Objectives and Tools of Science Communication in the Context of Globalization

Dissertation

zur Erlangung des Grades eines

Doktors der Philosophie

der Philosophischen Fakultäten

der Universität des Saarlandes

vorgelegt von

Alexandra Shults

Saarbrücken, 2008

Tag des Kolloquiums	21. November 2008
Dekan:	Prof. Dr. Rainer Krause
Berichterstatter:	Prof. Dr. Harald Zimmermann
	Prof. Dr. Michael Kröning
	Prof. Dr. Johann Haller

Inhaltsverzeichnis

TABLES AND GRAPHS

Zusammenfassung

Die modernen Mittel der Kommunikation und der Mobilität verändern die Welt in einem noch nicht absehbaren Maße, was man in der Wirkung mit dem Begriff ‚Globalisierung' zusammenfassend charakterisieren kann. Die Industriegesellschaften internationalisieren sich kulturell und ökonomisch, ihre Institutionen und das Leben und den Lebenshorizont des einzelnen. Vieles muss neu bewertet und geregelt werden, unter anderem auch die Wissenschaftsgemeinschaften, die international zusammenwachsen und gleichzeitig in einem dynamischen Wettbewerb stehen bei der Entwicklung und Anwendung von Wissensressourcen.

‚Wissen' wird im Zuge dieser Entwicklung zu einem marktfähigen Produkt, die Zahl und die Qualität der ‚Wissenschaftler' zum Kapitel. Die Globalisierung führt zu einem Wettbewerb um Ressourcen – Produktionsstandorte konkurrieren über Standortfaktoren, die ihre Attraktivität kennzeichnen sollen und um internationale Absatzmärkte, wobei global agierende Industrieunternehmen diesen Prozess treiben.

Von diesem Umfeld wird auch die öffentlich-rechtlich organisierte Wissenschaft beeinflusst. Sie muss sich der Internationalisierung der Wissensentwicklung stellen, um ihre Exzellenz zu wahren und – im Falle der angewandten Wissenschaft – relevant zu bleiben für die Innovationsfähigkeit ihres Standortes.

Erfolgreiche Innovationen werden überwiegend vom Markt angestoßen. Ihre Entwicklung erfordert eine effiziente Nutzung der besten Talente und Technologien. Beides erfordert eine professionelle Kommunikation, die aus dem rein akademischen Exkurs herauswächst.

Erkennbar ist - insbesondere in den angelsächsischen Ländern – die Entwicklung einer neuen akademischen Disziplin, die als ‚Wissenschaftskommunikation' bezeichnet wird und ein neues Berufsbild formt. Die Arbeit beschreibt diese Entwicklung, ihre Anstöße und analysiert den Kommunikationsbedarf und adäquate Kommunikationstechniken.

Eine wesentliche These dieser Arbeit ist, dass die Wissenschaftskommunikation ein großes, unverzichtbares Potential aufweist, Wissenschaft exzellent und relevant in einem sich dynamisch verändernden Umfeld zu gestalten. Eine zweite These ist, dass trotz dieses erkennbaren Potentials insbesondere in traditionellen akademischen Wissenschaftsgemeinschaften diese sich schwer tun, eine effektive Wissenschaftskommunikation zu gestalten. Eine dritte These ist die Folgerung, dass Wissenschaftskommunikation ähnlich zum Qualitätsbewusstsein in einem Unternehmen auf der oberen Leitungsebene geführt und mit Vollmachten ausgestattet werden muss.

Zur Vermittlung dieser Thesen wird im Kontext der jeweiligen gesellschaftlichen Bedeutung der Wissenschaft die Entwicklung und die Rolle der Wissenschaftskommunikation beschrieben mit Schwerpunkt auf die Bundesrepublik Deutschland.

Diese Studie verfolgt die Wurzeln und ergründet die gegenwärtige Bedeutung der Kommunikation in den Wissensgemeinschaften selbst und im Zusammenhang mit anderen relevanten sozialen Gruppen. Der Einfluss der Wissenschaftskommunikation auf dem Erfolg wissenschaftlichen Arbeitens ist ein Aspekt dieser Analyse, die von frühen Initiativen bis zu modernen Organisationsformen der Wissenschaftskommunikation reicht. Eine empfehlenswerte Form zur Organisation einer wirkungsvollen, professionellen Wissenschaftskommunikation ist z.B. die Integration von ‚Kommunikationsexperten' in Projekte als Vermittler und Moderator externer Erwartungshaltungen und interner Effizienz und Kreativität.

Die Literaturanalyse wird erweitert um Expertenbefragungen, um den aktuellen Stand der Wissenschaftskommunikation zu erfassen. Befragt wurden Industriemanager, Vertreter von Wissenschaftseinrichtungen und der Wissenschaftsförderung (Ministerien), die direkt in der wissenschaftlichen Kommunikation in Europa und Nordamerika involviert sind. Schwerpunkt der Befragung war die Analyse der angestrebten Ziele der eingesetzten Kommunikationsstrategien und Fertigkeiten bei der Führung von wissenschaftlichen Einrichtungen.

