

20th ICCRTS

Cybernetics: A General Theory that Includes Command and Control

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A paper prepared for the

20th International Command and Control Research and Technology Symposium

http://www.dodccrp.org/events/20th_icrts_2015/20th_icrts_call_for_papers.pdf

Annapolis, MD

June 16-19, 2015

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Abstract

The field of cybernetics originated in the United States in the late 1940s and early 1950s in a series of meetings sponsored by the Josiah Macy, Jr. Foundation. Norbert Wiener named the field after the Greek word, *kybernetes*, for governor. In 1948 he defined cybernetics as control and communication in animal and machine. Social systems were soon added. Although originally based on the study of biological and social systems, information technology has progressed so rapidly, the prefix “cyber” now means either computers or the internet to most people. There are currently no academic programs in the U.S. that cover the broad field of cybernetics. The authors of articles in cybernetics journals used to be predominantly from the U.S. Now most articles are by authors from European countries or China. This paper reviews the history of cybernetics in the U.S. and other countries and points out some non-technical aspects of cybernetics with security implications.

THE ORIGIN OF CYBERNETICS

Cybernetics as a field of scientific activity in the United States (U.S.) began in the years after World War II. Between 1946 and 1953 the Josiah Macy, Jr. Foundation sponsored a series of conferences in New York City on the subject of “Circular Causal and Feedback Mechanisms in Biological and Social Systems.” (Pias, 2004). After Norbert Wiener published his book *Cybernetics* in 1948, Heinz von Foerster suggested that the name of the conferences be changed to “Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems.” In this way the meetings became known as the Macy Conferences on Cybernetics.

In subsequent years cybernetics influenced many academic fields – computer science, electrical engineering, artificial intelligence (AI), robotics, management, family therapy, political science, sociology, biology, psychology, epistemology, music, architecture, philosophy, etc. Cybernetics has been defined in many ways: as control and communication in animals, machines, and social systems; as a general theory of regulation; as the science or art of effective organization; as the art of constructing defensible metaphors; etc. (Richards, 1987) The term “cybernetics” has been associated with many stimulating conferences, yet cybernetics has not thrived as an organized scientific field within American universities. Although a few cybernetics programs were established on U. S. campuses, these programs did not survive the retirement or death of their founders.

INTERPRETATIONS OF CYBERNETICS

Not everyone originally connected with cybernetics continued to use the term. The original group of cyberneticians created several research traditions.

1. The cybernetics of Allen Turing (1936, 1950) and John von Neumann (1944, 1961) became computer science, AI, and robotics. The related professional societies are the Association for Computing Machinery and the American Association for Artificial Intelligence.

2. Norbert Wiener's (1948) cybernetics became part of electrical engineering. This branch of cybernetics includes control mechanisms, from thermostats to automated assembly lines. The Institute of Electrical and Electronics Engineers (IEEE), including the Systems, Man, and Cybernetics Society, is the main professional society. The principal concern is systems engineering.
3. Warren McCulloch's (1965) cybernetics became "second order cybernetics." McCulloch chaired the Macy Foundation conferences. He sought to understand the functioning of the nervous system and thereby the operation of the brain and the mind. Heinz von Foerster (2003) and the American Society for Cybernetics continued this tradition.
4. Gregory Bateson (1972, 1979) and Margaret Mead (1964, 1970) pursued research in the social sciences, particularly anthropology, psychology, and family therapy. Work on the cybernetics of social systems is being continued in the American Society for Cybernetics and the Bateson Ideas Group.
5. The research on cognition conducted by Arturo Rosenblueth (1943) has been continued by Humberto Maturana and Francisco Varela (1980, 1992) and the American Society for Cybernetics.
6. In Europe the work of Niklas Luhmann (1995), influenced by von Foerster, Maturana, and others, has been popular in recent years. This work has been influential in the Socio-Cybernetics Working Group of the International Sociological Association.

Other groups can also be identified. For example, a control systems group within psychology was generated by the work of William Powers (1973). The Santa Fe Institute has developed simulation methods based on the ideas of self-organizing systems and cellular automata. (Waldrop, 1992)

A BRIEF HISTORY OF CYBERNETICS

This paper recounts about seventy-five years of the history of cybernetics in the U.S. and other countries, divided into five year intervals. The emphasis will be on the third, fourth, and fifth groups listed above.

Early 1940s

In 1943 two landmark papers were published. Warren McCulloch and Walter Pitts (1943) wrote, "A Logical Calculus of the Ideas Immanent in Nervous Activity." This article sought to understand how a network of neurons functions so that we experience what we call "an idea." They presented their explanation in mathematical form. Arturo Rosenblueth, Norbert Wiener and Julian Bigelow (1943) published, "Behavior, Purpose, Teleology." They observed behavior, which they interpreted as purposeful, and then sought to explain how this phenomenon could happen without teleology, using only Aristotle's efficient cause. Also in the early 1940s Wiener worked on a radar-guided anti-aircraft gun.

Late 1940s

In the late 1940s the early Macy Conferences were held in New York City. (Heims, 1991) They were attended by scientists including Norbert Wiener, Julian Bigelow, John von Neumann, Margaret Mead, Gregory Bateson., Ross Ashby, Grey Walter, and Heinz von Foerster. By 1949 three key books were published: Von Neumann's and Morgenstern's (1944) *Theory of Games and Economic Behavior*; Wiener's (1948) *Cybernetics: Or Control and Communication in the Animal and the Machine*; and Shannon's and Weaver's (1949) *The Mathematical Theory of Communication*. These books defined a new science of information and regulation.

Early 1950s

In the early 1950s more Macy conferences were held. This time proceedings were published with Heinz von Foerster as editor. (Pias, 2004) Meanwhile the first commercial computers were manufactured.

Late 1950s

In the 1950s the Central Intelligence Agency (CIA) was concerned about the possibility of brain-washing and mind control. Under the code name MKUltra experiments with lysergic acid diethylamide (LSD) and other drugs were conducted at Harvard University and elsewhere. (Marks, 1978) Some of the money for this research passed through the Macy Foundation.

Early checkers-playing programs were written and raised the possibility of artificial intelligence. (Samuel, 1959) In 1956 at a conference at Dartmouth University people interested in studying the brain and people interested in creating computer programs parted ways. Neurophysiologists valued work that illuminated the nature of cognition. Engineers valued work that led to useful machines. Thereafter the people interested in cybernetics and the people interested in AI had little interaction.

Following a sabbatical year working with Arturo Rosenblueth and Warren McCulloch, Heinz von Foerster founded the Biological Computer Laboratory (BCL) at the University of Illinois in 1958. During the 1960s and early 1970s BCL was the leading center for cybernetics research in the U.S. Frequent visitors were Humberto Maturana, Francisco Varela, Gordon Pask, and Lars Loefgren. Graduates included Klaus Krippendorff, Alfred Inselberg, Crayton Walker, Roger Conant, and Stuart Umpleby.

