

APPENDIX G. GLOSSARY OF SELECTED TERMS AND CONCEPTS¹

3D printing

The production of an object or component by a desk-top device analogous to a computerized printer because it takes information input and produces physical output; often equated with additive manufacturing and stereolithography, but potentially including other processes to shape, remove, or transform materials.

Additive manufacturing

Building parts by adding material on an existing structure, such as layer-by-layer deposition from digital computer-aided design files in stereolithography.

Antagonistic pleiotropy

An hypothesis that arose in genetics but now is applied to other fields, suggesting that typically any major development will have multiple competing effects, some positive and others negative.

Anticipatory governance

A convergent method of policy and decision-making based in foresight of and preparation for plausible future scenarios, integration of social science and humanities research with physical science and engineering, and engagement of publics in deliberations.

Assistive technology

Robots, computer interfaces, or other engineering solutions designed to compensate for a user's disabilities, but with the potential to help any user in accomplishing unusual tasks.

Big data

The use of very large troves of information in science and engineering, unprecedented in their demands on computers and the human mind, requiring development of new means to access, aggregate, analyze, and interpret their significance.

Biotechnology

Technologies that are oriented toward biological structures, whether interacting directly with living organisms or merely applying principles derived from them.

Boundary organizations

Neutral parties that facilitate and supply technical information to public policy decision-making processes involving two or more technical areas that have not yet fully converged but have significant implications for each other.

Citizen engineering

Technological design and development that incorporates contributions from non-specialists, for example, open-source software projects created by communities of volunteers.

Citizen science

The serious involvement of non-specialists in scientific research, often in the role of long-term volunteers, and increasingly acting as partners in the research rather than merely providing free labor.

Cloud

The storage and processing of data at locations remote from the user and usually in systems unknown to the user, establishing a new and as-yet unassessed relationship between users and the organizations operating the cloud.

Cognitive computing

A new paradigm in which computational systems and algorithms spontaneously recognize context and intent without having to be programmed by experts in arcane software languages, but rather learning successfully in an uncertain and changing environment.

Cognitive science

Rigorous research on animal and human mental functions, based on the convergence of previously separate sciences, notably cognitive psychology and neuroscience, but also including artificial intelligence and some branches of anthropology, philosophy, and education.

Cognitive Society, The

A society characterized by an ubiquity of convergent cognitive technologies that are leveraged to enhance human decision-making, well-being, and public health.

Cognome

The set of principles controlling mental functions in the individual and in the community to which the individual belongs; named by analogy with the genome that defines a genetic structure.

Collaboratory

A facility for research or development where individuals, groups, and organizations can cooperate while preserving much of their autonomy, often requiring a special investment outside the scope of any one of the participants.

Common core

Standards defining what students in one or more disciplines are expected to learn, ideally designed to be relevant to the real world, reflecting the knowledge and skills that students will need for success in their careers.

¹ These are informal definitions provided by the editors of selected terms and concepts used in this document.

Complexity

The property of a system consisting of many parts that are not uniform in their structure or interactions, such that the total information content is high, long-term predictability is low, and management is difficult.

Computer regimentation

The conjectured imposition of harsh control over humans by machines, as in the traditional factory assembly line or current offices if most work is done through rigidly designed software.

Consilience

An intellectual harmony between superficially different methods of analysis that lead to the same result, and therefore to the successful diffusion of an idea from one field to another where it proves to apply without major revision, thus becoming a conceptual link between the fields.

Convergence consultant

A hypothetical professional specialty in which experts on multidisciplinary communication and the management of technological convergence would advise corporations and individuals on how to take best advantage of the new opportunities.

Convergence culture

A unifying set of values, terms, methods, and theories that enable a team or network to communicate effectively applying convergence principles, and achieve success in projects that span multiple disciplines and domains of relevance.

Convergence

The creative union of sciences, technologies, and peoples, focused on mutual benefit; this is a process requiring increasing linkages across traditionally separate disciplines, areas of relevance, and across multiple levels of abstraction and organization.

Convergence–divergence process

A sequence of advances achieving significant progress, in four stages: (1) creative assembling of contributions from multiple fields, (2) system integration for known uses, (3) innovation, and (4) spin-off outcomes that lead to emerging new things and uses.

Co-robot

A semi-autonomous, intelligent machine designed to cooperate closely with human beings in accomplishing the goals of the humans.

Creative destruction

An hypothesis in economics stating that technological innovation has a net positive impact on the job market and the economy more generally, despite the fact that innovation renders old technologies obsolete and thus causes some unemployment and investment losses.

Cultural cognition

Thinking entirely within the conventional limits of a culture or subculture, causing people to interpret new evidence in a biased way that reinforces their predispositions.

