

The ECHORD (European Clearing House for Open Robotics Development) Project

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Abstract. ECHORD (European Clearing House for Open Robotics Development) is an EU-funded Large-scale Integrating Project (IP) aiming to strengthen the cooperation between scientific research and industry in robotics. ECHORD is coordinated by the Technical University of Munich and co-coordinated by the University of Naples Federico II and the University of Coimbra. Europe has a very strong robot industry and there is significant research potential as well as technological knowledge. There has been a long history of outstanding research and development in both robot manufacturers and research institutes. However, finding common ground between manufacturers and the research community has proven difficult in the past. This is one of the recurring themes on both sides, and a new level of cooperation is long overdue. Thus, ECHORD acts as a “clearing house” to streamline successful know-how transfers. It is truly open to those entrepreneurial research institutes able to carry out challenging robotics development in cooperation with manufacturers which are interested in focusing on research and technology development. This paper presents the contribution of the research groups belonging to the PRISMA group to the project.

1 Project's overview

The project consortium is composed by the coordinating partners, detailed in Table 1, as well as by partners conducting the so-called *experiments*, added to the original coordinating partners during the project development. The start date of the project was January 1st 2009, the programmed closing is on February 28th 2013.

PARTNER	COUNTRY	RESPONSIBLE
Technische Universität München	Germany	A. Knoll (Coordinator)
Università degli Studi di Napoli Federico II Linked to ECHORD via the PRISMA Lab:	Italy	B. Siciliano (Co-Coordinator)
Università degli Studi della Basilicata	Italy	F. Caccavale
Università degli Studi di Cassino	Italy	S. Chiaverini (ExC Chair)
Seconda Università di Napoli	Italy	C. Natale
Università degli Studi di Roma Tre	Italy	L. Sciavicco
Università degli Studi di Salerno	Italy	P. Chiacchio
Universidade de Coimbra	Portugal	N. Pires (Co-Coordinator)

Table 1. ECHORD consortium (coordinating partners).

1.1 Experiments

In the context of ECHORD, small-scale projects, so-called *experiments* are conducted, which use state-of-the art robot equipment. The proposers of experiments, typically research institutes, are given the opportunity to buy equipment from a qualified equipment list from European Robot manufacturers at special prices. To this aim three calls for equipment quote have been issued. The research institutes perform research and development with relevance to industrial applications, so as to initiate knowledge transfer between industry and academia. The timing of the three calls are reported in Table 2.

CALL	QUOTE FOR EQUIPMENT	CALL FOR EXPERIMENTS
1	Jul 15–Aug 24, 2009	Oct 5–Dec 1, 2009
2	Feb 10–Mar 5, 2010	Mar 16–Apr 30, 2010
3	Jul 9–Aug 10, 2010	Aug 24–Oct 1, 2010

Table 2. Timing (opening and closing dates) of the three ECHORD calls.

Three *scenarios* for likely future robot use have been defined to outline the scope of research work to be performed in the experiments. These scenarios make it possible for all stakeholders to get a clear picture if and how their proposed work and envisaged results can be embedded into a coherent vision of robotic applications. Thus, they describe the application context from an exterior view. For breaking down the application-driven scenarios into concrete, four *research foci* have been identified. The research foci guide the research work. They were chosen so as to provide a complete coverage of the relevant aspects of all the scenarios.

Scenarios The set of research topics and subjects in the field of robotics is virtually unlimited. Thus, ECHORD uses a clear thematic research orientation which is reflected in scenarios. Three scenarios have been identified which are both scientifically challenging and commercially relevant. They represent comprehensive sets of

challenges in an illustrative way, so that robotics experts can easily relate their own research to them. The scenarios build on each other.

The first scenario of ECHORD is the *human-robot co-worker*. In this scenario, the traditional idea of a robot performing pre-programmed action will change drastically, in that a robot co-worker interacts with a human towards achieving a common goal.

The second scenario is the *hyper-flexible cells* scenario. This scenario envisages not only one or more highly dexterous and cooperative robots, but also the hardware and software integration of the robots with an automatic warehouse system and the other devices present in the cell.

The third scenario is the *cognitive factory*. This future scenario will embrace both the first and the second scenario and take the classical concept of the flexible manufacturing systems to a new level. Cognitive factories will, to a large extent, configure themselves and be fault-tolerant. They will contain autonomous robots jointly participating in the production process with their human counterparts

Research Foci Within the scenarios, different research foci have been identified. The research foci are reference points for the expected scientific progress of experiment proposals. They bring together mechanical design and controller technology from manufacturers with the knowledge and experience in sensing, cognition and behaviour control of the research community.