During the same period the Mental Health Research Institute (MHRI) at the University of Michigan was the leading center for general systems research in the U.S. The founding director of MHRI was James G. Miller. Other systems scientists at MHRI were Kenneth E. Boulding, Anatol Rapoport, Richard L. Meier, and John R. Platt.

Early 1960s

In the early 1960s several conferences on self-organizing systems were held. (Yovits and Cameron, 1960; Yovits, *et al.*, 1962). One of these conferences was held in 1961 at the University of Illinois's Allerton Park. (von Foerster and Zopf, 1962) As a result of an invitation made at this conference, Ross Ashby moved from England to Illinois. The work on self-organizing systems was a forerunner to the field of study now called "complexity" or complex systems.

Although the Macy Foundation Conferences ended in 1953, the American Society for Cybernetics (ASC) was not founded until 1964. Part of the reason for founding the ASC was the international tension due to the Cold War. (Dechert, 1966) During the Presidential campaign in 1960, when John F. Kennedy was elected, there was talk about a "missile gap" between the United States and the Soviet Union. Not long thereafter there began to be talk about a "cybernetics gap." Some people in the Soviet Union thought cybernetics would provide the theory they needed to operate their centrally planned economy. Consequently, the Soviet government generously funded cybernetics research. Some people in the U.S. government feared that the U.S. might fall behind in a critical area of research, if this country did not also fund cybernetics research.

In Washington, DC, a cybernetics luncheon club was meeting. The participants included Paul Henshaw, Atomic Energy Commission; Carl Hammer, Univac; Jack Ford, CIA; Douglas Knight, IBM; Walter Munster; and Bill Moore, lawyer. This group founded the American Society for Cybernetics (ASC). A grant from the National Science Foundation (NSF) helped the Society to establish the *Journal of Cybernetics*. A conference on the social impact of cybernetics was held at Georgetown University in 1964. (Dechert, 1966) The first conference arranged by the ASC was held in 1967 at the National Bureau of Standards in Gaithersburg, MD. (von Foerster, *et al.*, 1968)

Late 1960s

Social movements in the United States – against the Viet Nam war and for civil rights, women’s rights, and environmental protection – produced a time of student activism on campuses. In terms of research it was a productive period for the Biological Computer Laboratory (BCL) at the University of Illinois. (Mueller and Mueller, 2007)

Early 1970s

At a meeting of the ASC in 1974 in Philadelphia, Heinz von Foerster introduced the term “second order cybernetics.” (Von Foerster, 1979) The Mansfield Amendment, which was an attempt to reduce campus unrest caused by the Viet Nam War, cut off government funds for research that was not related to a military mission, including research on cybernetics at BCL. (Umpleby, 2003b)

There was an argument between the officers of ASC and the publisher of the *Journal of Cybernetics*. The dispute was submitted to arbitration, and the publisher won. Thereafter the journal continued to be published, but without ASC involvement. The journal published articles primarily in engineering. However, the work in ASC was increasingly emphasizing biology and the social sciences.

Late 1970s

Heinz von Foerster retired from the University of Illinois in 1976 and moved to California. There he communicated with Paul Watzlawick, John Weakland, and others at the Mental Research Institute in Palo Alto. During this time second order cybernetics or constructivist epistemology had a significant impact on the field of family therapy. (Watzlawick, 1984)

In the late 1970s no meetings of the ASC were held. The people connected with BCL attended meetings of the Society for General Systems Research, which a few years later changed its name to the International Society for the Systems Sciences.

Under an NSF grant for an Electronic Information Exchange for Small Research Communities, the BCL group moved into cyberspace. (Umpleby, 1979; Umpleby and Thomas, 1983) This group, discussing General Systems Theory, was one of nine academic groups using the Electronic Information Exchange System (EIES) at New Jersey Institute of Technology. For three years in the late 1970s cyberneticians and systems scientists across the United States and a few in Europe communicated with each other using email and computer conferencing via dumb terminals and, initially, 300 baud modems. The long distance telephone charges were paid by the NSF grant. When the grant ran out, universities would not pay the communications charges. It took almost fifteen years before costs declined sufficiently to permit regular email communication among academics.

Early 1980s

In 1980 a planning conference was held by the members of the ASC to chart a new direction for the Society both in topics addressed and the manner of communication. (Umpleby, 1981) ASC began holding conferences again and reestablished connections with its former journal, now called *Cybernetics and Systems*.

A series of meetings with Soviet scientists was started as a way to bring leading American scientists together to review fundamentals, in particular to discuss second order cybernetics. (Umpleby, 1987b; Umpleby and Sadovsky, 1991) The meetings were funded by the American Council of Learned Societies and the Soviet Academy of Sciences. These meetings were quite productive for exchanging views; however, a controversy with the Soviet side arose over the participation of Vladimir Lefebvre, a Soviet émigré. Prior to *glasnost* and *perestroika* Lefebvre's theory (1982) of two systems of ethical cognition was not accepted by the Soviet government. However, during the break up of the Union of Soviet Socialist Republics (USSR) Lefebvre's work was used by people at the highest levels of government in both the United States and the Soviet Union to prevent miscommunication. (Umpleby, 1991) Lefebvre's work is being further developed through annual conferences organized by Vladimir Lepsky in the Institute of Psychology of the Russian Academy of Sciences in Moscow. Lefebvre's theory of reflexive control is being used by psychologists and educators to help with the psychological and cultural difficulties involved in the social, political, and economic transition in Russia. (Umpleby and Medvedeva, 2001)

Late 1980s

Members of the ASC began offering tutorials on first and second order cybernetics prior to systems conferences (see Table 1). They were seeking to make a scientific revolution. (Umpleby, 1974) At a conference in St. Gallen, Switzerland, in 1987 the members of the American Society for Cybernetics decided to focus their attention almost exclusively on advancing second order cybernetics. (Umpleby, 1987a) The focus on second order cybernetics to the exclusion of other interpretations of cybernetics had the effect of reducing the membership of the ASC to about one hundred members. However, there was more interest in second order cybernetics in Europe. (Umpleby, 1997)

Table 1. Definitions of First and Second Order Cybernetics

Author	First Order Cybernetics	Second Order Cybernetics
Von Foerster	The cybernetics of observed systems	The cybernetics of observing systems
Pask	The purpose of a model	The purpose of a modeler
Varela	Controlled systems	Autonomous systems
Umpleby	Interaction among the variables in a system	Interaction between observer and observed
Umpleby	Theories of social systems	Theories of the interaction between ideas and society

Early 1990s

In 1990 two symposia on “Theories to Guide the Reform of Socialist Societies” were held in Washington, DC, and Vienna, Austria (Umpleby, 1991). These meetings were the beginning of a multi-year effort both to understand the changes occurring in the former Soviet Union from the perspective of social theory and to use knowledge of social systems to guide the transitions.