Eine Fallstudie betrachtet als Situationsanalyse gelebte Wissenschaftskommunikation in einem Forschungsinstitut der angewandten Wissenschaft. Die Fallstudie wurde am Fraunhofer Institut Zerstörungsfreie Prüfverfahren IZFP, einem Institut an der Saarland Universität, Saarbrücken durchgeführt.

Das Institut finanziert sich überwiegend über industrielle Auftragsforschung mit einem erheblichen Anteil an Aufträgen aus dem Ausland. Das IZFP konnte erfolgreich Wissens- und Technologietransfer in unterschiedlicher Weise in den Markt hinein organisieren und verfügt über zahlreiche internationale Partnerschaften, um internationale Märkte und Ressourcen zu erreichen. Unter Ressourcen sind Technologien, Expertenwissen und junge Talente zu verstehen.

Die Fallstudie belegt, dass ungeachtet dieser Anpassung an relevante Ziele und Aufgaben einer angewandten Forschung und Entwicklung in einem globalen Umfeld die Wissenschaftskommunikation nach innen und nach außen mit allen Problemen behaftet ist, die in der Literatur als Barrieren in traditionellen Wissenschaftseinrichtungen beschrieben werden.

Ursächlich dafür ist sicherlich die Komplexität und die Vielfalt der kulturellen, psychologischen, nationalen und internationalen sowie historischen Aspekte menschlicher Kommunikation in Bezug auf das wissenschaftliche Arbeiten. Dennoch sollten und können auch praxisnahe Lösungen empfohlen werden, die einen Richtliniencharakter haben.

Die wichtigste Schlussfolgerung, die gezogen werden kann, ist, dass – wenn richtig am Arbeitsplatz integriert und effektiv von den Teilnehmern umgesetzt – Wissenschaftskommunikation einen unverzichtbaren Beitrag leistet zur Relevanz, Akzeptanz und Qualität der wissenschaftlichen Arbeit.

Summary

The arrival of modern means of communication and growing mobility of people and resources have dramatically contributed to the changes occurring in the world. This process might be characterized as globalization. A lot of things are exposed to reconsideration and should be organized in a more effective manner, including, in particular, the scientific community which should be dynamically developing in international environment and should have the tools for staying competitive in terms of application of its resources and knowledge.

As knowledge is turning into a commercial commodity, the abilities of a scientist is becoming a capital. At the same time, globalization exercises a strong influence over the struggle for resources where productions centers fight each other to gain the qualities stressing their competitive edge.

This ever-changing environment has a considerable impact on the publicly-funded scientific institutions. To sustain the high level of research projects, the scientific community should be able to secure the internationalization of development of resources on which its knowledge is based. In case of applied science, the research projects should be relevant and successful from the viewpoint of creating innovations.

The market sends impulses to successful innovations, but development of such innovations requires the most effective application of best talents and technologies. The achievement of these goals are directly dependant on professional communication shaped within the peculiarities of academic environment.

The demand for such communication, particularly in English-speaking nations, had led to forming a new field of knowledge known as *science communication* which progressed in successful self-identification and professionalization. This doctoral thesis offers the study of emergence and development of science communication, including an overview of the instances indicating a growing demand for communication, and focuses on its methods.

The central thesis of the study suggests that science communication has a great potential and natural ability in presenting scientific projects in the best way suited for dynamically changing environment. The second thesis asserts that practical application of science communication in scientific community is a difficult process slowly progressing despite the obvious benefits attached to this type of communication. The third thesis pins the success of implementation of science communication strategies to the unwavering support of the management and extending authority of the communicators.

The actual evidence for justification of the theses presented in this work was analyzed on the example of Germany to trace development and role of communication efforts in scientific institutions.

The present study makes an analysis of the basics of communication and proposes a modern definition given the complexity of issues related to the scientific community and other social groups involved in the process. The influence of science

communication on the success of research projects is a key point of the study which includes an overview ranging from the earliest initiatives in this area to current forms of organization of communication in scientific environment. A method of rational and professional communication between scientists and their target groups is seen by the author of the study in integration of communication experts into research projects carried out in scientific institutions to act as mediators in contacting outside audiences and to bear responsibility for creating new cultural background in such institutions.

The current status of science communication was evaluated not only at theoretical level by analyzing the earlier studies on the subject, but also enriched by empirical study of expert opinions collected in the course of a poll. The interviewing involved the top managers and professional communicators from the largest scientific and educational organizations and state agencies of Germany, Europe and the U.S. The principal objective of the poll was the analysis of the goals of communication strategies adopted by these institutions and analysis of the issues related to communicating science.

The final part of the work, a case study, was carried out in the Fraunhofer Institute of Nondestructive Testing (IZFP), with head office in Saarbrücken, Germany, a major scientific organization largely financed at the expense of orders placed by industrial customers of international origin. The Institute has been successful in managing technology transfer at different levels and is involved into a large number of joint projects for assuring its participation at the international market and gaining valuable resources, including technologies, expertise and young talents.

