Coordination of Biological and Chemical IT Research Activities

FP7-ICT-2009.8.9 Coordinating Communities, Plans and Actions in FET Proactive Initiatives
Project No. 270371

www.cobra-project.eu

Annual Project Activity Report – Year 2

WP 5 D5.2

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FRONT PAGE

PROJECT PERIODIC REPORT

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Project acronym: COBRA

Project title: Coordination of Biological and Chemical IT Research Activities

Funding Scheme: FP-INFSO-FET

Date of latest version of Annex I against which the assessment will be made: 17/9/10

Periodic report: 1st ☐ 2nd ☑ 3rd ☐ 4th ☐

Period covered: 1/12/11 to 30/11/12

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Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate):

  ☑ has fully achieved its objectives and technical goals for the period;

  ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

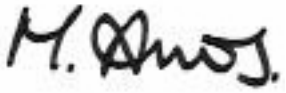
- The public website, if applicable

  ☑ is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Prof. Martyn Amos



Date: 30/1/2013

3.1 Publishable summary

3.1.1 Project context and objectives

COBRA is a coordination action to help organize the international CHEM-IT community towards the next major science and technology revolution, involving the integration of information processing with production during deployment. The industrial revolution mechanized production with factories, and the information revolution mechanized information processing with computers. The next large-scale technological revolution most likely involves their integration and its decentralization, as found so far only in living systems and it is now clear that significant scientific and technical progress towards this integration is imminent. The EC-sponsored CHEM-IT projects are spearheading the development and exploration of the first simple systems integrating production and information processing. This is done at the nano-bio-info interface, involving cellular engineering, protocells, artificial neurons and programmable information chemistry. At the centre of this work is a desire to create ICT-based systems with living and intelligent desirable properties that current technologies lack (such as robustness, autonomy, self-repair, adaptation, learning and local intelligence, as well as self-replication and evolution). The potential long-term impact of this emerging enabling technology will be considerable, as even minor progress on making technology more life-like and intelligent can improve processes in all sectors of society. CHEM-IT addresses issues of sustainability in production and deployment, and the information explosion of ubiquitous nanoscale systems. The COBRA project, centered on the coordination of biological and chemical IT research activities, will engage the European research community to construct the first roadmap for how best to develop ICT-based integrated information processing and production technology.

Our specific objectives are as follows:

- To formulate, develop and maintain a coherent European vision and strategy for bio/chem IT.
- To identify areas of critical importance in bio/chem IT, and to help focus research in these areas.
- To facilitate improvement in the quality, profile and applicability of European research in bio/chem IT.
- To provide a high-profile, high-quality framework for the discussion and resolution of current issues in bio/chem IT.
- To facilitate industrial involvement with bio/chem IT.
- To encourage and support the involvement of students and early-career researchers, and to promote high-quality teaching of topics in bio/chem IT.

3.1.2 Work performed, and main results

WP1: Stakeholder Consultation

The Community Audit has been completed, and the consultation report produced.

WP2: Strategy and Vision

The Roadmap has been designed, and the document drafting and associated vision refinement are ongoing.

WP3: Community Building

The second annual conference was delivered, as was the summer school.

WP4: Dissemination and Outreach

Public outreach activities have continued, and a journal special issue dedicated to COBRA has been produced.

3.1.3 Expected final results, potential impact and use

Being a coordination action, COBRA is primarily directed towards networking, coordination and dissemination. This proposal squarely addresses the "alternative paths to ICT components and systems" transformation specified in the work programme. The added value of the proposed activity lies in the

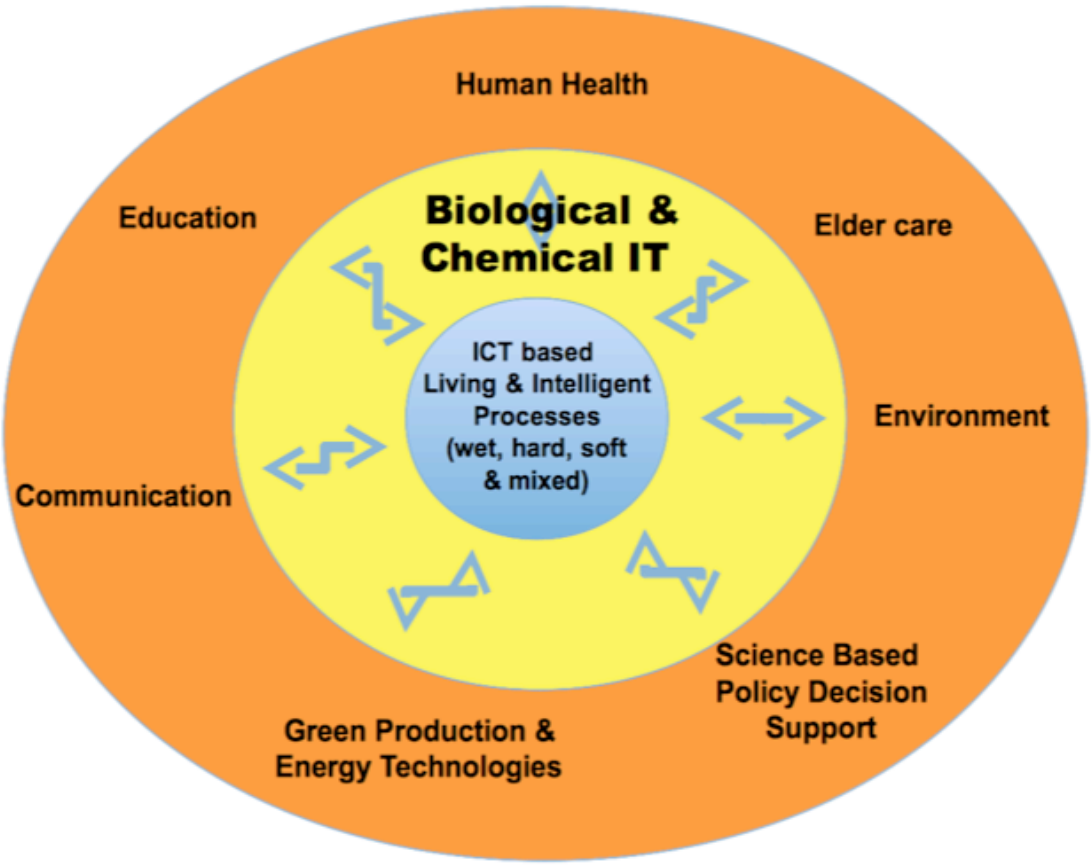
potential long-term impact of bringing together many different scientific disciplines, focussing attention on strategy and developing a coordinated and sustainable community in biological and chemical IT.