The work on second order cybernetics was also changing. The members of the ASC had worked almost twenty years on developing and promoting the point of view known as second order cybernetics or constructivism. Some people wanted to move from a period of revolutionary science to a new period of normal science. (Umpleby, 1990) One way to understand the change is to say that the period of engineering cybernetics lasted from the mid 1940s to the mid 1970s. The period of biological cybernetics or second order cybernetics lasted from the mid 1970s to the mid 1990s. And the period of social cybernetics began in the mid 1990s (see Table 2).

Table 2. Three versions of cybernetics

	Engineering Cybernetics	Biological Cybernetics	Social Cybernetics
The view of epistemology	A realist view of epistemology: knowledge is a “picture” of reality	A biological view of epistemology: how the brain functions	A pragmatic view of epistemology: knowledge is constructed to achieve human purposes
A key distinction	Reality vs. scientific Theories	Realism vs. constructivism	The biology of cognition vs. the observer as a social participant
The puzzle to be solved	Construct theories which explain observed phenomena	Include the observer within the domain of science	Explain the relationship between the natural and the social sciences
What must be explained	How the world works	How an individual constructs a “reality”	How people create, maintain, and change social systems through language and ideas
A key assumption	Natural processes can be explained by scientific theories	Ideas about knowledge should be rooted in neurophysiology	Ideas are accepted if they serve the observer’s purposes as a social participant
An important consequence	Scientific knowledge can be used to modify natural processes to benefit people	If people accept constructivism, they will be more tolerant	By transforming conceptual systems (through persuasion, not coercion), we can change society

Late 1990s

Symposia on the transitions in the former Soviet Union continued to be held as part of the European Meetings on Cybernetics and Systems Research. These meetings are held every two years in Vienna, Austria. The symposia bring together scientists from East and West.

In Washington, DC, a series of meetings on the Year 2000 Computer Problem, often referred to as Y2K, were held with the support of *The Washington Post*. The Y2K problem arose because in many computer programs the dates of years were abbreviated to two digits. Hence, 1999 and 2000 became 99 and 00. The possible failure of computer programs due to this abbreviation was the first major problem of an information society and was treated as an unintended experiment which would reveal the amount of interconnectedness in our increasingly cybernetic society. (Umpleby, 2000)

Niklas Luhmann's writings in sociology introduced ideas such as constructivism and autopoiesis to social scientists in Europe. (Luhmann, 1995) A Socio-Cybernetics Working Group within the International Sociological Association was established by Felix Geyer and others.

Early 2000s

In the early years of the 21st century large conferences on informatics and cybernetics were organized by Nagib Callaos and his colleagues in Orlando, FL. One result has been organizing efforts in Latin America stimulated by the conferences in Orlando. Annual conferences on reflexive control began to be held in Moscow, organized by Vladimir Lepsky.

In the International Society for the Systems Sciences there was growing interest in group facilitation and participation methods. (Bausch, 2004) An increasing number of books about cybernetics began to appear, frequently by German authors. (Mueller and Mueller, 2007) A Heinz von Foerster Society was established in Vienna to further develop the ideas explored in the Biological Computer Laboratory at the University of Illinois in Urbana-Champaign. A new biography of Norbert Wiener was published which explained the break that occurred between Wiener and McCulloch. (Conway and Siegelman, 2005)

The "global university system" created by the internet and the Bologna Process was not only greatly facilitating communication among scientists around the world but also led to a new metaphor for the social implications of cybernetics, an alternative metaphor to the "global brain." (Umpleby, 2003a)

Late 2000s

Since 1970 European Meetings on Cybernetics and Systems Research (EMCSR) were held in Vienna, Austria, every two years. These were the most diverse and well-organized meetings on cybernetics and systems research. The International Federation for Systems Research (IFSR), established in 1981, grew out of these meetings. In 2010 an honor society, the International Academy for Systems and Cybernetic Sciences was established by IFSR to recognize scholars who have contributed to these transdisciplinary fields.

Ranulph Glanville, president of the ASC and a consultant to schools of architecture, organized a series of conferences that introduced the topic of cybernetics and design. Several architecture professors became active in the Society.

Early 2010s

A small group of people from Australia and India worked to reintroduce cybernetics into the U.S. by holding a special conference of the IEEE Systems, Man and Cybernetics Society in Waltham, MA, in 2014 to commemorate the fiftieth anniversary of Norbert Wiener's death. A second annual IEEE conference on cybernetics is planned for Poland in 2015.

Research in Second Order Cybernetics led to discussions of Second Order Science. Two conceptions of Second Order Science were presented and discussed in a special issue of the journal *Constructivist Foundations*. (Mueller and Riegler, 2014)

QUESTIONS ABOUT THE HISTORY OF CYBERNETICS

Given the promising and exciting beginnings of cybernetics, the outstanding scientists involved, and the subsequent impact of cybernetics on many disciplines, it is curious that the term "cybernetics" is not widely known in the U.S. today, even though most professional people spend several hours a day in "cyberspace."

Why did the cybernetics movement break up following the Macy Conferences? Perhaps it never came together. People stayed in their home disciplines. Many very thought-provoking meetings were held under the label of cybernetics, but the educational programs that were established did not survive in discipline-oriented universities. When their founders retired, the programs were closed. One consequence of the lack of educational programs in cybernetics at U.S. universities is that key ideas tend to be reinvented. One example is the work on complex systems centered at the Santa Fe Institute. These writers rarely refer to the prior work in cybernetics on self-organizing systems. (Yovits and Cameron, 1960; von Foerster and Zopf, 1962; Yovits, *et al.*, 1962)

What prevented unity? There was never agreement on fundamentals. Eric Dent in his doctoral dissertation at The George Washington University provides an explanation of the continuing heterogeneity of the fields of cybernetics and systems science. (Dent, 1996) Dent claims that after World War II the systems sciences dramatically expanded the scientific enterprise. Specifically, science expanded using new interpretations of eight concepts -- causality, determinism, relationships, holism, environment, self-organization, reflexivity, and observation. (Dent, 2001) However, not all of the various systems fields chose to emphasize the same concepts. Indeed, each field chose a unique combination. This meant that the various systems fields did not agree on what the key issues were. As a result each subfield developed its own language, theories, methods, traditions, and results.

These eight concepts have both united and divided the systems sciences. The concepts unite the systems sciences because each of the subfields of systems science uses at least one of the new assumptions, whereas classical science uses none. The concepts divide the systems sciences because each subfield emphasizes a different concept or set of concepts. Hence, issues that are very important in one subfield are less important or do not arise in other subfields. Given different questions, the answers in theories and methods have been different. (Umpleby and Dent, 1999) A task for the future will be to integrate more successfully the several fields of systems science and cybernetics.

