

Executive Summary

The European Commission and Member States are called upon to recognize the novel potential of Converging Technologies (CTs) to advance the Lisbon Agenda. Wise investment in CTs stimulates science and technology research, strengthens economic competitiveness, and addresses the needs of European societies and their citizens. Preparatory action should be taken to implement CT as a thematic research priority, to develop *Converging Technologies for the European Knowledge Society (CTEKS)* as a specifically European approach to CTs, and to establish a *CTEKS* research community.

These are the major findings of the High Level Expert Group “Foresighting the New Technology Wave.” The expert group was constituted in December 2003 and submitted its report in July 2004. The 25 members of the group – chaired by Kristine Bruland and with Alfred Nordmann as rapporteur – come from a variety of countries and disciplinary backgrounds. The group met formally four times (2-4 February, 14-15 April, 6-7 May, 16-17 June 2004). The report was prepared on the basis of the group’s discussions, of individual written contributions by group members, of a scenario exercise, and of reports by four subgroups. Preliminary drafts of the final report were submitted to the group and discussed mainly at the June meeting.

The group was charged to explore in breadth the potential and the risks of CTs. It confronted a dual demand, namely

- to delineate areas of interest and fields of application for CTs, and
- to relate these CTs to the European environment and policy goals.

It met this demand by proposing a European approach to converging technologies: *CTEKS: Converging Technologies for the European Knowledge Society*.

THE CHALLENGE

Information and communication technology helped produce the profound transformation of daily life in the 20th Century. Biotechnology is transforming agriculture, medical diagnosis and treatment, human and animal reproduction. Most recently, the transformative potential of nanotechnology has captured the imagination. Add to this that cognitive and neuroscience are challenging how we think of ourselves, or that the rise of the social sciences parallels that of bureaucracies and modern forms of governance.

The convergence of these profoundly transformative technologies and technology-enabling sciences is the first major research initiative of the 21st Century. If these various technologies created controversy and anxiety each on their own, their convergence poses a major challenge not only to the research community, but from the very beginning also to policy makers and European societies. In this challenge resides the opportunity for *CTEKS*.

TRANSFORMATIVE POTENTIAL

The expert group identified four likely characteristics of CT applications. Each of these presents an opportunity to solve societal problems, to benefit individuals, and to generate wealth. Each of these also poses threats to culture and tradition, to human integrity and autonomy, perhaps to political and economic stability.

- *Embeddedness*: CTs will form an invisible technical infrastructure for human action – analogous to the visible infrastructure provided by buildings and cities. The better they work, the less we will notice our dependence on them or even their presence. Over the last decades society has witnessed effects on the sense of reality and responsibility of those who are immersed in computer games, Internet surfing, and chatting. Once all of us are living continuously in the pervasively artificial environment of ambient computing, smart materials and ubiquitous sensing, society will be confronted with far more frequent and deep transformations of people’s and groups’ self-understanding.
- *Unlimited Reach*: Nanotechnology’s dream to control everything molecular follows upon information technology’s increasing ability to transform everything into information. As the convergence draws in other technologies and technology-enabling sciences, it would appear that nothing can escape the reach of CTs and that the mind, social interactions, communication, and emotional states can all be engineered. This promise is productive and dangerous at once. One can expect that for every problem, someone may propose a more or less creative, viable or desirable technological fix. However, complacency induced by the fix-all potential of technology could be dangerous in the extreme.
- *Engineering the Mind and the Body*: Some proponents of CTs advocate engineering *of* the mind and *of* the body. Electronic implants and physical modifications are to enhance our current human capacities. The expert group proposes that CT research should focus on engineering *for* the mind and *for* the body. Changes to the cognitive environment or medical self-monitoring can improve decision-making and health. Either way, humans may end up surrendering more and more of their freedom and responsibility to a mechanical world that acts for them.
- *Specificity*: Research on the interface between nano- and biotechnology allows for the targeted delivery of designer pharmaceuticals that are tailored to an individual’s genome in order to effect a cure without side effects. More generally, the convergence of enabling technologies and technology-enabling sciences can be geared to address very specific tasks. Reliance on highly specific solutions can also have an unsettling effect, however. The invisibility of CTs raises questions as to their absence or presence. This is equally troubling when they are needed to sustain a specific action and when one does not know whether, like computer viruses, they might appear any time and attack a delicate technical system or organism at some unknown place. Even when they work as reliably and successfully as one could wish, CTs may have a socially destabilizing effect as economic efficiency produces greater unemployment, as targeted medical treatments increase longevity, as CTs exacerbate the divide between the rich and the poor, between technologically advanced and traditional cultures.