The case study clearly illustrates that despite the ongoing process of adjustment of strategies to relevant goals and objectives of applied R&D in global environment, science communication experiences a series of problems described in the literature as barriers of traditional scientific institutions.

The reasons for existing status quo in the scientific environment are deeply rooted in complexity and diversity of cultural, psychological, national and international as well as historical aspects of human communication. As a result, the implementation of practical solutions proposed for these purposes may and should be successful in combination with executive decisions.

The most important conclusion drawn in this study is that the integration of communication into scientific environment, provided that it is applied in correct and effective way, may significantly influence the quality of innovations and their acceptance by society.

Vorwort

Als ein relativ junges Forschungsgebiet und ein im Entstehen begriffenes Berufsfeld ist Wissenschaftskommunikation ein bedeutendes Element der weltweiten wissenschaftlichen Kooperation. Mit dem steigenden Wachstum der elektronischen Kommunikation und dem Wandel der Wissenschaft unter dem Einfluss der Globalisierung gewinnt der Dialog von Wissenschaftlern mit einer Vielzahl an unterschiedlichen Zielgruppen, wie z.B. der Industrie, den Medien und der breiten Öffentlichkeit, immer mehr an Bedeutung. Diese Studie stellt eine Analyse der Kommunikationsprozesse und -strategien vor und untersucht die Rolle eines professionellen Ansatzes an das Kommunizieren wissenschaftlicher Ideen und des Einflusses von Wissenstransfer in öffentlich finanzierten Institutionen in Europa und Nordamerika.

Danksagung

Meinen besonderen Dank spreche ich meinem Betreuer an der Universität des Saarlandes Herrn Prof. Dr. Harald Zimmermann aus, der die strategische Bedeutung dieses Themas erkannt und die Durchführung der Doktorarbeit unterstützt hat.

Weiterhin bedanke ich mich ganz herzlich beim Herrn Prof. Dr. Michael Kröning, Leiter des Fraunhofer-Institutes für Zerstörungsfrei Prüfverfahren, für die Übernahme des zweiten Gutachtens. Für seine Hilfe zur Strukturierung dieser Arbeit, seine ständige Unterstützung und interessanten Ideen bin ich sehr dankbar.

Für die Erstellung des dritten Gutachtens, die sachliche Kritik und die anregenden Anmerkungen bedanke ich mich beim Herrn Prof. Dr. Johann Haller.

Zum erfolgreichen Abschluss dieser Arbeit haben auch alle Teilnehmer der Befragung beigetragen: Herr Prof. Dr. Volker Linneweber (Universität des Saarlandes), Herr Karsten Heinz (Bundesministerium für Bildung und Forschung), Herr Dr. Ron Lehman (Livermore National Laboratory), Herr Eckhard Netzmann (Kuratorium der Fraunhofer-Instituts), Herr Prof. Dr. Michael Kröning (Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren), Herr Franz Miller (Fraunhofer-Gesellschaft), Frau Renilde van den Broek und Herr Dr. James Gillies (European Organisation for Nuclear Research). Ich bedanke mich bei allen für ihr Interesse an Thema meiner Arbeit, ihre wertvolle Antworten und für die ergebnisreichen Diskussionen während der Befragung.

Ich bedanke mich herzlich bei meinen Kollegen Frau Theiner für Ihre moralische und inhaltliche Unterstützung sowie bei Herrn Dirk Henn für seiner Optimismus und seinen Beistand bei den Übersetzungen.

Schließlich gilt mein allergrößter Dank meinem Mann Oleg und meinen lieben Eltern für ihre Geduld, ihr Verständnis und ihre Liebe während meiner Promotionszeit. Ohne ihre Unterstützung wäre diese Arbeit nicht möglich gewesen.

Introduction

In the time of global markets and electronic communications, the relationship between science and society is becoming more complex and versatile. This thesis explores the changing role and place of science communication understood as a process of two-way interaction aimed at serving the best interests of both scientists and those who benefit from scientific success. The study is primarily focused on the experience of publicly-owned applied research institutions in Europe (Germany) and North America, while similar forms of organization of research and development were also examined in some parts of the work.

The detachment of scientific community from the rest of society evident in its privileged and authoritative status has been conditioned by a number of historical factors. The unique position occupied by science among other social strata protected, on the one hand, academic liberty and facilitated institutionalization of science as a powerful tool in human development. On the other hand, the deficiencies of the detachment of scientific community are becoming more evident in a series of controversies over technical progress.

There are several groups of factors which played crucial role in the process of forming of science communication as a field of study.

Social and political factors

- In the 20^{th} century, the mankind has survived at least three global conflicts, including the Cold War, which consumed tremendous scientific resources. The collapse of bipolar world in the early 1990s manifested the beginning of process which gave impulse to turning science into more consumer-oriented and allowed to consider it a public enterprise.
- In the course of its formation, the technological society witnessed a number of frightening experiences starting from nuclear tests to Chernobyl disaster to global warming. Critical debates questioning the position of science and scientists in these events sparked ever-growing public interest and, at times, mistrust to the objectives and methods of research and its results. A social phenomenon known as public understanding of science emerged in response to criticism, trying to reconcile the conflicting interests by encouragement of public education.
- A definite catalyst for the changes in scientific society was and is the process of globalization which appears as powerful movement of capitals and human resources, paving the way for new markets and centers of scientific excellence challenging the traditional order of distribution of ideas, research projects and human talents.

