.

3. The ninth project meeting was held 21–23 March 2011 at the University of Verona in Verona, Italy. The team leader Tiziano Villa as responsible for the organization of the meeting and he was assisted by the members of his team. The number of participants was about 25. The scientific program consists of lectures by primarily the junior researchers of the teams. There was no work visit during this project meeting.

On Monday 21 March there was a meeting of the General Assembly of the C4C Project held.

### 9.4 C4C Consortium

#### Control Committee

Annex 1 of the Grant Agreement mentions in Subsection 2.1 at *Ways for monitoring and assessing project objectives* a subcommittee of the Project Coordination Committee (identical to C4C General Assembly). The committee has as members four senior researchers selected from the project. The task of the committee is to evaluate the performance of the project and to suggest to the coordinator ways to improve the performance.

The committee described above has been called the *Control Committee*. It consists of the members Jan H. van Schuppen (coordinator), René K. Boel, Fernando Lobo Pereira, and Marios M. Polycarpou. So far the committee has not met. The members have discussed bilaterally the issues of the committee.

### 9.5 Risk Committee

#### Members Risk Committee

Frank Ottenhof, Marios Polycarpou, Jan Tijmen Udding, Jan H. van Schuppen. The committee has never met. There were few matters of interest to the committee.

## 9.6 Contacts with the European Commission

The project officer of the CON4COORD project is Dr. Alkis Konstantellos. As part of the negotiations phase of the project, Dr. Konstantellos and Jan H. van Schuppen met on 6 February 2008 before the project started. Since the start of the project they have been in contact by email or by phone whatever seemed most convenient.

The coordinator has communicated the deliverables to the European Commission as stated in Sub-section 8.1.

The coordinator has attended meetings organized by the European Commission called *EU Concertation on Control*. The EU Concertation on Control meeting held on 2 June 2010 was attended by Jan H. van Schuppen (coordinator).

## 9.7 Planned review of project

The European Commission requires that the project is reviewed annually. For this purpose, the European Commission invites three researchers to evaluate the project, then called the *reviewers* of the project. The reviewers are provided access to the documents of the project including the research proposal, the Grant Agreement and its annexes, the deliverables, and copies of papers and of reports. The reviewers are invited to a meeting with representatives of the project. During a day, the reviewers can listen to reports of the workpackages by the workpackage leaders and can listen to a report of the complete project by the coordinator. The reviewers are expected to write a short report on their conclusions which is sent to the European Commission.

The dates of the third C4C Review Meeting has been set for Wednesday 6 and Thursday 7 July 2011 and the location is the the University of Porto in Porto, Portugal and for the demonstration of the underwater vehicles the location is the harbour of Porto.

## 9.8 External relations

The coordinator has had several contacts about the project with coordinators of other projects and with individual researchers.

The coordinator has been in contact with the following other coordinators and projects. Prof. Alessandro Giua (University of Cagliari, Cagliari, Sardinia, Italy) is the coordinator of the project Distributed Supervisory Control of Complex Plants (DISC; Grant Agreement Number INFOS-ICT-224498). Prof. Carlos Canudas de Wit (Université Joseph Fourier de Grenoble and INRIA Rhône-Alpes, Grenoble, France) is the coordinator of the project Co-design for networked control systems (FeedNetBack; Grant Agreement Number INFOS-ICT-223866). These are the two EU financed projects in control which are closest to the C4C project.

A delegation of the University of Grenoble and a researcher of the region of Grenoble with a responsibility for the local road networks have visited the company Trinite (TRI) in Uithoorn, the Traffic Control Center in North-Holland, and CWI in June 2010. The information was exchange was very useful.

## 10 Explanation of the use of the resources

### 10.1 Researchers paid by the project

Distinguish the researchers paid by the project in (1) the *junior researchers* paid for a large fraction of the time; and (2) the *senior researchers* who are paid for a small fraction of the time. Both groups of researchers are described below. In the next subsection are listed (3) researchers active for the C4C Project but *not paid* by the project.

Listed below are the junior researchers paid by the project.