Additionally, the expected impacts for Objective ICT-2009 8.3 Proactive 3 Bio-chemistry-based Information Technology (CHEM-IT) (in which the all of the core groups address through their associated projects) are:

1. The development of ICT systems and devices that utilise interactions between components to assemble complex functional information processing materials.

2. Enable a new generating of systems capable of interfacing with conventional IT systems that are self-replicating, self-repairing and/or capable of rapid adaptation/evolution as well as flexible reconfiguration in response to changing conditions.

We depict, in the figure below, some of the potential areas in which biological/chemical IT may have a significant impact (we show only a small subset in the outer ring). We can see from this figure how biological and chemical IT connects basic science with societal needs in a very natural fashion. By harnessing combinations of living and intelligent processes with other, more traditional technological substrates, we obtain a large number of possible devices and systems which may then be applied to a raft of significant problems, such as green energy, environmental monitoring and remediation, health, elder care and materials. The potential long term impacts on European quality of life and industry cannot be overstated.



3.1.4 Project website

This may be found at http://www.cobra-project.eu.

3.2 Project objectives, work progress and achievements, project management

3.2.1 Project objectives for the period

3.2.1.1 WP1: Stakeholder Consultation

(2) To engage the scientific community, industry and other stakeholders with the development of the roadmap document. (3) To provide foundational and visionary input to the development of the roadmap.

3.2.1.2 WP2: Strategy and Vision

(1) To develop the first draft of a comprehensive roadmap document for bio/chemical IT research and development in Europe.

3.2.1.3 WP3: Community Building

(1) To provide a platform for discussion, and exchange of ideas and research personnel. (2) To integrate students and early-career researchers with the bio/chem IT community. (3) To respond dynamically to fast-changing developments in the field. (4) To provide grass-roots technical input to the roadmap and project strategy. (5) To build links between the bio/chem IT community and other related areas. (6) To foster the dynamic development of communities centred on specific areas of strategic importance.

3.2.1.4 WP4: Dissemination and Outreach

(2) To promote the national and international profile of the project, and of bio/chem IT in general. (3) To establish and maintain links with other related projects and activities, and to handle external liaison.

3.2.1.5 WP5: Management

(1) To manage and control the project resources (personnel, finance, equipment, etc.) (2) To monitor and control the financial and administrative procedures of the project. (3) To direct and coordinate communication between the Consortium, external contacts and the European Commission. (4) To monitor consistency between the project results and the strategic objectives of the partners. (5) To ensure quality assurance procedures are established and observed.

3.2.2 Work progress and achievements during the period

3.2.2.1: WP1: Stakeholder Consultation

3.2.2.1.1 Summary of progress towards objectives and details for each task

Work during this period focussed on the final objective of WP1: "To provide foundational and visionary input to the development of the roadmap document."

Tasks were as follows:

- **T1.3**: Community Audit (reported in Deliverable **D1.3**: Collective intelligence site), and
- **T1.4**: Consultation Report (reported in Deliverable **D1.4**: On-line consultation report).

Each of these tasks has been successfully completed.

Milestones in the reporting period were as follows:

- **MS5**: Establishment of collective intelligence web infrastructure (M15).
- **MS7**: Overview of community audit completed (M18).

Both of these milestones have been met.

3.2.2.1.2 Highlight clearly significant results

For T1.3, a collective intelligence website was established and used as the basis for the online audit, as it hosted the stakeholder survey. Also, the expertise database (Task T1.1) was further expanded during the audit process (see Appendix A in Deliverable 1.4 for details). As a result of COBRA activities, a broad and engaged stakeholder base has been established within the scientific community. The main issue for the initial stakeholder audit has been the difficulty of identifying *industrial* stakeholders. Despite the existence of multiple ICT-based commercial enterprises with vested interests in biotech capabilities for emerging technologies, it has been difficult to locate the appropriate stakeholders. More effort in this area will be directed towards industrial liaison as the Roadmap efforts mature.

This online (as well as in-person) consultation has established a candidate set of Roadmap components and open issues, and helped to identify possible further participants in the Roadmap development. The stakeholder feedback process has been iterative, and has provided regular digested results of community-supplied information to all stakeholders as input to successive iterations of the Roadmap.