THE SHIFT OF CYBERNETICS TO EUROPE AND ASIA

Although important early work in cybernetics was done in the U.S., in recent years the location of cybernetics education and research has moved to other countries. The larger field of cybernetics (not just

computers, the internet and systems engineering) still exists in the U.S. in the form of annual conferences, but conference attendance is low and the cybernetics literature, if it is taught at all on university campuses, is offered only in elective courses. There are no degree programs in cybernetics in the U.S. Meanwhile, in Europe and Asia interest and activity in cybernetics is growing.

Apparently the reason why interest in cybernetics has prospered among Europeans but not Americans is that Europeans and Americans have different ways of establishing meaning (Tsay, *et al.*, 2009). If one presents a theoretical proposition to an American audience, the first question will be, How can the principle be applied in practice? If one presents the same theoretical proposition to a European audience, the first question will be, From what philosophical position is that proposition derived? Europeans think that creating more general theories is appropriate and useful. Americans do not. Americans evaluate theories by their practical utility. But before one can have applications, there must be a theory. Given the different intellectual habits of Americans and Europeans, encouraging cooperative research among Americans and Europeans is one way to maintain American understanding of how this key field is developing.

The hypothesis that cybernetics research is moving to Europe and Asia can be tested by examining the locations of authors of articles in cybernetics journals. (Umpleby and Wu, 2013) Articles from thirty years in three journals *Cybernetics and Systems*, *Kybernetes* and *Systems Research and Behavioral Science* were studied. Articles in all three journals were sampled in three year intervals from 1974 through 2010. If an article had more than one author, the article was counted only once. If an article had authors from more than one country, only the country of the first author was recorded. Appendix A shows the number of articles in each sampled year written by authors from the countries listed¹. The countries were then grouped by region (see Table 3) and the number of articles from each region for the sampled years is presented in Table 4. Figure 1 shows how the number of cybernetics articles from various regions has changed in recent years. Table 5 lists the number of articles in 1974, the number of articles in 2010, and the change. In 1974 North America had the largest number of articles. In 2010 the number of articles written by authors in North America is only 53% of that in Asia and 22% of that in Europe. Comparing the number of articles in 1974 and 2010, the number of North American articles declined 76%, the number of European articles increased 153%, and the number of Asian articles increased 433%. As indicated in Table 6 articles by U.S. authors alone outnumbered the combined number of articles by authors in Asia and Europe. In 2010 the number of U.S. articles is less than from the United Kingdom (U.K.) or from China. (Umpleby and Wu, 2013)

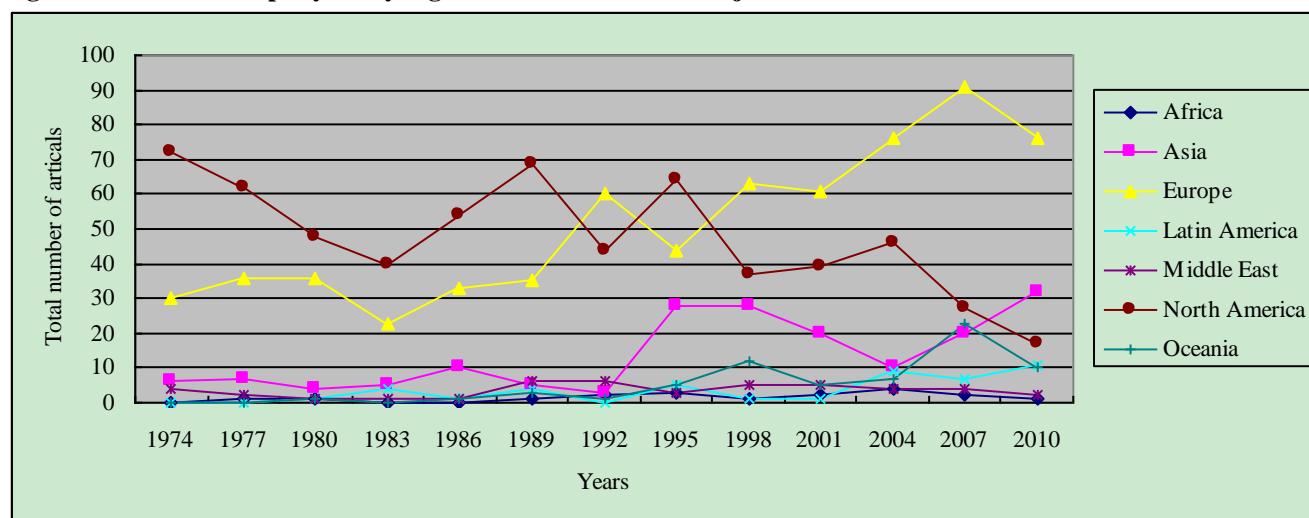
Table 3. Regions and countries

Regions	Countries
Africa	Algeria, Egypt, Gabon, Kenya, Nigeria, Senegal, South Africa, Tanzania, Uganda
Asia	Bangladesh, Brunei, China, India, Indonesia, Japan, Korea, Malaysia, Singapore
Europe	Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Italy, Lithuanian, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, U.K., Ukraine
Latin America	Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico
Middle East	Iran, Iraq, Israel, Jordan, Morocco, Oman, Pakistan, Saudi Arabia, UAE
North America	Canada, USA

¹ Note that the numbers listed exclude some articles in *Kybernetes*: all articles in issue 2 in 2004, and issues 2, 6 and 8 in 2010. These articles are mainly by Chinese authors, written on special topics. Including these articles will make the total number of articles in these years far more than other years, which is misleading. However, this omission does not affect the general trend discussed in this paper.

Table 4. Total number of articles per year and per region in the three journals

	Africa	Asia	Europe	America	Middle East	North America	Oceania	Total
1974	0	6	30	0	4	72	0	112
1977	1	7	36	0	2	62	0	108
1980	1	4	36	1	1	48	1	92
1983	0	5	23	4	1	40	0	73
1986	0	10	33	1	1	54	1	100
1989	1	5	35	4	6	69	3	123
1992	2	3	60	0	6	44	1	116
1995	3	28	44	5	3	64	5	152
1998	1	28	63	1	5	37	12	147
2001	2	20	61	1	5	39	5	133
2004	4	10	76	9	4	46	7	156
2007	2	20	91	7	4	27	23	174
2010	1	32	76	11	2	17	10	149