- CWI. Ms. Pia L. Kempker. Ph.D. student. Paid from the project for 20 % of the work time from 1 May 2010 till 1 May 2011 in the reporting period. For the remaining part of the time she is appointed at the Department of Mathematics of the VU University Amsterdam.
- CER. This team did not pay junior researchers in the reporting period.
- TUD. Yufei Yuan, Ph.D. student, 100 % of the work time 1 May 2011 through 30 April 2011.  
Mohsen Davarynejad, Ph.D. student, 100 % of the work time, from 1 May 2011 through 30 April 2011.
- TUE. J. Markovski, Postdoctoral researcher, from 1 May 2010 till 1 May 2011, Full time.  
K. Starkov, Ph.D. student, from 1 May 2010 till 1 May 2011, Full time.
- UCY. Christos Kourtellaris, Ph.D. Student, 1 July till 31 October 31 2010, 1 January till April 30 2011, Full time.  
Photios Stavrou, Ph.D. Student, 1 July till 31 October 2010, 1 February till 30 April 2011, Full time.  
Ioannos Tziortzis, Ph.D. Student, November 2010, 1 January till 30 April 2011, Full time.  
Theofanis Lambrou, Ph.D. Student, 1 May till 31 August 2010, Full time.  
Dimitris Iliades, Ph.D. Student, 1 May till 31 December 2010, Full time.  
Dimitris Stavrou, Ph.D. Student, 1 July till 31 December 2010, Full time.
- UGE.  
Dr. Jonathan Rogge, post-doctoral researcher, part-time costed to C4C from 1 May 2010 till 1 May 2011, part time.  
Mr. Nicolae-Emanuel Marinica, Ph.D. student, 100 % of the working time, from 1 May 2010 - 1 May 2011 in the reporting period. His research advisor is Prof. René K. Boel.  
Mohammad Moradzadeh Ph.D. student, full time, from 1 November 2010 to 1 May 2011.
- UPO. Rui Manuel Ferreira Gomes, Ph.D. student with field experience, full time, from 1 May 2010 till 1 May 2011, full time.
- UVR. Dr. Davide Bresolin, Post-Doc Researcher, from 1 May 2010 , Full time.  
Dr. Marta Capiluppi, Post-Doc Researcher, from 1 May 2010, full time.  
Dr. Luca Geretti, Post-Doc Researcher, from 1 Jul 2010, full time.  
Dr. Riccardo Muradore, Post-Doc Researcher, from 1 May 2010, full time.  
Mr. Francesco Stefanni, Ph.D Student, from 1 May 2010, full time.  
Mr. Matteo Lissandrini, Web designer, from 1 May 2010, full time.



Dr. Pieter John Collins, from 1 Nov 2010 till 1 January 2011, full time.

Dr. Matteo Piccoli, from 1 April 2011, full time.

Dr. Giovanni Castagnetti, from 1 April 2011, full time.

- HNN, MST, OCE, TRI, no junior researchers are appointed at the four industrial partners.

There follows an overview of the junior researchers paid by the project in the form of a table.

CWI	Ms.	Pia L. Kempker	Ph.D.	Amsterdam	Netherlands
CER				Volos	Greece
TUD	Mr.	Yufei Yuan	Ph.D.	Delft	Netherlands
TUD	Mr.	Mohsen Davarynejad	Ph.D.	Delft	Netherlands
TUE	Mr.	Jasen Markovski	Post-doc	Eindhoven	Netherlands
TUE	Mr.	K. Starkov	Ph.D.	Eindhoven	Netherlands
UCY	Mr.	Dimitris Iliades	Ph.D.	Nicosia	Cyprus
UCY	Mr.	Christos Kourtellaris	Ph.D.	Nicosia	Cyprus
UCY	Mr.	Theofanis Lambrou	Ph.D.	Nicosia	Cyprus
UCY	Mr.	Dimitris Stavrou	Ph.D.	Nicosia	Cyprus
UCY	Mr.	Photios Stavrou	Ph.D.	Nicosia	Cyprus
UCY	Mr.	Ioannos Tziortzis	Ph.D.	Nicosia	Cyprus
UGE	Dr.	Jonathan Rogge	Post-doc	Gent	Belgium
UGE	Mr.	Nicolae-Emanuel Marinica	Ph.D.	Gent	Belgium
UGE	Mr.	Mohammed Moradzadeh	Ph.D.	Gent	Belgium
UPO	Mr.	Rui Manuel Ferreira Gomes	Ph.D.	Porto	Portugal
UVR	Dr.	Davide Bresolin	Post-doc	Verona	Italy
UVR	Dr.	Marta Capiluppi	Post-doc	Verona	Italy
UVR	Dr.	Luca Geretti	Post-doc	Verona	Italy
UVR	Dr.	Riccardo Muradore	Post-doc	Verona	Italy
UVR	Mr.	Francesco Stefanni	Ph.D.	Verona	Italy
UVR	Mr.	Matteo Lissandrini	web design	Verona	Italy
UVR	Dr.	Pieter J. Collins	Post-doc	Verona	Italy
UVR	Dr.	Matteo Piccoli	Post-doc	Verona	Italy
UVR	Dr.	Giovanni Castagnetti	Post-doc	Verona	Italy