3.2.2.1.3 If applicable, explain the reasons for deviations from the original work plan and their impact on other tasks as well as on available resources and planning.

Not applicable.

3.2.2.1.4 If applicable, explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (the explanations should be coherent with the declaration by the project coordinator)

Not applicable.

3.2.2.1.5 A statement on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary from the original work plan

The PMs used for WP1 (and contributions to WP2) are a little lower in number than planned, due to using personnel with a higher hourly rate than anticipated. The total personnel cost in euros is a little more than planned, due to more hours from personnel with a higher hourly rate than anticipated. In the final year we will be sure to even out this discrepancy.

3.2.2.1.6 If applicable, propose corrective actions.

Not applicable.

3.2.2.2: WP2: Strategy and Vision

3.2.2.2.1 Summary of progress towards objectives and details for each task

This WP began in M16. The main work in the reporting period laid the foundations for achieving the first WP objective: "To develop the first draft of a comprehensive roadmap document for bio/chemical IT research and development in Europe."

Tasks were as follows:

- **T2.1**: Roadmap Design (reported in Deliverable **D2.1**: Web-based roadmap design).
- **T2.2**: Roadmap Drafting.
- **T2.3**: Vision Development.

T2.1 has been successfully completed. Tasks **T2.2** and **T2.3** are ongoing, and are scheduled for completion in M30 and M36 respectively.

Milestones in the reporting period were as follows:

- **MS5**: Establishment of collective intelligence web infrastructure (M15). See also WP1 report.
- **MS7:** Overview of community audit completed (M18). See also WP1 report.
- **MS8**: Roadmap structure designed (M24). Documented in **D2.1**.

All three of these milestones have been met.

MS7 (M18) Overview of community audit completed. With WP1, see WP1 report.

3.2.2.2.2 Highlight clearly significant results

Following completion of the survey, the roadmap structure (**T2.1**) was designed at RUB. Firstly, the input from the survey was further analysed and refined to determine the most meaningful focus of the roadmap, that could serve as an integrative motor to help drive the interests of the community towards realization, fruition and transformative effect on society.

Then multiple structures and approaches were examined and none that were completely appropriate to the unique set of challenges inherent to this multi-disciplinary terrain found. Rather than break completely new untried ground, it was decided to build on the success of a related initiative in roadmapping the quantum computing (QC) domain, by adopting those aspects of that approach that are applicable and deleting, modifying and adding others. ChemBioICT is very different from QC in not addressing a purely computational challenge. However we managed to attain a single unique focus for the distinctive core of ChemBioICT in *attaining integrated construction and computation* and formulate an overarching objective for the roadmap associated with this (see also D2.1):

"*Integration of production and information processing down to the molecular scale*: i.e. to develop a portfolio of emerging ChemBioInfoFab Technologies by 2024 that allow humanly configured but locally (e.g. genetically) encoded, autonomous control of computed ongoing fabrication in macroscopic artifacts, with precision down to molecular scales. The technologies should be sufficiently generic to serve as a solution toolkit for a diverse range of societal and technical challenges."

The structure of the roadmapping process is geared to attaining this overarching goal, with a plurality of approaches, taking advantage of cross-cutting contributions from a number of areas. The roadmap structure included a detailed list of approaches and sub-approaches and overarching themes such as simulation, energy, and ethical aspects. It also included a detailed proposal for benchmarks for progress in technical competence and for progress in reaching the revolutionary potential of ChemBioICT for technology according to a portfolio of metrics.

With regard to **T2.2:** Roadmap Drafting, the roadmap proposal draft (**D2.1**) was aired at a special session on ChemBioICT organized by COBRA at the Orleans conference on *Unconventional Computation and Natural Computation* in September 2012, attended by about 40 participants (see WP3 description for more details of the event). Valuable feedback (a) confirmed the proposed focus as a true consensus in the field, and (b) provided valuable criticism on the proposed metrics for progress towards the final goals.

The roadmap structure, which included a detailed list of approaches and sub-approaches, overarching themes such as simulation, energy, and ethical aspects, and a short text describing the nature of each sub-topic, was then sent to a list of 47 invitees from across Europe and the whole world, with an invitation to participate in the roadmap process. The list was chosen to provide duplicate coverage, with international representation from both academia and industry of all of the main approaches and overarching topics present in the topics list, and gleaned from the survey and resulting further analysis of the literature.

About 43% of those invited accepted, 12% declined, and 45% were too busy to answer. This was not unexpected, given the high profile character of the list of invitees. After digesting initial feedback, a first meeting of the proposed panel was organized as a Skype conference in November 2012. The major discussion items highlighted the approval of the overall roadmapping design proposed, but with important contributions aimed in particular at strengthening and making more visible the uniquely ICT contributions to the roadmap. The agenda and minutes of the Skype conference are available. A more major face-to-face workshop was then planned, and a suitable occasion for the majority of the participants found by Doodle-poll for the 31st January, 2013. It was agreed that participants should bring a written document to this road-mapping meeting constructed according to the template described in the roadmap design document. This workshop was organized and detailed logistic negotiations with participants managed by Sigrid McCaskill at RUB. At the time of writing, this workshop is still 1 week in the future.

The experience of contributors with the current roadmap structure and template for contributions will be used to elicit contributions with detailed instructions for the first full draft of the roadmap. This will include the existing panelists and further stakeholders identified by them, and will be a major activity of WP2 in year 3 up to M30, before the final iteration of the roadmap is prepared.