Cultural lag

The delay following the societal impact of a new technology, as the institutions of the society take time to adjust, typically requiring cultural innovations and causing temporary social problems.

Cultural science

An emerging science of the shared concepts and practices of large social groups, analogous to cognitive science in both structure and origins, based on convergence across sociology, political science, cultural anthropology, linguistics, and related fields.

Culture and personality

A subfield of anthropology and social psychology that examines the complex relationships between the norms, beliefs, and values of a society, and the cognitive or behavioral propensities of its typical citizens.

Cyberinfrastructure

The computational and networking hardware and software available for research and development; the definition is sometimes expanded to include the human-computer interface and the information itself.

Cyber-physical system

A tightly integrated network of devices that combine information processing with physical processes, such as sensor nets that monitor conditions in a city, or a partnership of robots and environmentally embedded components to accomplish factory production or facility maintenance in a semi-autonomous manner.

Data mining

Use of machine learning, mass information retrieval, automatic clustering, natural language processing, and other advanced techniques to derive meaningful information from vast existing sets of raw data.

Demographic transition theory

A classic social science theory that currently is very much in doubt, holding that the industrial revolution unleashed an only temporary explosion in the human population, because culture would naturally adjust over time until the birth rate and death rate were again in balance.

Design ethnography

Using methods like those developed by cultural anthropologists to empirically develop technology design criteria and evaluate prototypes with individual human subjects or in functioning groups of early adopters.

Digital divide

Lack of effective access to information technology by economically disadvantaged people or by those lacking the skills to use it effectively.

Digital government

Initially, the use of information technologies to improve communications within government agencies and from government to the citizenry, but now evolving into systems for participatory decision-making about public policies and services.

Distributed manufacturing

Production at many local facilities, often in very small and customized batches, enabled by process flexibility, modularity, in-process metrology, predictive sciences and technologies, and human-machine interaction.

Earth-scale platform

The environment for human activities oriented toward convergence, including global natural systems, communication systems, and the global economy.

Emerging technologies

Newly defined and newly feasible areas of engineering application, often requiring new scientific and economic paradigms, and investment in new industries.

Foundational tools

Relatively small-scale instruments, techniques, and assemblers that start from a basic element—such as atom, bit, DNA, or synapse—and generate an integrated system.

Geoengineering

Projects that have the goal of transforming some significant portion of the natural environment, such as air quality, the oceans, the biological organisms that live in the ecology, or climate change.

Global risk assessment

Analysis of the potential net costs of an event, such as a natural accident or an episode of technology innovation, for humanity as a whole, rather than just for the immediate decision-makers.

Grand challenge

A broad, difficult, yet well-defined goal for scientific research and technological development that can serve as the focus for several years of work by a significant number of teams advancing separate but compatible projects.

High-throughput sequencing

The bio-info-nano convergence enabling inexpensive gene sequencing of individuals and efficient assessment of the diversity of cells in a biological or medical sample.

Holistic interdependence

The principle that the elements of a system influence each other, more powerfully the more tightly coupled the system becomes, with the implication that globalization requires increasingly holistic scientific conceptions of nature and human action.

Hubsite

A physical or virtual nexus for communication and coordination, for example, a center used by a number of local universities to support their research and education in a convergence field.

Human factors

A multidisciplinary offshoot of psychology that identifies aspects of human psychology and its context that must be taken into account in the design and development of new technology.

Human potential

The possibilities for improvement in the ability of human beings to have the intelligence, wisdom, and health to achieve new beneficial goals.

Human-scale platform

The set of systems that enable convergence characterized by the interactions between individuals, between humans and machines, and between humans and the environment.

Inclusive development

Economic and social progress that benefits all people while minimizing the impact of human activities on Earth's climate and ecosystems.

Inclusive governance

Management of the conduct and applications of research and development that ensures effective involvement from all relevant stakeholders, agencies, and experts.

Industrial ecology

A science for assessing and minimizing the impact of industry on the environment, using such methods as material flow analysis, life-cycle analysis, and design for environment.

Information infrastructure

The system of well-organized data resources available for research and development; the term emphasizes the information content of the system, but performance also depends upon the hardware and the human-computer interface.

Information technology

A very general term that highlights electronic computing and communications technologies but also includes more traditional means for managing meaningful information.

Innovation spiral

A circular but progressive process over time in which information and innovation in one area stimulates development and innovation in another area, which feeds back to stimulate more innovation in the original area, and so forth.

Institutional infrastructure

The social institutions required for science, engineering, and other collective efforts, such as professional associations, industry partnerships, and government agencies.

Intellectual property rights

Legal regimes, notably patents and copyrights, that give innovators a temporary monopoly on exploitation of their innovations, which have become increasingly problematic as scientific and technological changes call their basic principles into question.