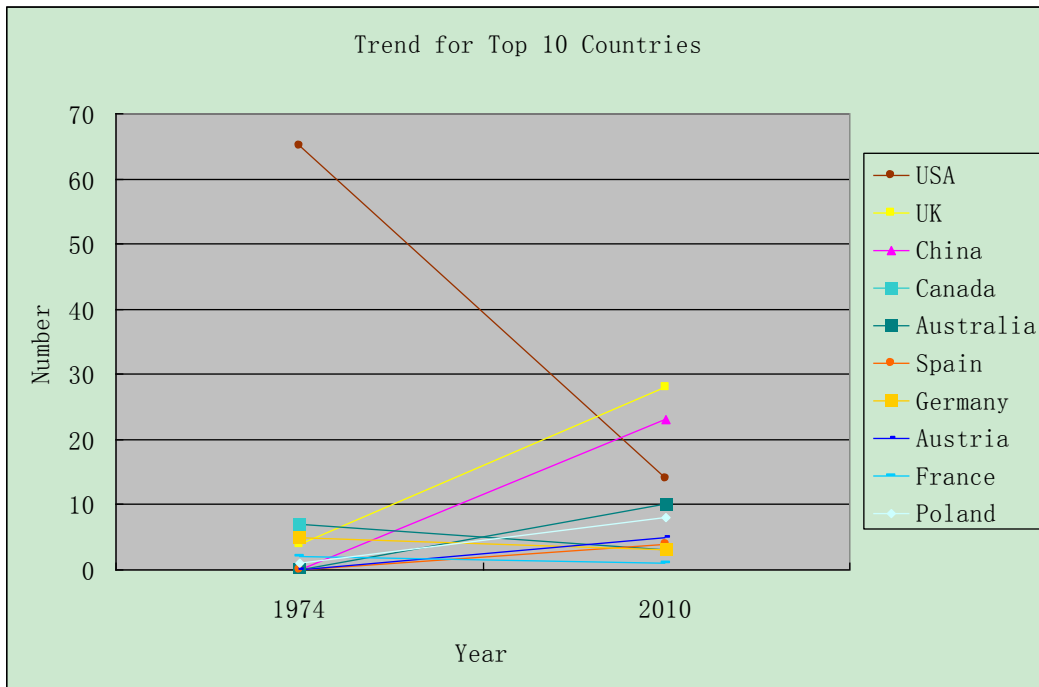
Figure 1. Total articles per year by region over time in the three journals**Table 5. Comparing the number of articles in 1974 and 2010 by region**

	1974	2010	Change	
			Number	Percentage
Africa	0	1	1	N/A
Asia	6	32	26	433%
Europe	30	76	46	153%
Latin America	0	11	11	N/A
Middle East	4	2	-2	-50%
North America	72	17	-55	-76%
Oceania	0	10	10	N/A

Table 6. Comparing the number of articles in 1974 and 2010 for the top ten countries (Ranked by the total number of articles from year 1974 to 2010)

Country	USA	UK	China	Canada	Australia	Spain	Germany	Austria	France	Poland
1974	65	4	0	7	0	0	5	0	2	1
2010	14	28	23	3	10	4	3	5	1	8

Figure 2. Compare the number of articles in 1974 and 2010 for the top ten countries (Ranked by the total number of articles from year 1974 to 2010)



These three journals, *Cybernetics and Systems*, *Kybernetes*, and *Systems Research and Behavioral Science*, are the leading journals in the field of cybernetics. In all three the number of articles written by North American authors has declined while the number of articles written by authors in Europe and particularly in Asia has increased.

WHY CYBERNETICS DECLINED IN THE U.S. AND IS RISING IN EUROPE AND ASIA

In the 1960s it seemed that cybernetics would become the foundational discipline for the social sciences, computer science, library science, and the design disciplines, in somewhat the same way that physics is the foundational discipline for engineering fields. This has not happened. Attention shifted to AI and robotics, leaving cybernetics unfunded. Figure 3 shows the frequency of usage of the words “cybernetics,” “artificial intelligence,” and “robotics” between 1940 and 2008 according to Google’s ngram program. Today people speak about cyberspace and cyber-infrastructure, but they seem not to know about cybernetics. Figure 4 shows the frequency of usage of the words “cybernetics,” “cyberspace,” and “cyber security” between 1940 and 2008 according to Google’s ngram program.

The Mansfield Amendment in 1970 prevented the Department of Defense from funding research on college campuses that was not related to a military mission. An unanticipated consequence of the amendment was to eliminate funding for the broad conception of cybernetics and increase funding for AI and robotics. (Umpleby, 2003b)

Figure 3. The frequency of usage of the words “cybernetics,” “artificial intelligence,” and “robotics” between 1940 and 2008 according to Google’s ngram program

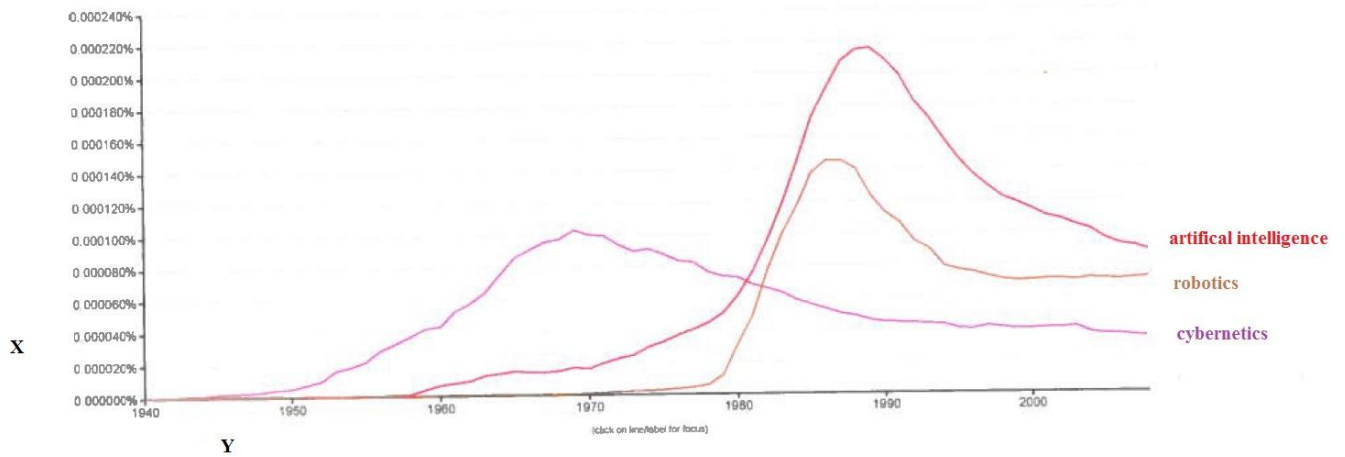
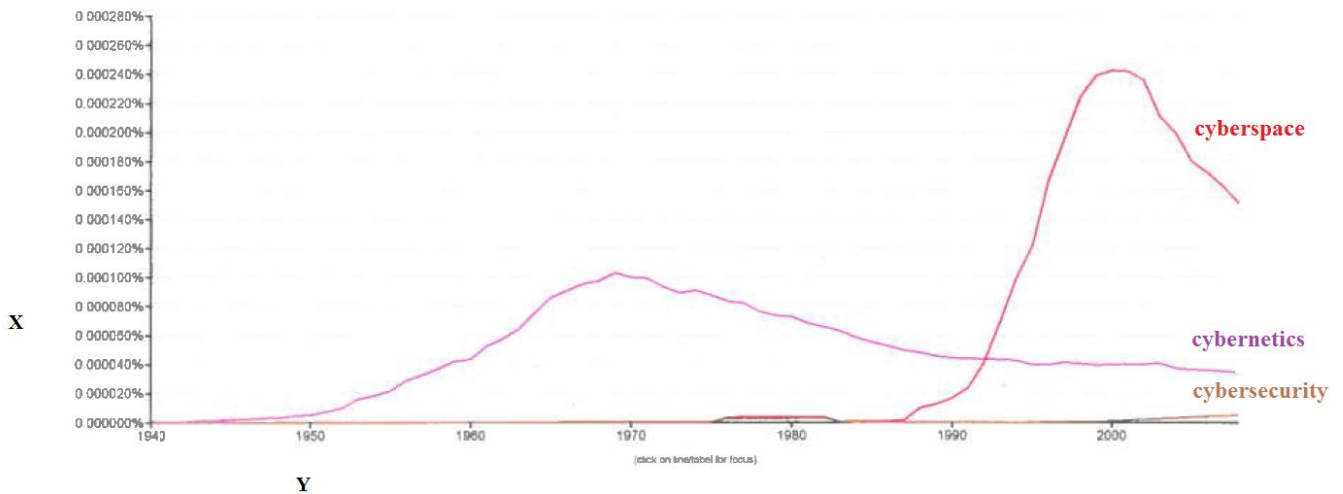