In terms of **T2.3**: Vision Development, the community has attained already a strong measure of convergence centered around the core vision proposed by McCaskill and Rasmussen:

“Integration of production and information processing down to the molecular scale.”

The ability to do this fully is currently the unique domain of biology, but biological systems do not explore the full range of potential applications of this capability because of both material and evolutionary considerations. The proposal differs from the objectives of nanotechnology in demanding ongoing production to be integrated with the operation and information processing by nanodevices. It differs from current ICT in also demanding ongoing construction. This ongoing construction must be information directed, and requires a certain level of introspection to be autonomous (reading nanoscale information to produce nanoscale structure) as in biology. Synthetic biology is one but not however the only approach, since it is restricted by the compatibily and controllability of the complex protein translation apparatus that is ubiquitous and characteristic of cellular life forms. Systems chemistry, spatially diffusive, nanorobotic, hybrid, and evolutionary approaches are all separately developed communities that are contributing valuable capabilities to the vision and roadmap.

Work in Year 2 included further digestion of the vision document, extraction of a core overarching goal (as taken up in the roadmap Deliverable **D2.1**) and communication of this focus via the web. It also included further analysis of the broader scientific landscape for ChemBioICT, starting from the references and projects identified in the consensus process.

3.2.2.2.3 If applicable, explain the reasons for deviations from the original work plan and their impact on other tasks as well as on available resources and planning.

Not applicable.

3.2.2.2.4 If applicable, explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (the explanations should be coherent with the declaration by the project coordinator)

Not applicable.

3.2.2.2.5 A statement on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary from the original work plan

The resources committed by-and-large matched the planning for this WP, with one small correction. Apart from personnel costs, travel to the Orleans Conference to present and discuss the roadmap strategy for John McCaskill was budgeted. In WP2: Strategy and Vision, led by partner 4 RUB, there has been a slight deviation from the planned work during period 2. The actual person months used to perform the work deviate slightly (by 0.8 PM) from the person months planned and contracted.

3.2.2.2.6 If applicable, propose corrective actions.

A consultation with the university administration revealed that a retrospective adaptation of work contracts is technically not feasible. Therefore RUB is claiming the total amount of 3.5 planned PMs in WP 2 and will invest the additional 0.8 PM to focus on the final roadmapping process in the final period, without extra charge.

3.2.2.3: WP3: Community Building

3.2.2.3.1 Summary of progress towards objectives and details for each task

Work during this period has focused mainly on objectives 2, 4, and 5: creating a integrating students and early-career researchers, building links between the bio/chem IT community and other related areas, and developing links with other fields after establishing a communication platform in the first period.

Tasks were as follows:

- **T3.2**: Annual COBRA conference (reported in Deliverable **D3.3**: Conference).
- **T3.3**: Coordination of exchange visits.
- **T3.4**: Summer School (reported in Deliverable **D3.2**: Summer School).
- **T3.5**: Technical Interest Groups.

Tasks **T3.2** and **T3.4** were successfully completed. Tasks **T3.3** and **T3.5** are ongoing, as the first runs throughout the project, and the second until M29.

Milestones in the reporting period were as follows:

- **MS6**: Summer school planned.

This milestone has been met (and, indeed, exceeded, as the summer school has actually been *delivered*).

3.2.2.3.2 Highlight clearly significant results

T3.2: The Second COBRA Workshop (BiChemIT2012) was held as part of *Unconventional Computation & Natural Computation* (UCNC) 2012 (previously *Unconventional Computation*), LIFO, University of Orleans (France), 3-7 September 2012. See Deliverable **D3.3** and our website at http://www.cobra-project.eu/biochemit2012_post.html for details. The event was well-attended by both students and early-career researchers, as well as by conference participants from outside the project (in this way, the meeting succeeded in helping to develop links with other fields). The third Workshop will take place as a satellite workshop at UCNC 2013, Milan, July 1-5 2013. A call for abstracts is currently open, and selected papers will appear in a special issue of the *International Journal of Unconventional Computing*.

T3.3 (exchange visits) and **T3.5** (Technical Interest Groups) are ongoing. We have launched a call for exchange visits, and received eleven applications for four funded visits. At the time of writing, we are currently reviewing and prioritising the applications. A first technical interest group meeting took place in August 2012, on "algorithmic materials". Further TIGs are planned for the third Period in 2013. One confirmed TIG is planned on "Information flow in molecular systems", to take place in Jena in April 2013.

T3.4 (summer school): The COBRA BioChemIT Summer School was successfully held on 9-21 September in San Candido, Italy. It covered different aspects of biological and chemical information technology (BioChemIT), including topics such as: chemical computing, molecular computing, bacterial computing, protocell technologies, electronic chemical cells and hybrid microfluidic systems. A particular highlight of the summer school was that all students could make, test and keep their own microfluidic chips. See http://www.cobra-project.eu/summerschool.html for further information, and Deliverable **D3.2** for a detailed report. This task is therefore completed.

3.2.2.3.3 If applicable, explain the reasons for deviations from the original work plan and their impact on other tasks as well as on available resources and planning.

No significant deviations; although the Conference and Summer School exact schedule deviated slightly from the originally planned schedule in order to synchronize them with a major conference and lecture time, respectively.

3.2.2.3.4 If applicable, explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (the explanations should be coherent with the declaration by the project coordinator)

Not applicable.