The first research focus is on *human-robot interfacing and safety*. Here, the main goal of the experiments is to show that safe human-robot cooperation is possible, taking all kinds of sensor failures and inconsistencies into account.

The second research focus is on *robot hands and complex manipulation*. Here, the experiments will have to show the improvement of laboratory setups towards practical usability as well as promising breakthroughs in the areas of sensors and sensor-guided manipulation.

The third research focus is on *mobile manipulators and cooperation*. Here, mobile manipulators will have to solve concrete problems in dynamically changing environments with moving obstacles and interaction with humans.

The fourth research focus is on *networked robots*. Here, two areas are possible: One is networked industrial robots, where we expect demonstrators that can only be built in collaboration between industry and academia, with industry providing controller architecture and academia contributing knowledge in advanced real-time networking technologies as well as service-oriented architectures. The second area concerns more loosely coupled systems, where experiments with mobile robots are expected that establish new showcases, e.g. in the area of search and rescue with robots, new applications of robots in urban areas, and robot systems for monitoring tasks.

1.2 Work plan

The work plan is structured into five work packages (Figure 1), which are aimed at achieving not only the goals formulated for technology transfer, but also additional goals for communications, monitoring and dissemination.

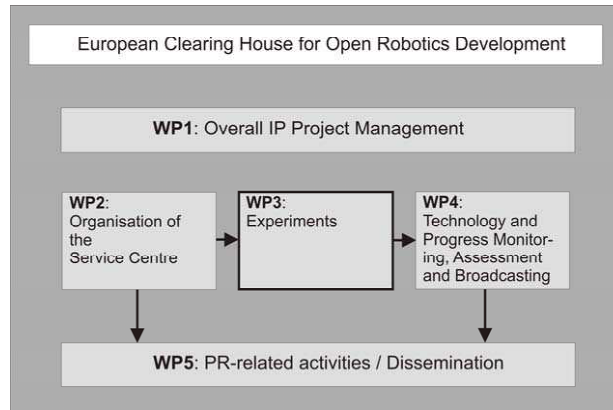


Fig. 1. Work package structure of ECHORD.

Apart from WP1, which contains all tasks related to project co-ordination and management, three work packages (WP2–WP4) focus on the technology transfer experiments in the interaction with RoM (Robot Manufacturers) and ReIO (Research Institutions and/or Organisations), their preparation and their evaluation. WP5 is concerned with public relations and dissemination in a wider sense (i.e., for RoM and ReIO, but also for the general public). WP 3 addresses the evaluation of proposals for experiments and the “clearing” of experiments. The Service Centre (WP2), apart from keeping the contact with RoM and ReIO, is involved in soliciting proposals and their pre-processing for evaluation. At the “other end”, WP4 is focused on processing of results of the experiments, drawing conclusions and continuously updating the research foci. In the following, the main aspects of the individual work packages are described.

WP1: Overall IP Project Management The objective of WP1 is to provide administrative, organizational and technical management to facilitate effective coordination of the project; the handling of legal issues and the management of relations with the EC - ensuring that the project complies with all relevant requirements and regulations. The first task of WP1 is project ‘boot-strapping’, i.e., to set up the IP management bodies: the Executive Committee (ExC), the Service Centre (SC) and the Advisory Board (AB). The regular and permanent tasks include the overall IP project management, which must: (i) ensure the timely and proper handling of all

financial matters, (ii) set up a reporting structure that helps to monitor the project schedules and timing as well as experiments' results, (iii) ensure that a communication flow is established between all participants that helps the scope of the project to be maintained during the project life, (iv) provide an adequate quality management and the identification of all the risks that can occur.

WP2: Organisation of the Service Centre The Service Centre is the “pulse” of the project and performs all the day-to-day operations for the project. It is the central contact point for all internal and external requests and questions. It is the permanent network secretariat, handles the paperwork and submission procedures for experiment proposals, and it is the operator of the electronic infrastructure (website, archives, teleconferencing). It is an active unit that continuously informs the communities of ReIO and RoM about relevant developments. It performs all the day-to-day tasks related to public relations, international cooperation, organisation of conferences, workshops and meetings (including agenda, minutes, follow-up actions), etc. The Service Centre, hence, provides continuous support to ReIO and RoM, but also to all other external individuals who are interested in robotics.