Figure 4. The frequency of usage of the words “cybernetics,” “cyberspace,” and “cyber security” between 1940 and 2008 according to Google’s ngram program



SOME IMPLICATIONS OF CYBERNETICS FOR SECURITY MANAGEMENT

Although since 1970 there has been no government funding for the broad interpretation of cybernetics, the field has progressed through the research activities of individuals. Below are several examples that are related to security concerns:

1. Cybernetics has made important contributions to psychotherapy and family therapy or “system therapy.” (Bateson, 1972, 1979; Watzlawick, 1984) This work can be helpful in treating post-traumatic stress and in helping populations cope with the consequences of violence, e.g., in Iraq and Afghanistan.
2. Reflexivity theory, advocated by George Soros (1987, 2013), is becoming more well-known by economists. It is quite compatible with contemporary cybernetics. The stability of the banking system is a national security concern.
3. Vladimir Lefebvre’s (1982) theory of reflexive control was used at the highest levels in the U.S. and USSR governments during the break-up of the Soviet Union to help prevent misunderstandings. It is a theory of two systems of ethical cognition, but also a theory of a very deep-seated cultural difference.
4. The field of management cybernetics, based on the work of Stafford Beer (1972, 1975, 1979), Russell Ackoff (1981) and others, has developed outside the meetings and journals of the Academy of Management (AOM), the main academic society for U.S. management professors. The result is a large gap in language and concerns with management cybernetics being well-grounded in theory, philosophy and practice. Because it is based on theories of information and regulation, management cybernetics is particularly suited to understanding and operating within a knowledge-based society.
5. The difficulties faced by the systems sciences since World War II (trying to survive in discipline-oriented universities) led John Warfield to propose a new college within universities. It would combine features of an Institute for Advanced Studies and a consulting firm. (<http://www.gmu.edu/depts/t-iasis/wandwaver/wandw.htm>) He suggested that universities be thought of as having three colleges. The Heritage College would contain the arts and sciences (knowledge from the past). The Professional College would contain schools of business, law, and medicine (current practice). The Horizons College would be design and policy oriented and the core curriculum would be systems science and cybernetics. The Horizons College would work with clients on large, multidisciplinary projects. No university has yet attempted to implement Warfield’s proposal, but the increasing specialization in universities is increasing the need for it.
6. Several fields, particularly anthropology, sociology, and social psychology have long been interested in the interaction between ideas and society. Cybernetics has recently extended this idea in claiming that scientists and scientific theories should be viewed as lying not outside but rather inside in the social system being studied. A result has been Second Order Science which combines meta research, or research on research, with attention to the social and political use and consequences of science. This new trend in the philosophy of science could lead to many new approaches to social systems.
7. People in the fields of information systems and management occasionally say that there is no theory in their field. However, the field of cybernetics, which has been developing since the late 1940s, provides a general theory of information and regulation. The theory provides a foundation for understanding the behavior of individuals, groups, organizations, nations, and machines.

CONCLUSION

Knowledge advances most rapidly when there is a combination of theory and practice. Cybernetics provides a theory which is particularly suited to integrating management systems containing both human and machine elements. Today in the U.S. the “cyber” prefix is associated primarily with computers and communications, where the U.S. is the leader. However, cybernetics had its origin in biological and social systems, and recent theoretical work has emphasized these fields. Research in the broader conception of cybernetics has now shifted dramatically toward Europe and Asia. If not corrected, this shift in the location of research might lead to difficulties in the not too distant future.

REFERENCES

- Ackoff, R. (1981), *Creating the Corporate Future*. New York: Wiley.
- Beer, S. (1972), *Brain of the Firm*. New York: Wiley.
- Beer, S. (1975), *Platform for Change*. New York, Wiley.
- Beer, S. (1979), *The Heart of Enterprise*. New York: Wiley.
- Bateson, G. (1972), *Steps to an Ecology of Mind*. San Francisco: Chandler Publishing.
- Bateson, G. (1979), *Mind and Nature: A Necessary Unity*. New York: Dutton.
- Bausch, K. (ed.), (2004), Special Issue on Agoras of the Global Village, *World Futures*. Vol. 6, No. 1-2.
- Conway, F. and J. Siegelman (2005), *Dark Hero of the Information Age: In Search of Norbert Wiener, the Father of Cybernetics*. New York: Basic Books.
- Dechert, C. (ed.). (1966), *The Social Impact of Cybernetics*. New York: A Clarion Book.
- Dent, E. (1996), *The Design, Development, and Evaluation of Measures to Survey Worldview in Organizations*. Ann Arbor, MI: University Microfilms.
- Dent, E. (2001), “System Science Traditions: Differing Philosophical Assumptions.” *Systems, Journal of the Polish Systems Society*, Vol. 6, No. 1-2.
- Heims, Steve J. (1991), *The Cybernetics Group*. Cambridge: MIT Press.
- Lefebvre, V. (1982), *Algebra of Conscience: A Comparative Analysis of Western and Soviet Ethical Systems*. London: Reidel Publishing Co.
- Luhman, N. (1995), *Social Systems*. Stanford, CA: Stanford University Press.
- Marks, J. (1978), *The Search for the Manchurian Candidate*. New York: Times Books.
- Maturana, H. and F. Varela (1980). *Autopoiesis and Cognition: The Realization of the Living*. Boston: Reidel.
- Maturana, H. and F. Varela (1992). *The Tree of Knowledge: The Biological Roots of Human Understanding*. New York: Random House.
- McCulloch, W. and W. Pitts. (1943), “A Logical Calculus of the Ideas Immanent in Nervous Activity.” *Bulletin of Mathematical Biophysics*, 5, pp. 115-133.