3.2.2.3.5 A statement on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary from the original work plan

One PM for a research assistant was funded by the project for the Summer School (San Candido). The following travel was covered: CMC2011 Conference, Paris, COBRA presentation (Dittrich); Brussels 2012, project meeting (Dittrich); 2nd Cobra Workshop at UCNC 2012, registration fees (Amos, Moreno, Taylor, Stepney, McCaskill); San Candido COBRA Summer School 2012 (Dittrich, Engler, Richter). Finally, we spend 519 EUR on consumables for the Summer School (printing, folder, pictures). The costs of the summer school were slightly larger than planned ,while the costs for the workshop were a bit lower than expected. These differences cancelled one another out.

3.2.2.3.6 If applicable, propose corrective actions.

The COBRA Summer School was successfully organised by ECLT, Ca' Foscari University of Venice, in tight co-operation with partners 1 and 3. Organisational costs for the Summer School were a bit larger than planned; UNIVE spent 30.798,00 EUR instead of 25k allocated to: travel, accommodation and subsistence costs for teachers, students and tutors. In order to cover Summer School additional costs, 10k has been shifted from personnel to other costs in agreement with the project coordinator. As a consequence, the PM initially allocated to UNIVE have been decreased to 1,5PM (4k Prof. Irene Poli, coordinating and support activities related to WP3. Tot. 0,3 PM; 4k Prof. Debora Slanzi, coordinating and support activities related to T3.4; tot. 1,2 PM). This transfer will have no appreciable impact on the project, since the expected results have been achieved.

3.2.2.4: WP4: Dissemination and Outreach

3.2.2.4.1 Summary of progress towards objectives and details for each task

Work has continued to focus on the effective dissemination of project outputs, the promotion of bio/chem IT in general, and public outreach and engagement with scientific activities.

Tasks were as follows:

- **T4.1**: Project website.
- **T4.4:** External liaison.
- **T4.5**: Project promotion.

Although **T4.1** (website) was initially constructed in M3, and then revamped after the first annual review, its maintenance has been ongoing. **T4.4** and **T.5** are also naturally ongoing.

3.2.2.1.2 Highlight clearly significant results

T4.1: Project website. The website was *substantially* improved after the first annual review, and now contains (in addition to standard contact details, etc.) a calendar of forthcoming COBRA (and other) events (as well as an archive of reports on previous events), information on the draft roadmap, slides and teaching materials, a video about "living technology" and COBRA participant Steen Rasmussen's contribution to the field, and a significant archive of regularly-updated feature stories. This now contains profiles of seven COBRA-affiliated researchers, highlights of ten papers from COBRA projects, and ten miscellaneous feature articles (ranging from the UK Synthetic Roadmap to amateur "DIYbio").

T4.4: External liaison. Project partners gave several international talks to scientific audiences of between 20 and 200. There were also two specific outreach public engagement activities:

- At the end of November 2012, COBRA participants took synthetic biology into a Manchester school, as part of the Junior Cafe Scientifique initiative. Professor Martyn Amos (Manchester Metropolitan University) and Dr Andy Balmer (University of Manchester) visited Urmston Grammar School to talk about the promise and pitfalls of this emerging scientific area. Prof. Amos presented a short overview of the science of synthetic biology, before Dr Balmer, a sociologist with a particular interest in the field, chaired a lively discussion session with a group of around twenty young people. "We were asked some really astute questions" said Prof. Amos, after the event. "Presenting to an audience other than our usual scientific peers is a really valuable experience, as it forces us to question assumptions and examine our work from the perspective of an outsider."
- Prof. Amos also contributed a chapter on "DNA Computing" to the *Encyclopædia Britannica Online* (available at http://www.britannica.com/EBchecked/topic/941575/DNA-computing*),* in which "Biochemistry-based information technology (bio/chem IT)" is specifically named as an emerging technology of significant importance.

T4.5: Project promotion. The First Annual COBRA Workshop on Bio/Chem IT resulted in a special issue of the Elsevier journal, *BioSystems* (Vol. 109, No. 1, pages 1-86 (July 2012)) . This is available at http://www.sciencedirect.com/science/journal/03032647/109/1, and was co-edited by Amos and Dittrich. It contains eight original scientific papers, covering both computational and experimental aspects of bio/chem IT. We reproduce here the editorial:

"This special issue contains papers arising from the First COBRA Workshop on Biological and Chemical Information Technologies (BioChemIT), which was held as part of the European Conference on Artificial Life(ECAL), Paris, 2011. COBRA is a coordination action, funded by the European Commission Future and Emerging Technologies (FET) programme.

"Traditional information technology (IT) relies on human-engineered solutions implemented on a silicon-based substrate. Although powerful in terms of raw processing capabilities, modern computers lack the adaptability, resilience and flexibility of natural systems. Even the simplest organisms are capable of reconfiguring their internal architectures in response to combinations of external signals and internal

"programming; a process that is inherently bio-chemical in nature. The field of biological and chemical information technologies (bio/chem IT) seeks to harness the capabilities of natural and chemical systems. Rather than simply deriving inspiration from living systems, bio/chem IT researchers seek to directly use or construct these systems for the purposes of engineering and computation"

We received twelve submissions, of which we accepted eight. In terms of content, the papers are divided equally between laboratory implementations and computational investigations, so we naturally partition the issue (acknowledging, of course, that laboratory work is often informed by computation, and vice versa).