WP3: Experiments WP3 concentrates the work dealing with the first four phases of the experiments' lifecycle according: Issuing of calls, evaluation, selection and monitoring. The entire process of the consecutive issuing of calls and the sequence of individual phases of experiments' lifecycles are shown in Figure 2. The lion's share of the work concerned with the management of the experiments is bundled in WP3, whereas the reporting and result extraction is concentrated in WP4. The calls will vary in content, since the focus of each of them has been focused on a different scenario.

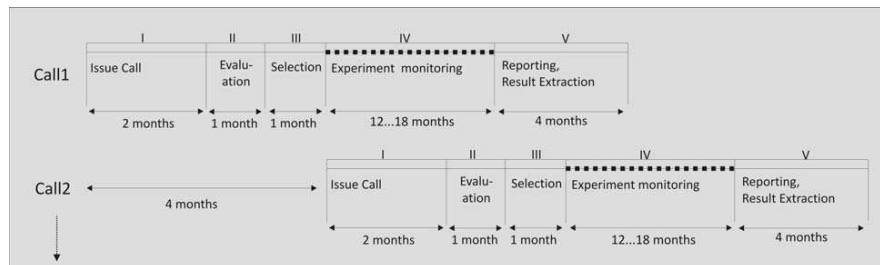


Fig. 2. Experiment phases and sequencing of calls.

In Phase I (*Issue Call*) two main activities take place: (i) Release and publication of call text (this starts Phase I) (ii) Help to initiate new partnerships between RoM and ReIO via hands-on brokering mechanisms and coaching. For item (i), the scientific issues to be addressed by proposals submitted in response to the call are defined by the four research foci. The call text (and documents referenced in it) advises the

prospective proposers on the kind of research that responds to the research foci (i.e., the reference points for the proposers) and more general ECHORD objectives. In order to attract as many potential partners as possible to submit proposals, in Phase I, the potential partners have been encouraged to submit pre-proposals until four weeks after the call start date. The response of ECHORD staff is limited to clarifying whether each pre-proposal fits into the call's scope (innovation, compatibility with call).

In Phase II (*Evaluation*), the full proposals are evaluated by two independent experts. In contentious evaluations, where the two evaluators per proposal have not agreed on a score, the ExC has the discretion to involve a third evaluator. The critical issues handled in the evaluation process are: (i) the selection of the evaluators, (ii) the evaluation, (iii) the acceptance/ranking criteria.

Phase III (*Selection*) ranks the experiments to be funded in a one-day on-site evaluation panel. The ranking is based on the individual evaluation reports from the remote evaluation, which will have to be calibrated by an evaluation panel. An annotated ranking and selection of the proposals is compiled at the end of the evaluation panel, together with evaluation summary reports. The reports and evaluation panel minutes are then forwarded to the Commission. At the end of Phase III, the proposals are modified as necessary to produce the contractual Descriptions of Work, and the budget for the experiments is finalised. The experimenters of selected proposals are proposed for accession to the ECHORD Grant Agreement by means of a request for amendment submitted to the Commission.

Phase IV (*Experiment monitoring*) can be considered the main challenge in the experiment flow (WPs 3 and 4). Experimenters have to submit six-monthly regular reports about the experiments to the ExC (via the Service Centre). Experiments have a specific (small) set of deliverables including regular (short) reports (typically one page), which are evaluated against the terms of the experiment's Technical Annex. In return for being lightweight in terms of preparatory paperwork, every experiment (which also means: every experiment type) has to produce a final demonstrator presenting the promised features. During the duration of the experiment, the experimenters are invited to produce multimedia material (video and pictures) showing their progress. Pre-versions of the demonstrator need to be in place as soon as possible, so that a mid-term review or demonstration can be performed.

WP4: Technology and Progress Monitoring, Assessment and Broadcasting This WP has been designed to monitor progress (in the outside robotics community as well as in the experiments) and to ensure that (emerging) trends relevant to ECHORD are detected. Moreover, roadmaps and overview workshops organised by the EU and by others are regularly evaluated and used for updating the research foci. The outcome of these studies is used internally to direct the discussions within ECHORD and are published as short position papers whenever appropriate. WP4 is in charge of assessing, consolidating and publishing the results of the experiments. WP4 also implements the concept of the structured dialogue, i.e., an iterative pro-

cess of successive information gathering and consensus finding between all parties involved in the operations of ECHORD.