The number of junior researchers paid by the C4C Project is then

14	Ph.D. students
9	Post-docs
1	Staff member
24	Persons

Listed below are the senior researchers paid by the project. All persons listed are paid for a fraction of the work time. The list is structured by the teams.

- CWI. Jan H. van Schuppen.
- CER.
- TUD. Jos Vrancken.
- UCY. Charalambos D. Charalambous, Christoforos Hadjicostis.
- UGE. René K. Boel.
- UPO.
- UVR. Prof. Tiziano Villa, Prof. Paolo Fiorini, Prof. Roberto Segala, Dr. Davide Quaglia.
- HNN. Jan Tijmen Udding.
- MST. Alexandre Sousa and Luís Madureira.
- OCE. Lou Somers.
- TRI.

## **10.2 Researchers active for the project but not paid by the project**

The reasons that the costs for the research activities of the persons mentioned below were not charged to the project are varying. Financial reasons or administrative reasons applied mostly. The researchers mentioned below were active for the project part time during the reporting period.

- CWI. Luc C.G.J.M. Habets (Department of Mathematics, Eindhoven University of Technology, Eindhoven, The Netherlands) senior researcher. He has been active for WP7 Control during the third year of the project.  
André C.M. Ran (Department of Mathematics, VU University Amsterdam, Amsterdam, The Netherlands). He is the co-advisor of the Ph.D. student Pia L. Kempker and co-worker of Jan H. van Schuppen. He has been active for WP7 Control during the third year of the project but also during the first two years.
- TUD Prof.dr. Alexander Verbraeck and Prof.dr. Frances Brazier.
- TUE Qin Li Department of Mechanical Engineering, Eindhoven University of Technology, Eindhoven, The Netherlands), post-doc researcher. He has been active for WP5 AGVs.
- TRI. Frank Ottenhof (Director and researcher of the company), Marcel Valé (researcher and manager), Peter van Seventer (developer at Trinit), and Yubin Wang (developer and Ph.D. student).

### 10.3 Financial resources - Overview

At the time this deliverable D-WP1-3 needs to be submitted to the European Commission, 30 April 2011, there is no information available yet on the financial means used for the project in the reporting period. It seems likely that the life time of the project is extended from 1 May 2011 till 1 September 2011. If so, then the reporting period will be extended to the period of 25-40 months. The financial information will then become available only in the Fall of 2011. The financial report will be included in the C4C Final Report which is due 30 November 2011 if the project is extended.

This subsection therefore contains only information on the budget of the project and overall information on the first two years of the project.

The project budget is summarized by the following table taken from Annex 1 of the Grant Agreement. If the contract for the extension of the C4C Project is signed, then there will be a change in the distribution of the financial resources. The reasons for the change in the budget is that the UPO Team needs additional budget for the demonstration of the autonomous underwater vehicles planned for the C4C Review Meeting 2011 and that the UCY Team is almost depleted its travel budget. The UCY Team has four senior researchers which are also leaders of four workpackages and because of the extreme location inside the European Union has higher travel costs than the other teams. The C4C General Assembly has voting in favor of a proposal made by the coordinator. The budget change will become effective only after the European Commission signs the contract on the amendment for the extension of the C4C Project.