Intelligent fiber

One of several terms referring to sensors and other electronic devices embodied in fabrics rather than boxes, including interactive textile devices and other forms of next-generation wearable technology.

Manufacturing process DNA

The design of manufacturing processes in a manner like the genetic code, allowing the rapid switching in and out of production steps and system components, and allowing precise control over product parameters with very little effort.

Medicalization

Defining a challenge in terms of a disease model requiring a standard cure, which often can be inappropriate, as in cases when a person's native characteristics do not harmonize with the dominant culture, which might be solved by building a subculture designed for people having that characteristic.

Metaparadigm

A conceptual structure developed to combine the conceptual structures possessed by two or more separate fields, thus a paradigm about the combination of existing paradigms, which may require revision of the component paradigms.

Mindfulness

Receptiveness, expanded perspectives, and context-relevant interpretations that can lead to more long-range, discriminating, and holistic innovation.

MOOC

A massively open online education course, reaching a large number and diversity of students over the Internet, central to a new movement in higher education, and especially suitable for some forms of technical training that do not require specialized laboratories or co-presence of students and teachers. (Pronounced "mook," like "moon.")

Multifunctional manufacturing

Versatile and usually small production facilities intended for brief production runs, even customizing of each item, capable of switching easily from one kind of product to another, ideally both efficient and inexpensive.

Multiscaling

Scientific research and engineering development across a wide range of dimensional sizes, enabled by convergence tools and theories.

Nanoelectronics

Electronic components with at least one dimension less than roughly 100 nanometers, posing challenges of reliability and production methods and issues of how to avoid or exploit quantum effects.

Nano-geobiochemistry

The field of study that examines how naturally occurring nanoscale materials behave in the Earth's environment, chiefly in terms of their biochemical implications.

Nanomaterial

Natural, incidental, or manufactured materials with any external dimension in the nanoscale (about 1–100 nanometers) or having internal structure (aggregate or agglomerate of particles or grains) or surface structure in the nanoscale.

Nanoscience

The study of phenomena, processes, and objects structured on the nanoscale, roughly with dimensions from 1 to 100 nanometers, which may be manufactured or natural, and within the provinces of fields as diverse such as genetics, geology, chemistry, and electrical engineering.

Nanotechnology

Technology at the nanoscale, which is about 1 to 100 nanometers, including respective processes, components, materials, devices, and systems at the nanoscale.

Nanotherapeutic medicines

Drugs delivered exactly at the targeted cells where they are needed in the body, for example, to attack cancer cells, by means of packaging the drugs within nanoparticles, with consequent reduction of side-effects.

Online community

A network or subculture of people sharing similar interests or connected in a social network, who communicate primarily via the Internet or comparable technological means.

Open access

Essentially free access to scientific journals and databases, without the need for a costly subscription or organization membership, to facilitate both multidisciplinary among professional scientists and citizen scientists.

Open science

A research approach emphasizing collaborations across fields, creative incorporation of contributions from non-specialists, and such mechanisms as virtual organization laboratories and online citizen science.

Open systems dependability

A methodology for continuous operation of huge, complex, and ever-changing systems that recognizes that failures cannot be entirely prevented but must be minimized in their effects, in a context that gives a high priority to accountability.

Open-source methodology

Inspired by open-source software development projects in which the programming code is widely available for modification and improvement, this approach seeks to achieve greater innovation and broader benefit by conducting many kinds of science and engineering in a public manner.

Orchestration

A form of dynamic leadership applied both before and during a complex endeavor to coordinate the productive interactions of people and ideas to achieve the most creative results.

Paradigm

In science and related endeavors, a more-or-less coherent conceptual framework that defines a field in terms of concepts, theories, and methods.

Participatory design

The involvement of representative users in the design and development of new technologies, often expressed in terminology like user-centered design, value-sensitive design, evaluation studies, and focus groups.

Pasteur's quadrant

Use-inspired basic research, in distinction from pure research that lacks immediate application and applied research that fails to explore fundamental principles, named after the work of Louis Pasteur.

Personal genomics

Genetic sequencing of ordinary individuals, rendered inexpensive by convergence of information and biological technologies, contributing to health by alerting the individual to risks of specific ailments and side-effects of medications.

Person-centered education

Individualized education, designed for the particular needs and learning style of the student, which could be facilitated through convergence of cognitive science and information technology with the field of science or engineering being learned, and which takes on new urgency in the context of the proliferation of online courses that are not inherently personalized.

Planetary boundary

One of several limits, such as a specific concentration of carbon dioxide in the atmosphere, that must not be violated, defining a safe operating space for humanity with respect to the Earth system.

Platforms for convergence

The general categories of enablers for scientific, technological, and societal convergence, including toolsets as well as complex systems on several scales.