WP5: PR-related activities / Dissemination In close cooperation with WP4, the main goal of WP5 is to make ECHORD known as the central agency/information point for the European robotics industry, to increase the general public's and the international community's awareness of the importance of European robotics science, for attracting potential experimenters, for branching out into new scientific disciplines, and for developing working relationships with other bodies and organizations that actively promote robotics. While WP4 is geared towards broadcasting relevant information into the more limited communities of RoM and ReIO with targeted and highly specialised information, WP5 comprises project-related activities that could also be of interest to the broader scientific community (e.g., ECHORD workshops) with dissemination of information about the project to a much wider audience (e.g., through press releases about ongoing work in the experiments). For the latter, the primary dissemination medium is the WWW-Site (which is maintained as part of WP2).

2 PRISMA Contributions to ECHORD

The PRISMA group participates to ECHORD as a Joint Research Unit (JRU). The roles and the key persons of each PRISMA unit within ECHORD are summarized in Table 3.

PARTNER	KEY PERSONS
Università di Napoli Federico II	B. Siciliano (Unit resp., Co-Coordinator) L. Villani (Area Editor)
Università della Basilicata	F. Caccavale (Unit resp., ExC Member)
Università di Cassino	S. Chiaverini (Unit resp., ExC Chair) G. Antonelli (Area Editor)
Seconda Università di Napoli	C. Natale (Unit resp., Area Editor)
Università di Roma Tre	L. Sciavicco (Unit resp.) F. Pascucci (Area Editor)
Università di Salerno	P. Chiacchio (Unit resp.)

Table 3. The PRISMA JRU in ECHORD.

It can be recognized that PRISMA is heavily involved in project coordination, B. Siciliano is co-coordinator and member of the Coordination Committee (CC), as well as in management of the core activities, S. Chiaverini serves as ExC Chair and F. Caccavale is member of the ExC. Moreover, the four Area Editor involved in the evaluation process are all PRISMA members. Moreover, the PRISMA JRU has been involved in the pre-proposal processing in all the three calls (P. Chiacchio).

Members of the PRISMA group have participated to the following meetings:

- Munich, 30 April 2009: Kick-off meeting.
- Brussels, 6 July 2009: CC meeting;
- Naples, 17–18 June 2009: ExC meetings.
- Munich, 3 September 2009: ExC meeting.
- Naples, 17–18 November 2009: ExC, CC and AB meeting;
- Munich, 4 September 2009: Infod day.
- Naples, 9 December 2009: ExC meeting.
- Luxembourg, 26 March 2010: CC meeting.
- Munich, 9-10 June 2010, 13 July 2010, 8-9 December 2010: ExC meetings.
- Ismaning 16 December 2010: AB meeting.

Although the PRISMA JRU is involved in all work packages, the PRISMA activities of the first two years have been mainly focused on WP3 and WP5. Thus, in the following, the activities related to experiments handling and dissemination will be described in more detail.

2.1 Experiments

The PRISMA JRU has contributed to the preparatory activities (Phase I of WP3) of the call issue. In detail, in order to launch each Call for Experiment Proposals, give the proposers suitable information sources and properly handle the evaluation process, a number of documents accompanying the call text were generated for Call 1 and updated, according to the evaluation process adaption, in Call 2 and 3:

- Call for Experiment Proposals. This was the official text of the call and contained: publication date, deadlines, background information about ECHORD aims and scope, information about form and content of proposals (including financial issues, evaluation and ECHORD consortium joining). The call text had two annexes:
 - Guide for Applicants. This text provided, in more detail, information and directions to applicants related to: ECHORD background information, coaching and pre-proposals, budgetary and financial issues, form of proposals, submission, evaluation and selection, implementation and monitoring.
 - Template for Experiment Proposals. This document represented the official template for writing and submitting the proposals. More detailed information on specific items of the proposal text has been provided in this document.
- Guide for Independent Experts, aimed at providing a closer view of the evaluation process and a set of evaluation guidelines for independent experts who agreed to act as evaluators.
- Two documents were generated for the proper handling of experts contracting:
 - Conditions of appointment for independent experts.
 - Acceptance of the appointment letter for independent experts.