Factors of scientific progress

- Sophistication of the nature of scientific knowledge, production processes and dependence of industrial societies on the success of innovation encouraged the search for external resources, both human and technical.
- The product of science, information technologies, have fundamentally changed the system of collection and transfer of knowledge, secured fast and

easy transmission of data, and helped develop a principally new approach to representation of knowledge.

Economic factors

- As a result of inevitable commercialization of science, the level of relevance of innovations acquired the same importance as the excellence of research. The relevance itself could not be guaranteed without special emphasis on communication efforts aimed at studying the market demands and taking heed of the most important trends and tendencies.
- Crisis tendencies in the social-market economies, including Germany, and their refocusing towards the needs of global development undermined the strategies of publicly-funded research, depending on budget financing and national markets.

The focal point of this thesis is the transformation of science communication under the influence of the said factors into a new field of academic research and professional occupation. The conjecture presented in the following chapters is that science communication has entered the stage where it is becoming an influential factor of mutual exchange as opposed to one-way concept of public understanding of science dominating the scene since the 1980s. The attempts to educate the different segments of society for better understanding of knowledge creation most probably succeeded and, in conjunction with social, political and economic changes, gave rise to a new phenomenon. In other words, the aspiration of understanding science by public was supplemented by the need of understanding of public by scientists.

As human society is growing increasingly dependent on technologies, the number of communication channels binding science and society is also growing. It comes as no surprise that increase in the number of technologies penetrating into life requires maintaining a lot of contacts with the world outside scientific environment: industry, media, government, public. Thus, science communication, as a new multidisciplinary field of knowledge, is assuming the functions normally assigned in business to public relations and marketing, and merging with such particularly important element as scientific expertise becomes the tool for effective management of knowledge transfer.

Since the dialogue between science and society would have been unimaginable without the involvement of scientists in this process, the practical implementation was expressed into steady growing level of professionalization of science communication in applied science organizations and other research institutions responsible for creation of innovations. Whatever admirable skills and qualities the researchers possess, their abilities and talents in communicating science often lag behind the abilities to present their needs and successes in positive light. Consequently, they remain indifferent to investing their time and efforts into communicating ideas and innovations. The situation is partially aggravated by the presence of stereotypes and conservatism which have been forming many years and by the lack of sufficient theoretical basis for science communication to which the present work purports to contribute.

The study in this thesis is divided into three principal parts. The first part is comprised of four chapters (1-4) devoted to the analysis of theoretical foundations of science communication and tracing it development from the origins to current stage. Chapter 1 covers the formulation of the issue and discusses the impact of globalization on the nature of science and the changing role of public mandate for research and development in Germany. It is followed by analysis of the competitive abilities of German applied research networks, in particular Fraunhofer Society, to assume a stronger position in global market of innovations.

Chapter 2 presents a new role of knowledge as a cornerstone element of the knowledge-based society and illustrates the process of commercialization of publicly-funded science. As information becomes a product in its own right, science communication appears as the tool for management and transfer of knowledge which may be instrumental in defining the relevance of technologies and help prevent the failure of innovations.

Chapter 3 examines how the very definition of science communication has changed in the literature and traces the transformation of what is known as 'deficit model' into 'trust model' which proposes contextual approach to science communication and two-way direction of exchange. This chapter also covers the influence of human factor in the creation of knowledge and exposes the benefits of multidisciplinary approach, at which point communication between different social groups and scientific community becomes crucial in formulation of scientific objectives.

Chapter 4 is devoted to discussion of instruments and methods of science communication and the factors affecting its development such as scientific culture and ethics which shape the dialogue between key players in the communication process.

The second part of this study (Chapter 5) is based on the material collected during the quality interviews with the people directly involved into the process of science communication either as decision-makers in research organizations or as press/information officers, including the well-known institutions in Europe and North America (Fraunhofer Society, European Organization for Nuclear Research – CERN, Hubble European Space Agency Information Centre, U.S. Center for Global Security Research). The contents of the interviews were analyzed in order to prove the hypotheses presented in theoretical part of the work and to compare the opinions of experts on a given number of subjects.

The final part of the thesis (Chapter 6), presented in the form of a case study, concentrates on the experience of the author and her involvement into science communication process carried out in the Fraunhofer Institute for Nondestructive Testing, Saarbrücken, Germany. The case study composed of the analysis of communication strategies and practices was intended to illustrate the development of this important element in an applied-research organization looking for deeper involvement into new markets and international cooperation. A set of closing remarks includes some recommendations for optimization of communication process and discussion of the relevant issues.

If any comparison is to be made, then science communication in applied research institutions of Germany and other nations should serve the purpose of navigation for the vessel of science and technology destined to sail in ever-changing global environment. It would exceed the scope of this study to prove the hypothesis that communication is the guarantee of success for applied science as many other factors affect the development of science. Nevertheless, the conjecture on the importance of science communication and its ability to influence the quality of innovations in modern world may appear being justified by facts and conclusions upon reading this work.