Polycentric governance

Managing resources simultaneously at multiple scales, or in multiple overlapping but distinct realms.

Post-Fordism

The doctrine that manufacturing industries should move beyond assembly-line production of uniform products in large facilities, named in contrast to the system exemplified a century ago in production of Ford Motor Company vehicles.

Post-industrial society

A concept from the 1970s that saw a major economic phase change occurring, as manufacturing became a smaller part of the economy, and as services grew to become the dominant sector, believed to increase the significance of science and information technology; the implications of this shift remain uncertain today.

Post-normal science

A problematic form of research under conditions when facts are uncertain, values are in dispute, stakes are high, and decisions are urgent.

Precision agriculture

An approach for rigorous site-specific management of crop production, maximizing efficiency and productivity, while minimizing environmental damage, employing geospatial data techniques and other convergence technologies.

Precompetitive research

Science and technology development in which competing companies share the funding and intellectual property of early-stage work, for example, through industrial consortia and collaboratories, after which they can separately develop patentable innovations.

Proactive convergence

Unification across fields of science or technology that is conducted intentionally, including some form of decision analysis in the convergence approach, thus future-oriented and potentially open-ended.

Reactive convergence

A limited form of unification across fields of science or technology, often triggered by coincidental factors, based on ad hoc collaborations of partners or individual fields for predetermined and limited goals.

Regenerative medicine

Restoring the cells and organs of the human body to support normal functioning, whether by stimulating the body's own repair mechanisms or by culturing person-specific replacement tissues initially outside the body.

Responsible governance

Management of science, technology, and the implementation of their results in a manner that addresses environmental, health, safety, ethical, legal, social, and equity concerns.

Services science

Research intended to discover fundamental principles and management guidelines for activities carried out in service industries, especially in the movement to redefine information processing as a service provided by an enterprise, rather than in terms of hardware owned by the user.

Smart homes

Integration of information technology and other NBIC developments in dwellings to achieve health monitoring, assistance with daily living activities, and prevention of illness and injury.

Social cognition

Processing of information by a social group or network rather than by a single individual, often involving a division of labor in which different people understand different parts of the puzzle.

Social intelligence

The ability of a social group or network to solve challenging problems, which may be more or less than the ability of an individual member, and could be enhanced by convergence of the problem-relevant field with cognitive science.

Societal convergence

The unification of humanity, facilitated by convergence of all fields of science and engineering, in peaceful and prosperous transcendence of traditional geographic, political, and cultural barriers, while maintaining healthy diversity.

Societal-scale platform

The set of convergence enablers characterized by the activities and systems that link individuals and groups on several larger scales; it consists of collective activities, organizations, and procedures, including the various forms of governance.

Stakeholder

A person or group having an interest in the outcome of a policy or implementation action, usually in the context of public decision-making.

Sustainable development

Progress that meets the needs of people today without compromising the ability of future generations to meet their own needs with respect to social, economic, and environmental conditions.

Synergy

The phenomenon in which a system of component parts has a different effect from the sum of those components, at the extreme a form of convergence creating a tightly integrated system from which none of the components can be removed without destroying the system.

Systemic convergence

Unification that goes beyond a few fields of science and technology to include major aspects of culture and society, driven by higher purposes and often guided by convergence organizations.

Technological unemployment

The loss of jobs when technological changes put people out of work, which may or may not in practice be balanced by the creation of new jobs required by the new technology.

Time banking

A form of community-based volunteering in which participants provide and receive services, following a bookkeeping system based on hours of work rather than money, managed through an information and communication system.

Transdisciplinary

When disparate knowledge converges to produce new knowledge without necessarily uniting the contributing fields.

Transformative governance

Creative management having a result-oriented, project-oriented focus and advancing multidisciplinary innovation, such that a sector of the economy or society may change markedly.

Universal access

The principle that the benefits of science and technology should be as widely available as possible, sometimes used in connection with disabled or disadvantaged populations, but broadly applicable.

Valley of death

The gap between laboratory research and real-world applications that is difficult to bridge and often results in a failure to benefit from new discoveries, and innovations because late-stage application steps like scalability and commercialization cannot be completed.

Virtual organization

A form of cooperation in some way outside traditional forms, usually employing electronic means of communication and thus not requiring a physical meeting place, but often also involving multiple groups and individuals who do not belong to a unified authority structure.

Visionary governance

Future-oriented management of innovation that looks beyond immediate results, including long-term planning and anticipatory, adaptive policies.

Vision-inspired basic research

Rigorous scientific research seeking to solve fundamental problems, motivated more by fresh ideas than by existing intellectual traditions or immediate practical applications.

Wellness

A conceptualization of human health that emphasizes prevention of disease more than cure, and proactive enhancement of general physical and cognitive well-being more than merely dealing with problems reactively when they arise