Amos, M., Stepney, S., Doursat, R., Vico, F.J. & Rasmussen, S. (2012) TRUCE: A coordination action for unconventional computation. *International Journal of Unconventional Computing* **8**:4, p.p., 333-337

TRUCE: A Coordination Action for Unconventional Computation

MARTYN AMOS[1,*], SUSAN STEPNEY[2], RENE DOURSAT[3], FRANCISCO J. VICO[3] AND STEEN RASMUSSEN[4]

[1]*Manchester Metropolitan University, UK*
[2]*University of York, UK*
[3]*University of Malaga, Spain*
[4]*University of Southern Denmark, Denmark*

Received: July 16, 2012. Accepted: July 16, 2012.

Unconventional computation (UCOMP) is an important and emerging area of scientific research, which explores new ways of computing that go beyond the traditional model, as well as quantum- and brain inspired computing. Such alternatives may encompass novel substrates (e.g., DNA, living cells, or mixtures of the two) as well as new paradigms which, for example, support combined information processing and material production (as living systems do). UCOMP researchers draw inspiration from a wide and diverse range of sources, from physics, to chemistry, biology and ecology. The field is growing quickly, and has the potential to revolutionize not only our fundamental understanding of the nature of computing, but the way in which we solve problems, design networks, do industrial fabrication, make drugs or construct buildings. The problems we already face in the 21st century will require new and creative approaches, conceptual frameworks, mechanisms and perspectives. UCOMP offers one route towards this. TRUCE is a coordination action to help organize the international UCOMP community. The inherent diversity of the field has led to fragmentation, with many sub-fields developing in parallel. With large-scale project support now being offered by the European Commission, the time is precisely right to organize and coordinate the field at the European level. This coordination action will engage the European community (and beyond), construct the first UCOMP roadmap, reach out to a wider public beyond the scientific community, and build the foundations for a new, sustainable and coherent scientific discipline.

Keywords: Unconventional computation; FP7; European Commission; Roadmap

*Corresponding author: m.amos@mmu.ac.uk

1. INTRODUCTION

The field of *unconventional computation*[1](otherwise known as *non-standard/ non-classical* computation) is growing rapidly, with dedicated funding programmes, conferences and journals. Although there exists a significant body of interested parties in Europe, we currently lack an over-arching organizational structure within which to coordinate, nurture and develop activities in this area. This deficit is precisely addressed by the TRUCE project (Training and Research in Unconventional Computation in Europe), which will provide an "umbrella organization" to coordinate and foster unconventional computation research in Europe (and beyond).

The objectives of TRUCE are to (1) Formulate, develop and maintain a European vision and strategy for UCOMP; (2) Identify areas of importance in UCOMP, and help to focus research in these areas; (3) Provide a framework for the discussion and resolution of current issues in UCOMP; (4) Facilitate improvement in the quality, profile and applicability of European UCOMP research; (5) Encourage and support the involvement of students and early career researchers in UCOMP; (6) Facilitate industrial involvement with UCOMP.

In order to achieve these objectives, TRUCE will: (1) Establish a roadmap document, describing the background, strategic objectives and future directions for European UCOMP research; (2) Provide support for innovative, high quality meetings and exchanges to support trans-national and inter-disciplinary links; (3) Offer training in UCOMP to students and early career researchers, through exchange visits and summer schools; (4) Establish high-quality channels of communication, including a dedicated website, newsletter and online networking facilities; (5) Encourage industrial engagement with UCOMP, by supporting exploratory/development meetings, and championing technology transfer.

As a community, we are approaching a *gateway event*, a transition which "...produces a profound and fundamental change to the system: once through the gateway, life is never the same again. We are currently poised on the threshold of a significant gateway event in computation: that of breaking free from many of our current *classical* computational assumptions. Our Grand Challenge for computer science is to journey through the gateway event obtained by breaking our current classical computational assumptions, and thereby develop a mature science of Non-Classical Computation."[2]

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[1] European Commission Unconventional Computation: http://cordis.europa.eu/fp7/ict/fet-proactive/ucomp_en.html

[2] S Stepney, SL Braunstein, JA Clark, A Tyrrell, A Adamatzky, RE Smith, T Addis, CG Johnson, J Timmis, P Welch, R Milner, D Partridge. Journeys in Non-Classical Computation I: A Grand Challenge for computing research. *Int. J. Parallel, Emergent and Distributed Systems* **20**(1):5-19, 2005

2. SCIENTIFIC FOCUS

A key focus of the project will be to identify and clarify certain questions in various non-classical computational areas that need to be addressed in order to lay the groundwork for establishing the *new science of non-classical (i.e. unconventional) computation*:

Hypercomputation : How can new models of computation be abstracted from the underlying physics? How expressive can these models be? Are proposed models of computation implementable given the constraints of physics? Precisely what assumptions about the physical laws are being made? What other undiscovered assumptions underlie the Turing model?

Bio-inspired Computing : What are the underlying bio-computational mechanisms? What of these are contingent on the organism being an embodied carbon-based life form? Can they be extended to other, virtual life-forms, i.e. "life as it could be"? (the paradigm underpinning the field of artificial life). Are there general principles that can be abstracted to other situations? How can this abstraction and mapping be performed when the application domain is radically different from the biological one? Can this work help the biological research programme?