1. Applied Research and Development under the Influence of Globalization

1.1 Public Mandate for Applied Research

As global production of knowledge entered the new century, traditional scheme of scientific research and implementation of its results in the form of economically oriented technologies are remaining relatively unchanged. The knowledge is born as a result of fundamental studies and continues its life in the area of applied research, where it acquires the forms and methods required for practical application in industry, services, agriculture and other sectors of economy. The terms for ‘applied research’ vary in academic works, including pre-competitive research, strategic research, mission-oriented research or industrial research.[1] A common characteristic in this case might probably be better defined as solution-oriented research[2] in which the quality of solutions are proportional to the quality of research process.

Existing as a bridge between fundamental studies and industrial production, the applied research is largely carried out by industrial research and development (R&D) departments as opposed to academic research concentrated in universities and research institutions, although both are linked by “mutually reinforcing vectors” [3]. The strength of applied research in Europe and North America is unequally distributed between educational institutions (universities, colleges, etc.) and research institutions oriented at receiving public funds for their studies. While universities in many countries remain the recognized centers of such studies, the present thesis is primarily focused on their potential competitors – publicly-funded applied research institutions.

In countries where the government plays a crucial role in assisting industry, fundamental and applied research is often conducted in state- and/or publicly-funded institutions. Germany is an example. Aside from industry and university-based studies, the applied research in this country is substantially concentrated in the Fraunhofer Society (*Fraunhofer Gesellschaft*), a non-profit research organization funded by government and earning revenues from government-sponsored projects and/or industry. Such structure differs from their counterparts, for instance, in the United States, where “many of the contract R&D and technology transfer

---

[1] “The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies”, by Michael Gibbons, Helga Nowotny, Camille Limoges, Martin Trow, Simon Schwartzman, Peter Scott (Sage Publications Inc., 1994), p. 9.

[2] “Fundamentals of Marketing Research”, by Gerald S. Albaum, Scott M. Smith (Sage Publications, 2005), p. 4.

[3] “The Impact of Academic Research on Industrial Performance”, by National Academy of Engineering (National Academies Press, 2003), p. 227.

functions… are performed… by a large, diverse, and dispersed population of public and privately held for-profit and nonprofit organizations.” [1]

Operating as non-profit organizations for decades, the German research institutes have been only marginally interested in public exposure. In accordance with the scheme defined in the years after World War II, the core of their interests lied in acquiring contracts from the industry, while public awareness for their work hardly affected any other factor except for professional prestige of the scholars.

However, the changes in global economy and changes at national level touched off a process of slow restructuring of applied research towards more transparent system where elements of scientific communication should play a vital role. Still in the end of 1990s, Germany was considered slow in this transition. “In Germany one might characterize the process as one of low institutionalized public involvement and sometimes open conflict. The scientists and decision-takers know best, and the public is expected to accommodate to expert opinion.”[2] The need for public understanding may still be difficult to perceive for many of those engaged in applied research in Germany, but a number of factors indicate that this process will intensify in the nearest future.[3] “Germany was slowest to adopt the PUS (public understanding of science) model into official policy, but in 2002 a coalition of scientific societies, backed by federal funding, launched a project on Public Understanding of Science and Humanities (PUSH) to promote better dialogue between science and the public. The PUSH agenda was consistent with the broader German definition of *Wissenschaft* (‘science’) as embracing all knowledge, including the natural, the social, and the humanistic.”[4]

Does an industrial research-oriented organization in Germany, which used to live off public and state financing and to serve the interests of one of the strongest economies of the world, really need any sort of public understanding by means of science communication? To answer this question, one should understand the nature of what is known as *public mandate*, a distinctive feature of German R&D structure.

Historically, the merits of scientific research and, especially, applied research were measured by successful financing for new projects, which brought fame and publicity for talented scientists and engineers. In the years preceding the German economic miracle of the 1950s, the national government developed a clear mandate for state- and publicly-funded institutions: in the social-market economy (*soziale Marktwirtschaft*) they were assigned to provide the German industry with all

---

[1] “Technology Transfer Systems in the United States and Germany”, by National Academy Press (National Academies Press, 1997), p. 10.

[2] “Between Understanding and Trust: The Public, Science and Technology”, by Meinolf Dierkes and Claudia von Grote (London, New York: Routledge, 2000), p. 148.

[3] See “Die Herstellung einer öffentlichen Hegemonie: Humangenomforschung in der deutschen und der US-amerikanischen Presse”, by Jürgen Gerhards, Mike Steffen Schäfer (Wiesbaden: VS Verlag für Sozialwissenschaften, 2006).

[4] “Designs on Nature: Science and Democracy in Europe and the United States”, by Sheila Jasanoff (Princeton University Press, 2005), pp. 251-252.

necessary technical inventions and improvements. Their public mandate was expressed in serving the national economic interests. The state provided all necessary funding, working environment, support in securing contracts, and, in its turn, required to keep the mechanism of innovation smooth and effective.