A significant amount of time was dedicated to setting up a list of independent experts. An initial list with about 170 names was drawn up and discussed by the ExC. Using the forms available on the ECHORD web platform, the experts could indicate their availability and possible conflicts of interest. From this set of experts, 52 were finally chosen to act as evaluators and rapporteurs. On average, each expert was assigned 6 proposals, 4 for initial evaluation and 2 for which they would act as a rapporteur. The same procedure of expert list refinement and evaluators selection took place for Call 2 and 3. For Call 2, an updated list with about 70 names of available experts was created and discussed within the ExC. From this set of experts, 44 were chosen to act as evaluators and rapporteurs. On average, each expert was assigned 5 proposals, 3 for initial evaluation and 2 for which they would act as a rapporteur. For Call 3, a new list with about 80 names of available experts was created and discussed within the ExC. From this set of experts, 33 were chosen to act as evaluators and rapporteurs. On average, each expert was assigned 6 proposals, 4 for initial evaluation and 2 for which they would act as a rapporteur.

Furthermore, an evaluation procedure was determined and then refined in Call 2 and 3. In detail, the evaluation developed according to the following steps:

- Initially, 2 experts independently evaluated the proposal.
- A 3rd evaluator was involved if the two initial evaluators' opinions differed as to whether or not the proposal was above the thresholds (each section mark above a threshold of 3 and the sum of the three marks not less than 10), or if the difference between individual markings for two sections was greater than or equal to 1.5 points for each section.
- When the individual evaluations were completed, the rapporteur started the consensus blog (via ECHORD web platform).
- Once the consensus was reached, the rapporteur prepared the final report and submitted it for approval by the other evaluators.

All of the above steps were handled via the ECHORD web platform. In Call 1 and 2, during the evaluation process, each Area Editor monitored a group of evaluators to provide advice and support. However, this set up caused overlapping communications between ECHORD staff and evaluators, since individual proposals were handled by experts supported by different Area Editors. Hence, in Call 3, a different assignment logic was adopted. Namely, four separate groups of experts were formed. Each group of experts covered a group of proposals that were separate and distinct from the others. In this way, each Area Editor was in charge of one group of experts and one group of proposals, thus avoiding over-lapping.

In the first Call for Experiment Proposals, there were a total of 117 pre-proposals received, processed and commented. The call was closed on December 1, 2009 and ECHORD received 108 proposals which were evaluated. In the second Call for Experiment Proposals, there were a total of 37 pre-proposals received, processed and commented. The call was closed on April 30, 2011, and for this call ECHORD received 70 eligible proposals which were evaluated. In the third Call for Experiment Proposals, there were a total of 44 pre-proposals received, processed and

commented. The call was closed on October 1, 2011, and for this call ECHORD received 65 eligible proposals which were evaluated.

As for the Phase III (Selection), for each Call, first preparations for the Panel Meeting took place, which comprised the following steps:

- Setting up panel meeting details: number of independent experts to be invited, place, indicative date.
- Detailed procedures to achieve ranking during panel (proposals with equal scores, etc.).
- Setting up procedures for awarding of selected experiments, i.e., for accession to ECHORD Grant Agreement (GA).

All three panel meetings were held in the Munich area: the first one on February 26, 2010, the second one on July 13, 2010, and the third one on December 9, 2010, all moderated by the ECHORD ExC Chair and the ECHORD Project Manager. Each panel consisted of a group of about 10 independent experts who acted as evaluators and rapporteurs for the respective call. During the panel meeting, the panelists discussed the evaluation reports and the corresponding scores, especially in cases where the consensus among the evaluators and the rapporteur of a proposal could not be easily reached or cases brought up by a panelist when revising a set of proposal evaluations assigned to him or her. After that, as the final result of the tasks of the independent experts, the panel agreed on a ranking of the proposals above the thresholds (as defined in the call texts and the Guides for applicants). Based on that ranking, ECHORD discussed the “cut-off line” between the proposals to be funded and those not to be funded even though they were above the thresholds. This limit was defined based on the indicative budget as given in the call texts and on the necessity of avoiding splitting one group of proposals which had equal overall scores.

In the first Call 16 experiments were selected, where in Call 2 and 3 20 and 15, respectively, were selected and proposed for funding.