Embodiment and in materio **computing :** what are appropriate abstract models of classes of *in materio* computation? In other words, what kind of *in materio* computations have at least some degree of substrate-independence? (They might require some complex non-linear dynamical behaviour, but that kind of behaviour might be exhibited by many substrates; How many essentially different kinds of models are there? Do any provide universality? Do any provide the self-referentiality that allows meta-programming and Strange Loops? How expressive can these models be? Is *material* embodiment essential to ground the semantics of the system, or can virtual systems exhibit the same kind of properties?

Growth and self assembly : How can software systems be made rich enough so that new structures and behaviours, and new *kinds* of structures and behaviours, can "grow" naturally out of these systems? What are the mathematical techniques for modelling systems whose dimensionality changes and grows in essentially unpredictable (because contingent and emergent) ways as the system develops, where the dimensions are hybrid (a mix of discrete and continuous), and where new dimensions may be of new types?

Programmability : How can we program our novel computational devices? What are the languages and associated programming tools of

non-classical computation? What are the underlying formalisms of non-classical computational models? Are distinct formalisms required for different kinds of models, or can a unified approach that crosses different regimes be found?

There are additional areas that need to be included, and further questions that need to be posed, refined, and addressed. The aim of the project is to bring together people and enable them to start addressing these questions from a *unified* perspective (many are indeed working on these and related questions, but rarely from the perspective that is needed). Addressing such questions are major research activities: the project will enable initial collaborations to form, so that these researchers can prepare well-reasoned funding proposals for such activities.

3. IMPLEMENTATION

The project is managed by a scientific board, comprising the original co-investigators, plus the coordinators of the funded UCOMP projects. The board is responsible for overall scientific direction, liaison with the European Commission and the International Advisory Board, and for developing an international dialogue around UCOMP, through an Outreach/Advocacy work-package. A novel aspect of this activity is a planned art/science exhibition, which will bring UCOMP-related work to a general audience. The scientific activities of TRUCE centre on a number of thematic areas, which we have identified as being of particular interest. Each area is led by a thematic champion, and these operate within a Community Building work-package, which aims to foster links between research areas, and with other global initiatives. All participants contribute to the construction of the Roadmap, which has a dedicated work-package. An Education work-package focusses on training needs, mainly through the provision of a summer school and online curricula, with the aim of building a *sustainable base* of trained UCOMP researchers (Fig. 1).

4. OUTCOMES

The outcomes/deliverables of TRUCE are expected to be (1) the scientific/technological roadmap document; (2) a number of international workshops (either stand-alone or in association with major conferences); (3) an edited collection of articles describing the state-of-the-art; (4) a summer school; (5) a number of public outreach events, including the exhibition, and an event aimed specifically at young people.

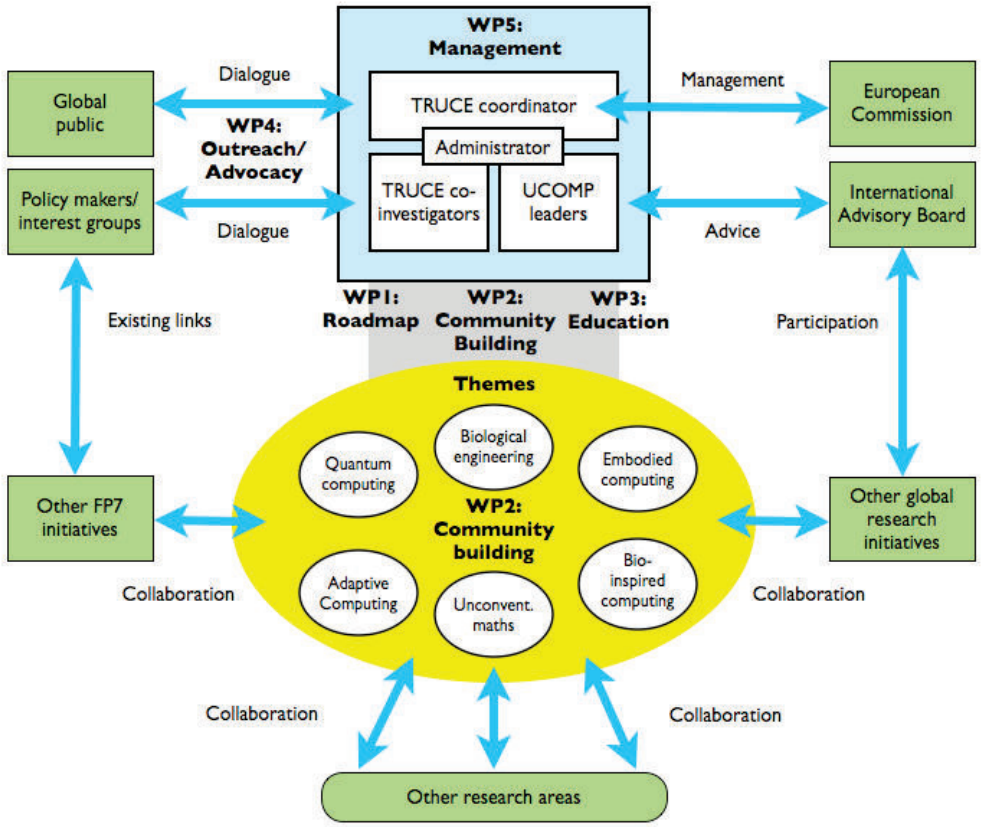

FIGURE 1
The project's structure.

ACKNOWLEDGEMENT

The TRUCE project acknowledges the financial support of the Future and Emerging Technologies (FET) programme within the ICT theme of the Seventh Framework Programme for Research of the European Commission.