The essence of public mandate for applied studies may have remained untouched should the borders of national markets preserved intact in the 21st century. However, the international production and diffusion of knowledge reached a new paradigm, where the frontiers between national and international activity is practically blurred. In this situation, the German science and applied research institutes are not exceptions.

Structural changes in the German economy, including a shift from domestic to global operations, affected the innovation in a way that traditional leaders in this field found themselves facing a new competition from the rising economies of the East. The emergence of new markets might be seen as a good advantage for application of German technologies, but these markets operate within the rules of strongest competition. This circumstance may pose a certain difficulty for the applied research institutes in Germany, if they try to reach these new markets, while "disproportion between external dynamics and the innovation system"[1] should be balanced.

A certain option for the German applied research is to continue working with national companies, but these tactics might lead to further complications as the German companies will seek for cost-effective solutions, which may be found outside Germany, in the countries where cheap labor costs may in the near future permit to create technologies comparable to German in terms of quality, but less expensive. The opponents argue that traditionally strong points of the German innovation research can not be easily achieved by competing nations. However, the policy of keeping low profile at international level may cause much more important consequences for the German science.

The strategy of scientific development is normally implemented at both micro- and macro-level. The current success of operations in a given research organization may lead to overlooking the deficiencies in global strategy of development for the applied science on the whole. A recent study on the issues of knowledge management in modern world conducted by the German scientists, including a representative of the Fraunhofer Institute Systems and Innovation Research (*Fraunhofer-Institut für System- und Innovationsforschung*), identifies two paradigms behind the organization of global science. The first model characterized as old is driven by the market motivation (*Marktmotiv*), while the new paradigm is defined by the aspirations of transnational structures for global optimization of knowledge retrieval (*Wissensmotiv*).[2]

---

[1] "Surviving Globalization? Perspectives for the German Economic Model", by Stefan Beck, Frank Klobes, Christoph Scherrer (Dordrecht: Springer, 2005), pp. 46-48.

[2] "Internationalisierung industrieller Forschung und grenzüberschreitendes Wissensmanagement", by Jakob Edler, Roland Döhrn, Michael Rothgang (Heidelberg: Springer, 2003), p. 12.

As evident from the existence of these two different approaches, the modern science follows the trends of multinational concerns looking for new sources of knowledge, including labor resources and technologies. The science and applied research in Germany cannot exist in isolation from the processes occurring in other parts of the world. By ignoring the process of knowledge globalization, the applied research structure may found itself excluded from the mainstream and will be unable to catch up the most progressive ideas and breakthrough technologies and innovations. The interest in new knowledge markets is conditioned not simply by economic reasons and profitable contracts, but by the whole process of sustainable scientific development. It should be noted that the perception of the necessity of broader involvement of the German scientific centers exists at macro level and should still find its way to understanding by scientists.

Globalization of applied science in Germany may not be unanimously favored as globalization itself is a subject of many controversial discussions, but recognition of the fact that the place of applied research in global world is changing will necessarily lead to extension of the current public mandate. Achieving the state when all interested parties would agree on implementation of such changes on the basis of public understanding of science should be considered among the most important priorities since globalization as historic process still fuel hot debates and mixed emotions as well as civil protests occurring all over the world.

The formation of a public opinion favoring the idea of global science and, consequently, a new public mandate for extending the boundaries of scientific research cannot be completed only by implementing national programs such as PUSH. One of the main audiences where the changes in public mandate should be realized is the scientific community, including publicly-funded institutions. Though this task is evidently not a simple one, the scientists outside the industrial labs or classical applied-research scholars should be given an opportunity to see the benefits of scientific globalization on macro level. In this sense, public understanding of science will play a role of external catalyst and science communication will be the most important tool for continuous dialogue between the public and scientists.

The interaction between scientific community and other interested parties should be routed through regular means of communication for exchange of information, opinions and ideas. If such dialogue becomes effective, practical aspects of science communication in applied-research community will serve a number of purposes:

- Shaping positive public opinion on importance of global development of national applied-research institutions
- Explaining the new role of publicly-funded research institutions in global community for its staff to foster motivation to act not only as scientists, but as market-oriented experts
- Acting as intermediary between scientific community not involved into daily business activities and business partners from the industry and other sectors of economy

The call for changes in formulating the public mandate for research institutes is directly related to the reconsideration of the whole model of German economy and innovation market. In the most recent studies, some authors[1] question the stability and competitiveness of the German model, insisting on a shift towards what is known as Anglo-American model. This view is not universally shared and a solution proposed by Stefan Beck is compliant with an argument for introducing changes to the public mandate: "In contrast to an imitation of the Anglo-American model, the careful and path-dependent alteration or rearrangement of existing institutions combined with the importation of lacking capacities could preserve existing comparative advantages instead of gambling with them." [2]

The perils of global commercialization of public science may be a serious challenge for preserving the nature of 'public mandate' as it used to be understood. However, it does not necessarily mean that the future of such mandate should be questioned. Currently, when the public nature of science is challenged by a growing number of social and economic factors ("public nature of science under assault" as defined by Nowotny)[3], the goals of reforming the mode of interaction between scientific community and the public cannot be achieved without effective set of communicative skills.