The first paper, by McCaskill, *et al*., describes a route to complex programmable chemistry, via an approach that hybridizes self-constructing chemical systems with electronic computation. The paper of Zauner *et al*. also focusses on chemical computation, this time from the perspective of reaction media in microfluidics. Stano *et al*. describe semi-synthetic minimal cells capable of communicating with living organisms, and Chaplin *et al*. close the experimental section with a description of their work on implementing Boolean logic using photochromic molecules.

The computational section opens with Goni-Moreno and Amos' discussion of representation and measurement issues in engineered gene circuits. Kharma *et al*. then describe their design for a single-input delay flip-flop in *E. coli*. Holley *et al*. show how Boolean logic circuits may be implemented in an excitable chemical medium, before we close the issue with Manca and Marchetti's consideration of how the dynamical inverse problem may be solved using metabolic P systems.

We thank the European Commission for supporting the COBRA project, the ECAL organizers for accommodating the workshop, the anonymous reviewers and the BioChemIT participants. The next COBRA BioChemIT workshop will be held as part of Unconventional Computation and Natural Computation, September 6 2012, Orleans, France."

Papers from the Second COBRA Workshop (see WP3 report) are currently being submitted and reviewed for a special issue of the MIT Press journal *Artificial Life*.

3.2.2.4.3 If applicable, explain the reasons for deviations from the original work plan and their impact on other tasks as well as on available resources and planning.

Not applicable.

3.2.2.4.4 If applicable, explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning (the explanations should be coherent with the declaration by the project coordinator)

Not applicable.

3.2.2.4.5 A statement on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary from the original work plan

As planned, a full-time administrator has been employed since February 2012, whose time is split over WP4 and WP5. Expenditure on personnel is therefore lower than expected, as the post was vacant for 2.5 months at the beginning of the year. The PI has worked across WP4 and WP5 as expected. Travel budget has been spent on attendance at the BioChemIT2012 workshop (PI and administrator), and the PI attended a FEBS workshop to present. The travel and subsistence costs of Angel Goni Moreno for teaching at the Summer School are included in the claim; these will be covered by a transfer from the Summer School budget at ECLT. Costs are also claimed that were incurred in Year 1 but not included in that year's claim, which cover the previous administrator's attendance at the Coordination Action Workshop, and costs from the COBRA Kick-Off meeting.

3.2.2.4.6 If applicable, propose corrective actions.

None required.

3.2.3 Project management during the period

3.2.3.1 Consortium management tasks and achievements

The following tasks were undertaken, as specified in Articles II.2.3 and II.16.5 of the Grant Agreement:

(a) Administration of European Union financial contribution.

We have ensured that the financial contribution has been correctly allocated to the previously agreed activities.

(b) Records and financial accounts.

Full records and accounts have been kept, and are available for inspection.

(c) Notification of transfer dates.

The following payments were made on July 31 2012 (amounts converted from UKP, with an exchange rate of 1.28): €12,473.74 to SDU; €15,581.36 to FSUJ; €17,532.16 to RUB; €6,592.76 to UNIVE.

(d) Financial reports.

The submitted reports are consistent with the project tasks.

(e) Compliance.

All beneficiaries have complied with their obligations.

3.2.3.2 Problems/solutions

The reviewers identified a lack of "proactive management" as one major fault of the project in the first year. This has now been addressed by (a) having an administrator in place, and (b) a review of local processes and workflows for monitoring and execution of project tasks, such that tasks and deliverables become the pre-eminent driver.

3.2.3.3 Consortium changes, if any

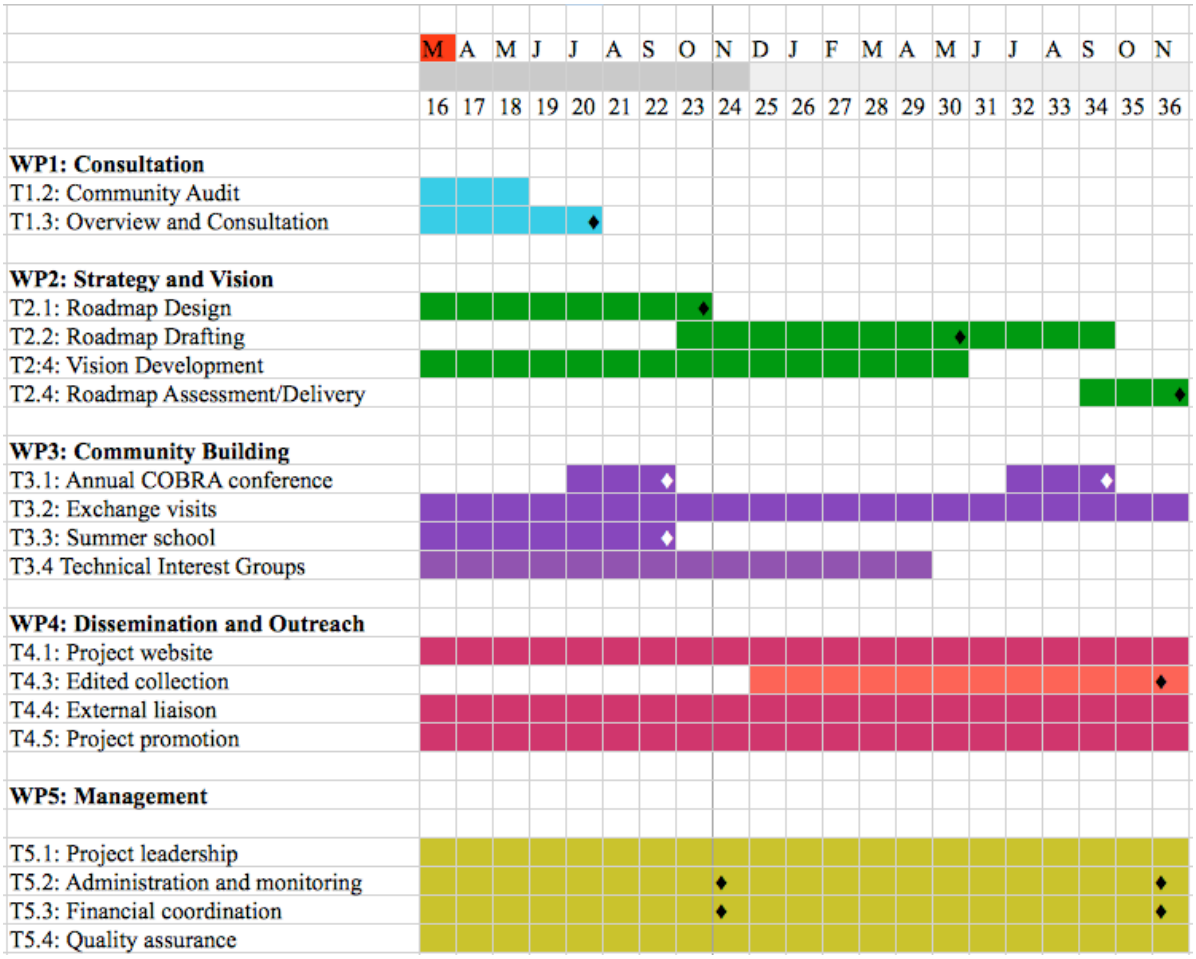
None.