The proposal for the change in the EU Contribution for the C4C Teams is:

Team	EU Contribution Grant Agreement	EU Contribution Change	EU Contribution New value
CWI	364.920	- 6.000	
CWI		- 4.000	354.920
CER	202.080		202.080
TUD	324.000	- 3.000	321.000
TUE	416.000	- 3.000	413.000
UCY	304.000	- 3.000	
UCY		+ 4.000	305.000
UGE	233.000		233.000
UPO	272.000	+ 24.000	296.000
UVR	356.000	- 3.000	353.000
HNN	43.000	- 3.000	40.000
MST	182.000		182.000
OCE	24.500	- 2.000	22.500
TRI	178.500	- 1.000	177.500
C4C	2.900.000		2.900.000

The cost statements provided by the teams for the first two years of the life time of the project will be listed in the following tables. Due to the many columns, the table is split into three separate tables. The sources of these tables are: Annex 1 and the NEF costs statements. NEF is a webbased computer program of the European Commission for the finances of EU sponsored projects. Below reference is made to the original budget of the Grant Agreement, not to the modified budget.

Costs in Year 1 and Year 2 are distinguished into the following categories: (A) RTD Innovation. (B) Demonstration. (C) Management. (D) Other.

There follows first the table with the costs of RTD Innovation. The RTD costs in the second year of the project are 61,7 % of the budgetted costs (= 2.411.302,00/3.906.657,33).

Team	RTD/Innovation Budget	RTD Costs Cum.	RTD Costs Year1	RTD Costs Year2
CWI	432.300,00	212.646,00	43.757,00	168.889,00
CER	269.440,00	124.311,00	33.142,00	91.169,00
TUD	421.333,33	284.802,00	126.556,00	158.246,00
TUE	546.000,00	437.864,00	182.313,00	255.551,00
UCY	396.332,00	162.234,00	78.582,00	83.652,00
UGE	310.667,00	173.564,00	57.875,00	115.689,00
UPO	358.934,00	241.234,00	113.172,00	128.062,00
UVR	470.624,00	389.013,00	179.849,00	209.164,00
HNN	72.000,00	10.262,00	9.602,00	660,00
HNN Demonstration		6.320,00		6.320,00
MST	239.467,00	124.670,00	45.470,00	79.200,00
OCE	43.560,00	16.521,00	2.594,00	13.927,00
TRI	346.000,00	234.361,00	122.397,00	105.464,00
C4C	3.906.657,33	2.411.302,00	995.309,00	1.415.993,00

Next there follows a summary of the cost statements for Management Costs.

Team	Management Budget	Management Costs Cum.	Management Costs Year 1	Management Costs Year2
CWI	40.695,00	16.109,00	9.207,00	6.902,00
CER	0,00		0,00	0,00
TUD	8.000,00	6.227,00	3.000,00	3.227,00
TUE	6.500,00		0,00	0,00
UCY	9.000,00		0,00	0,00
UGE	0,00		0,00	0,00
UPO	2.800,00	2.792,00	2.792,00	0,00
UVR	3.032,00			0,00
HNN	7.000,00	24.417,00	9.636,00	14.781,00
MST	2.400,00	1.343,00	375,00	968,00
OCE	3.000,00		0,00	0,00
TRI	5.500,00	6.500,00	0,00	6.500,00
C4C	87.927,00	57.388,00	25.010,00	32.378,00

Finally there follows the costs statement for the totals. In the first two years of the life time of the project 61,8 % of the budgetted cost was spent (= 2.470.473,00/3.994.584,33). Not listed are the two minor corrections of the teams CWI and UGE.

Team	Total Budget	Total Costs Cum.	Total Costs Year1	Total Costs Year2
CWI	472.995,00	228.755,00	52.964,00	175.791,00
CER	269.440,00	124.311,00	33.142,00	91.169,00
TUD	429.333,33	291.029,00	129.556,00	161.473,00
TUE	552.500,00	437.864,00	182.313,00	255.551,00
UCY	405.332,00	162.234,00	78.582,00	83.652,00
UGE	310.667,00	173.564,00	57.875,00	115.689,00
UPO	361.734,00	244.026,00	115.964,00	128.062,00
UVR	473.656,00	398.013,00	179.849,00	209.164,00
HNN	79.000,00	42.157,00	20.396,00	21.761,00
MST	241.867,00	126.638,00	46.470,00	80.168,00
OCE	46.560,00	16.521,00	2.594,00	13.927,00
TRI	351.500,00	234.361,00	122.397,00	111.964,00
C4C	3.994.584,33	2.470.473,00	1.022.102,00	1.448.371,00

The EU contribution of the cost statements are summarized in the next table.