One of the reasons for failures of publicly-funded research to be competitive within global environment is rooted in historical isolation of scientific institution of this type. In case of Germany and other countries with social-oriented economies, the existence of public mandate for studies in its former shape provided sufficient protection for scientists in relationship with the market. Formulated in the charters of scientific societies and defined as non-profit (Fraunhofer Society, for example), this concept provided for *economic safety* of people and organizations engaged into applied and basic research. As long as such state of safety could be guaranteed, any strategic management and marketing made little sense. The specter of targets was defined either by government or by industrial customers, while publicly-funded institutions did not feel any pressing need to look for additional sources of revenue or new audiences.

With transformation of technology into wealth concept, science becomes increasingly commercialized. "Science and technology are sustainable sources of

---

[1] "Deutschland global? Mit falschen Rezepten in die Globalisierung", by Joachim Jahnke (Norderstedt: Books on Demand GmbH, 2005); "The Globalization of Labor and Labor Relations: German Case", by Michael Fichter in Strategies Towards Globalization: European and Japanese Perspectives, ed. by Sung-Jo Park, Seigo Hirowatari (Freie Universität Berlin: Institute for East Asia Studies, 2002), pp. 143-182; "The Future of the German Economy: An End to the Miracle?", ed. by Rebecca Harding, William E. Paterson (Manchester University Press, 2000); "Is the German Economic Model Still Viable?", by D.B.Audretsch in *Wirtschaftspolitische Blätter*, vol. 46, No. 3, pp. 276-285;

[2] See "After the Miracle: the Exhaustion of the German Model?", by Stefan Beck in "Surviving Globalization? Perspectives For The German Economic Model", op. cit.

[3] See "The Public Nature of Science Under Assault: Politics, Markets, Science and the Law", by Helga Nowotny (Berlin: Springer, 2005).

wealth."[1] Such conclusion reflecting the current world trend supports the hypothesis concerning the contradiction between publicly-defined goals in science and market tendencies. The state of relative isolation of publicly-financed scientific organization is no longer supported by surrounding circumstances. As a result, marketing technologies shaped as science communication tools will be crucial in transforming the meaning of public mandate in the nearest future.

[1] "New Wealth: Commercialization of Science and Technology for Business and Economic Development", by George Kozmetsky, Frederick Williams, Victoria Williams (Westport: Praeger: 2004), pp. 3-22.

1.2 Globalization of Markets, Producers and Innovations

The confrontation between world political systems was one of the driving forces behind scientific development in the second part of the 20th century. Although the confrontation is over, a new phenomenon dominating the world, *globalization*, succeeded in influencing the minds of scientists and architects of scientific development. Globalization has been existing as a relatively new concept since the turn of the millennium, but its influence on development of science could hardly be underestimated.

Joseph Stiglitz, Nobel laureate in economics (2001) and former chief economist of the World Bank, defined globalization as "closer integration of the countries and peoples of the world which has been brought about by the enormous reduction of costs of transportation and communication, and the breaking down of artificial barriers to the flow of goods, services, capital, knowledge, and (to a lesser extent) people across borders."[1] It would be difficult not to take notice that "knowledge" in this definition is listed along with three other material components constituting the principal flow: goods, services and capital. In application to scientific development, globalization means a merger of interests, ideas and goals of scientific research, which become common for various nations and societies.

Applied research as the area where knowledge received with the help of fundamental studies is transformed into technologies and materials has always been a focal point where interests of industry met the achievements of science. The impact of globalization on applied research in the industry is evident in new investments, while publicly-funded applied research is left before uneasy choice of balance between public interests and commercialization.

One of the principal features of globalization is the process of creating new commodities not only in terms of sales market. Besides being an object of global flow, knowledge as a product of research cannot be omitted from the list of such 'goods.' It would be not quite correct to say that globalization put knowledge and science on the list of trading goods, but it is certain that it encouraged this development and paved new ways for turning science into business to a larger extent than it used to be. The world scientific community found itself in a position of adjusting to new social and economic environment. As a consequence, "more emphasis is now put on what is called 'strategic research – research of strategic importance to societal issues – the economy, health, environment, defense, energy, and so forth."[2] The advancement of strategic plans inevitably led to the state of things, where "science has become a commodity."[3]

---

[1] "Globalization and its Discontents", by Joseph E. Stiglitz (Penguin, 2002), p. 9.

[2] "Handbook of Science and Technology Studies", ed. by Sheila Jasanoff, James C Petersen, Trevor Pinch, Gerald E Markle (SAGE Publications, 2001), p. 612.

[3] "Science as a Commodity: Threats to the Open Community of Scholars", ed. by Michael Gibbons and Bjorn Wittrock (Longman: 1985).