3.2.3.4 Project meetings

- Second COBRA Workshop (BioChemIT2012). Held as part of *Unconventional Computation and Natural Computation* (previously *Unconventional Computation*), LIFO, University of Orleans (France), 3-7 September 2012.
- COBRA Summer School, San Candido, Italy, 9-21 September, 2012.

We have also held a number of Skype conference calls, especially dealing with the roadmap and annual review.

3.2.3.5 Project planning and status



From M25, the main activities are (1) the continued drafting of the Roadmap document (and associated Vision Development), followed by its final delivery and assessment; (2) the final COBRA workshop (to be run as a satellite workshop to UCNC 2013 at the Università degli Studi di Milano-Bicocca, Milan, Italy, 1–5 July 2013); (3) the collation of an edited collection of review articles and original research; (4) exchange visits and Technical Interest Group activities.

3.2.3.6 Impact of possible deviations

No significant deviations or impacts.

3.2.3.7 Changes in legal status

None.

3.2.3.8 Project website

Available at http://www.cobra-project.eu.

3.3 Deliverables and milestones tables

Table 1: Deliverables									
No.	**Name**	**WP**	**Lead**	**Nature**	**Diss. Level**	**Month**	**Actual**	**Status**	**Comments**
D1.3	Collective intelligence site	1	SDU	O	PU	18	18	**D**	Delivery date adjusted after Year 1 review
D1.4	Consultation report	1	SDU	R	PU	20	20	**D**	Delivery date adjusted after Year 1 review
D2.1	Roadmap design	2	RUB	R	PU	23	23	**D**	Delivery date adjusted after Year 1 review
D3.2	Summer school	3	FSUJ	O	PU	22	22	**D**	Delivery date adjusted after Year 1 review
D3.3	Conference	3	FSUJ	O	PU	22	22	**D**	
D4.2	Project publications	4	MMU	R	PU	Ongoing		**D**	

Some deliverables have moved slightly, as agreed after the first annual review, and reported in the Year 1 Activity report, D5.1.

Table 2: Milestones							
No.	**Name**	**WP**	**Lead**	**Date**	**Achieved?**	**Actual**	**Comments**
5	Establishment of collective intelligence web infrastructure.	1/2	SDU	M15	**Yes.**	M18	
6	Summer school	3	FSUJ	M22	**Yes.**	M22	
7	Overview of community audit completed.	1/2	SDU	M18	**Yes.**	M18	
8	Roadmap structure designed	1/2	RUB	M24	**Yes.**	M24	

3.4 Explanation of the use of resources

See the attached version downloaded directly from the participant portal.

Use of Resources

Period 2 (13 - 24)
(01-12-2011 - 30-11-2012)

Project Number	270371	Project Acronym	COBRA

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 1 for the period.

THE MANCHESTER METROPOLITAN UNIVERSITY

Work Package	Item description	Amount in €	Explanation	Free Text
WP 3	Personnel costs	2,898 €	MARTYN AMOS	
WP 4	Personnel costs	1,584 €	MARTYN AMOS	
WP 5	Personnel costs	3,740 €	MARTYN AMOS	
WP 3	Personnel costs	1,003 €	ANGEL GONIMORENO	Summer school.
WP 4	Personnel costs	4,898 €	MARGARET TAYLOR	
WP 5	Personnel costs	9,283 €	MARGARET TAYLOR	
WP 4	Other direct cost	289 €	Kick-off meeting costs (conference bags)	
WP 4	Other direct cost	490 €	Zarka Khan travel and subsistence for Coordination Action Workshop	
WP 5	Other direct cost	661 €	Martyn Amos and Zarka Khan travel and subsistence for negotiation meeting	
WP 5	Other direct cost	187 €	Courier documents to partners and Commission	
WP 4	Other direct cost	854 €	Martyn Amos and Margaret Taylor travel and subsistence for UCNC12	
WP 4	Other direct cost	481 €	Martyn Amos travel and subsistence for FEBS	
WP 4	Other direct cost	79 €	Website costs	
WP 4	Other direct cost	491 €	Angel Goni Moreno travel and subsistence for Summer School	
WP 5	Other direct cost	796 €	Martyn Amos and Margaret taylor travel and subsistence for 1st COBRA review	
WP 5	Other direct cost	555 €		