Team	EU Contribution Cumulative	EU contribution Year 1	EU contribution Year2
CWI	174.389,00	42.024,00	133.568,00
CWI			- 1.203,00
CER	93.232,00	24.856,00	68.376,00
TUD	219.806,00	97.917,00	121.899,00
TUE	328.397,00	136.734,00	191.663,00
UCY	121.675,00	58.936,00	62.739,00
UGE	141.312,00	43.406,00	86.766,00
UGE			+ 11.140,00
UPO	183.717,00	87.671,00	96.046,00
UVR	291.759,00	134.886,00	156.873,00
HNN	33.866,00	15.595,00	18.271,00
MST	95.470,00	35.102,00	60.368,00
OCE	8.260,00	1.297,00	6.963,00
TRI	177.395,00	91.797,00	85.598,00
C4C	1.869.278,00	770.221,00	1.099.057,00

Payments by the European Commission. The sources of the following table are Annex I and the CWI Financial Administration for the distribution of the Advance Payment.

Team	EU contrib. Annex 1	EU Payments Cumulative	EU Advance paym.	EU Year 1	EU Year 2	EU Year 3
CWI	364.920,00	253.988,00	170.512	42.024	41.452	
CER	202.080,00	171.768,00	94.416	24.856	52.496	
TUD	324.000,00	275.400,00	151.381	97.917	26.102	
TUE	416.000,00	353.600,00	194.375	136.734	22.491	
UCY	304.000,00	258.400,00	142.045	58.936	57.419	
UGE	233.000,00	198.050,00	108.861	43.406	45.783	
UPO	272.000,00	272.000,00	127.085	87.671	57.244	
UVR	356.000,00	302.600,00	166.340	134.886	1.374	
HNN	43.000,00	36.550,00	20.095	15.595	860	
MST	182.000,00	154.700,00	85.040	35.102	34.558	
OCE	24.500,00	12.747,00	11.450	1.297	0	
TRI	178.500,00	175.197,00	83.400	91.797	0	
C4C	2.900.000,00	2.465.000,00	1.355.000	770.221	339.779	

There follows the table with the claimed EU contribution of Year 1 in comparison with the Advance Payment and the Budget. The sources of the information are the data in the NEF tool for the C4C Project, the CWI Financial Administration for the distribution of the Advance Payment, and Annex I for the budget.

Team	EU Contribution Cumulative	EU Payments Cumulative	Budget
CWI	174.389,00	212.536,00	364.920,00
CER	93.232,00	119.272,00	202.080,00
TUD	219.806,00	249.298,00	324.000,00
TUE	328.397,00	331.109,00	416.000,00
UCY	121.675,00	200.981,00	304.000,00
UGE	141.312,00	152.267,00	233.000,00
UPO	183.717,00	214.756,00	272.000,00
UVR	291.759,00	301.226,00	356.000,00
HNN	33.866,00	35.690,00	43.000,00
MST	95.470,00	120.142,00	182.000,00
OCE	8.260,00	12.747,00	24.500,00
TRI	177.395,00	168.998,00	178.500,00
C4C	1.869.278,00	2.465.000,00	2.900.000,00

## **11 Certificates**

No certificates can be reported in this deliverable because the financial reporting will be completed after the deliverable has been submitted. The information on the certificates will be included in the C4C Final Report which is due three months after the C4C Project has been terminated. The rules for the certificates are defined in Grant Agreement Article II.4.4.

## **12 Response to C4C Review 2010**

The report of the C4C Review 2010 lists several recommendations for the C4C Consortium. A few of the suggestions are discussed elsewhere in this deliverable. It does not seem of interest to be more explicit in the C4C Consortium reaction to the review report at this time. During the C4C Review Meeting the issues of the 2010 report can be discussed.