Tremendous transformative potential comes with tremendous anxieties. These anxieties need to be taken into account. When they are, converging technologies can develop in a supportive climate. To the extent that public concerns are included in the process, researchers and investors can proceed without fear of finding their work over-regulated or rejected.

CTEKS

Converging technologies converge *towards* a common goal. CTs always involve an element of agenda-setting. Because of this, converging technologies are particularly open to the deliberate inclusion of public and policy concerns. Deliberate agenda-setting for CTs can therefore be used to advance strategic objectives such as the Lisbon Agenda.

Agendas for convergence include “Converging technologies for improving human performance” or “Converging technologies for battlefield domination.” The expert group does not recommend there or any one such agenda. By proposing “Converging technologies for the European Knowledge Society (*CTEKS*),” it places the emphasis on the agenda-setting process itself. It envisions that various European CT research programs will be formulated, each addressing a different problem and each bringing together different technologies and technology-enabling sciences. These might include “CTs for natural language processing,” “CTs for the treatment of obesity,” or “CTs for intelligent dwelling.”

CTEKS agenda-setting is not top-down but integrated into the creative technology development process. Beginning with scientific interest and technological expertise it works from the inside out in close collaboration with the social and human sciences and multiple stakeholders through the proposed WiCC initiative (“Widening the Circles of Convergence”). For the same reason, ethical and social considerations are not external and purely reactive but through the proposed EuroSpecs process bring awareness to CT research and development.

Agenda-setting for CT research is a research policy tool that along with the research programs can create a climate of investor and consumer confidence. It also supports the research community by exercising a catalytic effect and focusing creative energy. It invests research and development of science and technology with social imagination by providing a broader vision.

RECOMMENDATIONS

The expert group offers 16 recommendations.

Converging Technologies (CTs) present equally significant opportunities and challenges. CTs converge on common goals or shared visions, and first among the opportunities and challenges is the formulation of such goals. “Converging Technologies for the European Knowledge Society (CTEKS)” designates the European approach to CTs. It foregrounds the process of deliberate and creative agenda-setting for CT research.

Establishing CTEKS: Vision and strategy.

1. That the European Commission implement the WiCC-initiative (“Widening the Circles of Convergence”) in order to create a CTEKS research community, in the first instance by establishing a coordinating WiCC office.
2. That the Commission now integrate a CT dimension in FP6 programme calls (in particular in the thematic priorities of nanotechnology, life sciences, information technologies, social sciences and humanities).
3. Member States are encouraged to promote the CTEKS process by launching prototype CT research initiatives through national foresighting activities and funding programs.
4. In the context of the seventh EU framework programme for research, Member States should be invited to participate in a European Competition for Centers of CTEKS Excellence; the European Research Council should provide visiting fellowships at the Centers.

Harnessing the Dynamics of Convergence: New research agendas.

5. Interdisciplinarity should be strengthened, beyond planned or institutional collaboration, in program calls and research policies from the Commission and from the European nations.
6. The Commission and Member States should expand and deepen their commitment to Cognitive Science.
7. Commission and Member States need to recognize and support the contributions of the social sciences and humanities in relation to CTs, with commitments especially to evolutionary anthropology, the economics of technological research and development, foresight methodologies and philosophy.

Developing a framework for CTEKS: The research and support environment.

8. A permanent societal observatory should be established for real-time monitoring and assessment of international CT research, including CTEKS.
9. That the Commission implement a “EuroSpecs” research process for the development of European design specifications for converging technologies, dealing with normative issues in preparation of an international “code of good conduct.”
10. The integration of social research into CT development should be promoted through *Begleitforschung* (“accompanying research” alongside science and technology R&D).

Dealing with CTEKS: Ethics and social empowerment.

11. That a strict line be maintained between military ambitions for CTs and their development in Europe.
12. Upon advice from the European Group on Ethics (EGE), the mandate for the ethical review of European research proposals should be expanded to include ethical and social dimensions of CTs. Funding organizations in Member States are asked to take similar steps.
13. In the face of new models for participatory research governance, transparent decision making processes need to be developed and implemented.
14. The question of intellectual property rights must be addressed proactively and on an international level.
15. Member and Associated States are encouraged to stimulate national discussions of CTs and the *CTEKS* perspective.
16. CT modules should be introduced at secondary and higher education levels to synergize disciplinary perspectives and to foster interaction between liberal arts and the sciences.