Due to the fact the official start of the experiments selected in Call 1 was October 1 2010, the remote and on-site monitoring of the experiments did not begin in 2010. Thus, the main objectives for the period were to define the monitoring procedures (i), to implement these procedures (ii) and to extract results from the monitoring activities (iii). The implementation of the Phase V activities (including on-site reviews, assessment of the work performed, including usefulness to industry and research) started with the general definition of the monitoring process framed in a general roadmap. The monitoring strategies were extensively discussed between core partners and resulted in the communication scheme presented in Figure 3. The central node of this communication platform is a customized blog that handles the communication between the experimenter, the moderator (ECHORD core), the ECHORD consortium and the general public. To ensure the proper levels of data privacy and to promote inter-experiment communication, 3 levels of privacy were de-fined and implemented in this blog: private (experimenter and ECHORD core), consortium (ECHORD consortium) and public. Furthermore, in order to keep the monitoring tasks effective and lightweight, this blog reports where defined in

a way that promotes the reuse of Summaries in the final annual reporting and the automatic maintenance of a Wikipage based on the public parts of the summary.

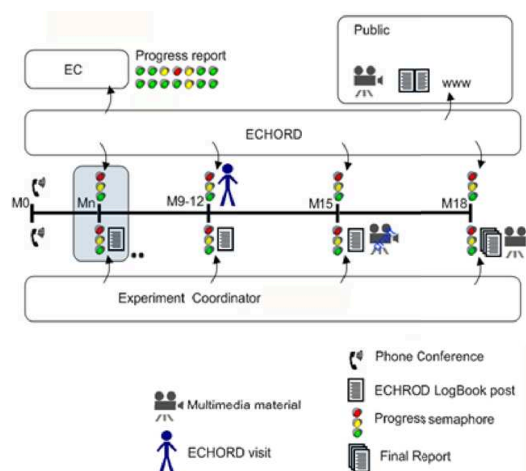


Fig. 3. Communication scheme.

Two documents resulted from this process: the Guide for experimenters and the IT guide for the platform.

Finally, it is worth mentioning the Lab Tour initiative. Inspired by the results of the well-known WTEC tour of 2005/2006, the ECHORD action plan calls for two international lab tours: the first one to North America and Canada in the first half of October 2011, and the second one to Asia in April/May 2012. The experiences of these tours, combined and described in detail in a final report which will be presented at the AUTOMATICA fair in Munich in June 2012, can be expected to make a major contribution to the “structured dialogue” beyond the European continent. Thus, ECHORD will not only profile the current state of European research, but will also provide a cross-section of research both academic and industrial from beyond the borders of Europe. B. Siciliano will contribute to the Lab Tour initiative.

2.2 PR-related activities / Dissemination

As for WP5 activities, PRISMA has contributed to generation of content for the website and for presentation at all other events (in the form of papers and slides):

- press club,
- project presentations,
- call texts for equipment quotes and experiment proposals,
- inputs to FAQ.

The PRISMA group presented ECHORD in a number of conferences and meetings:

- IEEE International Conference on Robotics and Automation, May 2009, Kobe, Japan.
- IEEE/RSJ International conf on Intelligent Robots and Systems, October 2010, St. Louis, MO, USA.
- Schunk Expert Days, February 2010, Brackenheim, Germany.
- EUROP/EURON annual meeting, March 2010, San Sebastian, Spain: organization and participation to workshops.
- IEEE International Conference on Robotics and Automation, May 2010, Anchorage, Alaska: organization of the Workshop *The European Effort to Strengthen Academia-Industry Collaboration*.
- AUTOMATICA Fair, Munich, Germany, June 2010: ECHORD presentation and kick-off meeting for selected experiments.
- Portuguese Control Conference, Coimbra, Portugal, September 2010.
- Directorate E INFSO, Luxembourg, December 2010.
- National University of Singapore / SMART, Singapore, December 2010.
- European Robotics Forum, Västerås, Sweden, April 2010.
- IEEE International Conference on Robotics and Automation, Shanghai, China, May 2011.

Finally, the PRISMA group contributed to content generation for media coverage (announcements posted in several newspapers, journals, and mailing lists, articles in newspapers and journals) and press release (press release after kick-off and info days, ads in the major european newspaper). In detail, B. Siciliano co-authored two articles published in the *IEEE Robotics and Automation Magazine* (September 2009 and December 2010) focused on ECHORD activities and outcomes.

3 Conclusions

A short overview of the activities carried out by the PRISMA group in the first two years of the ECHORD project has been given, with special emphasis on the handling of the first three phases of the experiments' lifecycle (issuing of the calls, evaluation and selection). The activities of next two years will be focused mainly on Phase IV (monitoring of the experiments), which are, in turn, strictly related to the activities of WP 4 (technology and progress monitoring, assessment and broadcasting).