- McCulloch, W. (1965), *Embodiments of Mind*. Cambridge, MA: MIT Press.
- Mead, M. (1964), *Continuities in Cultural Evolution*. New Haven: Yale University Press.
- Mead, M. (1970), *Culture and Commitment: A Study of the Generation Gap*. Garden City, NY: Natural History Press.
- Mead, M. (1968), "Cybernetics of Cybernetics." In von Foerster, *et al.* (eds.), *Purposive Systems*, Spartan Books.
- Mueller, A. and K. Mueller (eds.). (2007), *An Unfinished Revolution? Heinz von Foerster and the Biological Computer Laboratory / 1958-1976*. Vienna: Ecoraum.
- Mueller, K. and A. Riegler. (2014). "A New Course of Action." Special issue on Second Order Science. *Constructivist Foundations*. (<http://www.univie.ac.at/constructivism/journal/10/1>)
- Pias, C. (ed.). (2004), *Cybernetics – Kybernetik: The Macy Conferences 1946-1953*. Zurich-Berlin: Diaphanes.
- Powers, W. (1973), *Behavior: the Control of Perception*. New York: Aldine Publishing.
- Richards, L.(1987), "Defining 'Cybernetics'," <http://www.asc-cybernetics.org/foundations/definitions.htm>
- Rosenblueth, A., N. Wiener, and J. Bigelow (1943), "Behavior, Purpose and Teleology." *Philosophy of Science*, 10, pp. 18-24. Reprinted in W. Buckley (ed.) *Modern Systems Research for the Behavioral Scientist*. Chicago: Aldine, 1968, pp. 221-225.
- Samuel, Arthur (1959), "Some Studies in Machine Learning Using the Game of Checkers" (PDF). *IBM Journal* 3 (3): 210-229.
- Shannon, C. and W. Weaver (1949), *The Mathematical Theory of Communication*. Urbana, IL: University of Illinois Press.
- Soros, G. (1987). *The Alchemy of Finance*. New York: Simon & Schuster.
- Soros, G. (2013). "Fallibility, Reflexivity, and the Human Uncertainty Principle." *Journal of Economic Methodology* 20(4): 309-329.
- Tsay, Han-Huei, Mateo Ruggia and Stuart Umpleby. "Convergers and Divergers: A Dimension of Cultural Difference between the U.S. and Europe." Proceedings of the Annual Meeting of the Society for the Advancement of Socio-Economics, Paris, France, July 16-18, 2009.
- Turing, A.(1936), "On Computable Numbers, with an Application to the Entscheidungsproblem," *Proceedings of the London Mathematical Society* 42 (2), 230-265. Reprinted in Martin Davis (ed.) *The Undecidable*. Hewlett, NY: Raven Press, 1965.
- Turing, A. (1950), "Computing Machinery and Intelligence", *Mind* LIX (236): 433-460.
- Umpleby, S. (1974), "On Making a Scientific Revolution." H. von Foerster (ed.), *Cybernetics of Cybernetics*. Reprinted in 1995, Minneapolis: Future Systems.
- Umpleby, S. (1979), "Computer Conference on General Systems Theory: One Year's Experience." In Henderson, M. and M. MacNaughton. (eds.), *Electronic Communication: Technology and Impacts*. Boulder, CO: Westview Press.
- Umpleby, S. (1981), "The 1980 Planning Conference of the American Society for Cybernetics." *Cybernetics Forum*, Vol. 10, No.1.
- Umpleby, S. and K. Thomas (1983), "Applying Systems Theory to the Conduct of Systems Research." In Anthony Debons (ed.), *Information Science in Action: System Design*. Vol. 1, The Hague: Martinus Nijhoff.
- Umpleby, S. (1987a), "Three Conceptions of Conversation." *Continuing the Conversation: A Newsletter of Ideas in Cybernetics*, No. 10.

- Umpleby, S. (1987b), "American and Soviet Discussions of the Foundations of Cybernetics and General Systems Theory." *Cybernetics and Systems*, Vol. 18.
- Umpleby, S. (1990), "The Science of Cybernetics and the Cybernetics of Science." *Cybernetics and Systems*, Vol. 21, No. 1.
- Umpleby, S. and V. Sadovsky (eds.). (1991), *A Science of Goal Formulation: American and Soviet Discussions of Cybernetics and Systems Theory*, New York: Hemisphere Publishing Co.
- Umpleby, S. (1991), "A Preliminary Inventory of Theories Available to Guide the Reform of Socialist Societies." In S. Umpleby and R. Trappl. (eds.), *Cybernetics and Systems*, Vol. 22, No. 4.
- Umpleby, S. (1997), "Cybernetics of Conceptual Systems." *Cybernetics and Systems*, 28/8: 635-652.
- Umpleby, S. and E. Dent. (1999), "The Origins and Purposes of Several Traditions in Systems Theory and Cybernetics." *Cybernetics and Systems*, Vol. 30.
- Umpleby, S. (2000), "Coping with an Error in a Knowledge Society: The Case of the Year 2000 Computer Crisis," in G. Lasker, et al. (ed.), *Advances in Sociocybernetics and Human Development*. Volume VIII. Windsor, Canada: International Institute for Advanced Studies in Systems Research and Cybernetics.
- Umpleby, S. and T. Medvedeva (2001), "Psychological Adjustment to Economic and Social Change," *Reflexive Control*. Vol. 1, No. 1, pp. 102-112.
- Umpleby, S. (2003a), "Strengthening the Global University System," in R. Meyer (ed.), *Perspectives in Higher Education Reform*, Volume 12. Alliance of Universities for Democracy, American University in Bulgaria, Blagoevgrad, Bulgaria.
- Umpleby, S. (2003b), "Heinz von Foerster and the Mansfield Amendment," *Cybernetics and Human Knowing*, Vol. 10, No. 3-4.
- Umpleby, S. and X. Wu. (2013). "The Shift of Cybernetics from the U.S. to Europe and Asia," Working Paper, Research Program in Social and Organizational Learning, George Washington University, Washington, DC, 12 pages.
- Von Foerster, H. and G. Zopf (eds.). (1962), *Principles of Self-Organization*. New York: Pergamon Press.
- Von Foerster, H., J. White, L. Peterson, and J. Russell (eds.). (1968), *Purposive Systems*. New York: Spartan Books.
- Von Foerster, H. (1979), "Cybernetics of Cybernetics," in K. Krippendorff (ed.), *Communication and Control in Society*. New York: Gordon and Breach.
- Von Foerster, H. (2003), *Understanding Understanding: Essays on Cybernetics and Cognition*. New York: Springer.
- Von Neumann, J. and O. Morgenstern. (1944), *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.
- Von Neumann, J. (1961). *Collected Works*. General Editor A.H. Taub. New York: Pergamon.
- Waldrop, M. (1992), *Complexity: The Emerging Science at the Edge of Order and Chaos*. New York: Touchstone.
- Watzlawick, P. (1984), *The Invented Reality: How do we Know what we Believe we Know?: Contributions to Constructivism*. New York: Norton.
- Wiener, N. (1948), *Cybernetics: or Control and Communication in the Animal and the Machine*. Cambridge, MA: MIT Press.
- Yovits, Marshall and Scott Cameron (eds.). (1960), *Self-Organizing Systems*. London: Pergamon Press.