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 1 for the period. THE MANCHESTER METROPOLITAN UNIVERSITY				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
			Margaret Taylor conference fee, travel and subsistence for UKRO conference	
WP 5	Other direct cost	72 €	Courier documents to partners and Commission	
WP 5	Other direct cost	12 €	Consumables	
	Indirect costs	5,674 €		
	TOTAL COSTS	34,047 €		

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 2 for the period. SYDDANSK UNIVERSITET				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
	Other direct cost	711 €	Travel to COBRA Summerschool	
	Other direct cost	52 €	Website, Mail Charges	
WP 1	Personnel costs	17,969 €	Rasmussen, Svaneborg, Dörr og Storm Pedersen	
WP 2	Personnel costs	9,535 €	Rasmussen, Svaneborg og Storm Pedersen	
	Indirect costs	5,653 €		
	TOTAL COSTS	33,920 €		

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 3 for the period. FRIEDRICH-SCHILLER-UNIVERSITAET JENA				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
WP 3	Personnel costs	2,947 €	personnel costs	Engler, Martin (0,75 PM)
	Other direct cost	129 €	travel costs	Brüssel, 23.-24.02.2012, project meeting
	Other direct cost	1,243 €	travel costs	Reg. Fee UCNC 2012,03.-07.09.2012, Amos, Moreno, Taylor, Stepney, McCaskill
	Other direct cost	238 €	travel costs	Fortainebleau, 22.-25.08.2011, Conference CMC 2011

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 3 for the period. FRIEDRICH-SCHILLER-UNIVERSITAET JENA				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
	Other direct cost	1,478 €	travel costs	San Candido, 09.-22.09.2012, Dittrich, Engler, Richter
	Other direct cost	520 €	other costs	printing costs for folder + picture Summer School San Candido
WP 3	Personnel costs	1,048 €	personnel costs	Meusel, Marvin (0,25 PM)
	Indirect costs	532 €		
	TOTAL COSTS	8,135 €		

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 4 for the period. RUHR-UNIVERSITAET BOCHUM				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
WP 2	Personnel costs	2,098 €	Personnel costs for 1 administrator (S. McCaskill) in Period 2	
	Subcontracting	0 €	no subcontracting	
	Other direct cost	0 €	no other direct costs	
WP 1 WP 2	Personnel costs	28,903 €	Personnel costs for 1 professor (J. McCaskill) and 1 senior researcher (U. Tangen) in period 2	
WP 1 WP 2	Other direct cost	658 €	Travel Costs: Review meeting Brussels, J. McCaskill24.2.12, UCNC Conference Orleans, J. McCaskill, 5.-7.9.12 Consumables: Courier costs for shipping CA to coordinator	
	Subcontracting	0 €	no subcontracting	
	Indirect costs	2,488 €		
	TOTAL COSTS	34,147 €		

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 5 for the period. UNIVERSITA CA' FOSCARI VENEZIA				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**

Table 3.1 Personnel, subcontracting and other Major cost items for beneficiary 5 for the period. UNIVERSITA CA' FOSCARI VENEZIA				
Work Package	**Item description**	**Amount in €**	**Explanation**	**Free Text**
WP 3	Personnel costs	4,000 €	Prof. Irene Poli, coordinating and support activities	Prof. Irene Poli, coordinating and support activities related to WP3. Tot. 0,3 PM
WP 3	Personnel costs	4,000 €	Prof. Debora Slanzi, coordinanting and support activities for Summer School 2012	Prof. Debora Slanzi, coordinanting and support activities for Summer School 2012 related to T3.4; tot. 1,2 PM
WP 3	Other direct cost	25,278 €	Summer School 9-21 Sept. 12: Accommodation and subsistance costs for students, teachers, tutors	Summer School 9-21 Sept. 12: Accommodation and subsistance costs for students, teachers, tutors
WP 3	Other direct cost	1,127 €	Summer School 9-21 Sept. 12: Travel costs for students	Travel costs for students : bus service from Venice to San Candido round trip
WP 3	Other direct cost	4,315 €	Summer School 9-21 Sept. 12: travel costs for teachers	Summer School 9-21 Sept. 12: travel costs for teachers from other partners/insitutions as well as teachers and tutors from ECLT (Poli, Slanzi, Packard, Zauner, King, Borrotti, De March, Stano, De Planque, Gorecki). All travels made between the period 9-21 September, except 2 trips to San Candido (School venue) of Prof. Poli and Prof. Slanzi made on 11-12/06/2012 for organisational purposes
WP 3	Other direct cost	78 €	Summer School 9-21 Sept. 12: consumables, leaflets	Summer School 9-21 Sept. 12: consumables, leaflets
	Indirect costs	7,759 €		
	TOTAL COSTS	46,557 €		