Yovits, Marshall, George Jacobi, Gordon Goldstein (eds). (1962), *Self-Organizing Systems – 1962*. Washington: Spartan Books.

Appendix A

Total number of articles per year and per country in the three journals

Country	Region	1974	1977	1980	1983	1986	1989	1992	1995	1998	2001	2004	2007	2010
Algeria	Africa	0	0	0	0	0	0	0	0	0	2	3	1	0
Argentina	Latin America	0	0	0	0	1	4	0	0	1	0	1	0	1
Australia	Oceania	0	0	1	0	1	2	1	4	12	5	7	18	10
Austria	Europe	0	8	10	3	1	1	2	1	2	4	2	2	5
Bangladesh	Asia	0	0	0	0	0	0	0	0	1	0	0	0	0
Belarus	Europe	0	0	0	0	0	0	0	0	0	0	0	1	0
Belgium	Europe	0	0	0	0	0	1	1	0	0	3	1	1	0
Brazil	Latin America	0	0	1	3	0	0	0	3	0	1	0	3	2
Brunei	Asia	0	0	1	0	0	0	0	0	0	0	0	0	0
Bulgaria	Europe	1	2	0	0	0	1	1	0	3	1	0	0	0
Canada	North America	7	7	9	4	6	9	4	9	3	5	3	2	3
Chile	Latin America	0	0	0	0	0	0	0	0	0	0	1	1	3
China	Asia	0	0	0	0	6	2	2	19	18	16	5	10	23
Colombia	Latin America	0	0	0	0	0	0	0	2	0	0	5	2	2
Costa Rica	Latin America	0	0	0	1	0	0	0	0	0	0	0	0	0
Croatia	Europe	0	0	0	0	0	0	0	0	0	0	0	1	0
Cyprus	Europe	0	0	0	0	0	0	0	0	0	1	0	0	0
Czech	Europe	1	0	2	0	0	1	3	0	0	0	0	0	0
Denmark	Europe	0	0	0	0	0	0	0	0	1	1	0	1	0
Egypt	Africa	0	0	0	0	0	1	0	0	0	0	0	0	0
Finland	Europe	0	0	0	1	1	1	0	1	2	2	1	1	1
France	Europe	2	2	3	4	4	3	7	2	5	3	3	2	1
Gabon	Africa	0	0	0	0	0	0	0	0	1	0	0	0	0
Georgia	Europe	0	0	1	0	0	0	0	0	0	0	0	0	0
Germany	Europe	5	4	2	2	2	2	6	0	4	2	10	4	3
Greece	Europe	0	0	0	3	2	0	2	0	1	0	0	2	2
Hungary	Europe	3	0	0	0	0	1	1	0	1	0	0	0	0
India	Asia	3	5	0	2	1	2	1	2	3	2	1	7	3
Indonesia	Asia	2	0	0	0	0	0	0	0	0	0	0	0	0
Iran	Middle East	0	0	0	1	0	0	0	1	1	0	0	3	1
Iraq	Middle East	0	0	1	0	0	1	0	0	0	0	0	0	0
Ireland	Europe	0	0	1	0	0	0	0	0	0	0	0	1	1
Israel	Middle East	3	2	0	0	0	4	6	2	4	4	3	1	1
Italy	Europe	2	1	0	3	4	1	2	3	2	1	0	4	3
Japan	Asia	1	2	3	3	3	1	0	5	4	2	3	2	4
Jordan	Middle East	0	0	0	0	0	0	0	0	0	1	0	0	0
Kenya	Africa	0	0	0	0	0	0	0	2	0	0	0	0	0
Korea	Asia	0	0	0	0	0	0	0	2	0	0	1	1	2
Lithuanian	Europe	0	0	0	0	0	0	0	0	0	0	0	0	0
Macedonia	Europe	0	0	0	0	0	0	0	0	0	1	0	0	0
Malaysia	Asia	0	0	0	0	0	0	0	0	0	0	0	0	0
Mexico	Latin America	0	0	0	0	0	0	0	0	0	0	2	1	3
Morocco	Middle East	1	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	Europe	0	1	0	2	1	2	1	1	1	3	2	3	2
New Zealand	Oceania	0	0	0	0	0	1	0	1	0	0	0	5	0
Nigeria	Africa	0	0	0	0	0	0	1	0	0	0	0	0	0
Norway	Europe	0	1	0	0	0	0	1	0	1	0	0	0	2
Oman	Middle East	0	0	0	0	0	0	0	0	0	0	0	0	0
Pakistan	Middle East	0	0	0	0	0	0	0	0	0	0	1	0	0
Poland	Europe	1	3	2	1	4	0	2	1	3	1	5	5	8
Portugal	Europe	0	0	0	0	0	0	0	0	0	1	1	0	1
Romania	Europe	3	1	1	0	1	1	1	1	0	1	0	0	0
Russia	Europe	4	1	0	0	3	4	2	1	1	0	1	1	0
Saudi Arabia	Middle East	0	0	0	0	1	1	0	0	0	0	0	0	0
Senegal	Africa	0	0	0	0	0	0	1	0	0	0	0	0	0
Serbia	Europe	0	1	0	0	0	0	1	0	1	0	0	0	0
Singapore	Asia	0	0	0	0	0	0	0	0	2	0	0	0	0
Slovakia	Europe	0	0	0	0	0	0	0	0	0	0	0	0	1
Slovenia	Europe	0	0	0	0	0	0	0	1	1	0	2	6	4
South Africa	Africa	0	1	1	0	0	0	0	0	0	0	1	1	0
Spain	Europe	0	0	1	1	4	2	11	2	4	4	7	12	4
Sweden	Europe	2	1	1	0	1	0	2	4	5	8	0	4	0
Switzerland	Europe	2	1	0	0	0	1	1	0	0	6	5	2	6
Tanzania	Africa	0	0	0	0	0	0	0	1	0	0	0	0	0
Turkey	Europe	0	0	0	0	0	0	0	0	1	0	2	2	4
UAE	Middle East	0	0	0	0	0	0	0	0	0	0	0	0	0
Uganda	Africa	0	0	0	0	0	0	0	0	0	0	0	0	1
UK	Europe	4	8	12	3	5	13	13	26	24	18	34	36	28
Ukraine	Europe	0	1	0	0	0	0	0	0	0	0	0	0	0
USA	North America	65	55	39	36	48	60	40	55	34	34	43	25	14
Total		112	108	92	73	100	123	116	152	147	133	156	174	149