Long before globalization came to the surface to be judged by public opinion and economists, the markets were the first place, where it set foot and flourished. However, transnational corporations quickly realized that not only inexpensive working force and natural resources are the most attractive advantages of moving their plants to the countries of the third world. Cooperation and collaboration between different cultural communities proved to be a valuable factor for increasing the investment into international R&D projects. The focus on business improvement imminently led to realization of importance of investments in technology.

The costs of R&D projects were among the most attractive features exploited by transnational giants. While hourly manufacturing wages in the U.S., Japan and European Union in 1995 were $17.2, $23.66, and $21.0, respectively, the similar figures for India and Malaysia made up only $0.25 and $1.59. [1] The advantages of cheap labor and other privileges for investors led to the restructuring of R&D market. The rise in overseas research and development started to accelerate in the 1990s when a growing number of transnational corporations begun to outsource their R&D projects to the developing world.

Steady increase in the internationalization of R&D was conditioned by various factors, including as the most important:

- *Rapid growth of devices for exchange of all kinds of information*. The Internet appeared as unprecedented communication tool, which helped make business contacts more efficient and less expensive. The investors received an opportunity to monitor the implementation of their R&D projects in most comfortable way at low cost.
- *Expansion of service network*. More sophisticated information devices required a recruitment of significant recourses capable of managing the existing means of communication and information management. Everything, from Internet providers to online support to trade portals represent a vast area of commercialized services based on the success of latest innovations.
- *Mobility of human resources*. As globalization of markets and producers required more and more talented individuals to cross the borders, the governments of world powers could not resist the demands of the market. Some countries succeeded in creation of their own hi-tech development areas in the manner of California's Silicon Valley, where researchers from around the world joined their efforts in creating new technologies.
- *Competitive nature of hi-tech technologies*. Creation of computer software through the interaction of individuals from various countries became a virtual round-the-clock process, which helped overcome national borders, cultural and lingual differences.
- *Normalization of international trade*. As western investors were interested in certain guarantees for their capitals and unification of numerous standards for

[1] "Globalization and a High-tech Economy: California, the United States and Beyond", by Ashok Deo Bardhan, Dwight M Jaffee, Cynthia Anne Kroll (Kluwer Academic Publishers, 2003), p. 80.

business, the governments of developing countries passed favorable legislation and joined international financial and trade organizations.

The complexity of the factors influencing innovation markets is directly related to the nature of global business environment, which has significantly changed in the last 10-15 years. These changes could not pass unnoticed for organizations of applied science in different countries. What seemed as a daydream for the scholars of early 1900s, today became a reality with extensive opportunities for research and, what is very important, cooperation within international scientific community. However, the brightest prospects for new scientific wonders are overshadowed by the nature of economic processes, dominating the world.

There is hardly anything new in the concept of innovation for profit, but national boundaries and state protectionism measures served for a long time as natural environment for pure scientific minds. Today's global trends are directed towards breaking old-fashioned manner of academic presentation and thinking. Innovation is currently defined as "the use of new technological and market knowledge to offer a new product or service that customers will want… The product is new in that its cost is lower, its attributes are improved, it now has attributes it never had before, or it never existed in that market before."[1]

In many countries, publicly-funded applied research institutions were exempted from direct involvement into business and technological transfer. As a consequence, communicative and business skills were largely excluded from a list of priorities defined for successful professional in science. Researching the problems of continuing education for scientist, Ventura and Ramsay stress that "basic business skills, including entrepreneurial skills, are also recommended for managers in charge of science and technology projects. More and more emphasis is being placed upon the need to develop entrepreneurial skills: calls for such skills come from policy makers and politicians, human resource directors of large companies and labour market analysts throughout the world."[2] If those employed in industrial R&D labs are more flexible in adjustment to fast-changing economic environment, applied-research scholars in public science are more vulnerable in their exposure to global market's demands.

In practice, it means that scientists may need further education in terms of improving their entrepreneurial abilities in combination with better science communication skills. The authors investigating the features of knowledge-based economy assert that globalization of knowledge and accompanying competition "are likely to figure as the most important ways globalization is transforming the

---

[1] "Innovation Management: Strategies, Implementation, and Profits", by Allan Afuah (Oxford University Press, 2003), pp. 4-5.

[2] "A Natural Scientist and a Social Scientist Explore the Dilemma of Science", by Arnoldo K. Ventura, Angela Ramsay (Kingston: Ian Randle Publishers, 2003), p. 27.

economy."[1] Inevitably, the process of economic transformation affect the producers of knowledge including those belonging to the sector of public science.

[1] "Regions, Globalization, and the Knowledge-Based Economy", ed. by John H. Dunning (New York: Oxford University Press, 2000), p. 45.

1.3 Global Centers of Knowledge and the German Model

The presence of global knowledge in our world has never been so evident as in the time of far-reaching electronic communication. As soon as the mankind entered the Age of Electronic Communication, the Internet and other sophisticated technologies offered tremendous opportunities for binding the knowledge and experience collected in the last two thousand years into a new intellectual entity. Such definitions as "world science" give way to a new definition of "global science," a phenomenon emerging on the verge of the 20th and 21st centuries and having online communication as a permanent feature.

Before science reached the status of product, the world powers spent decades in finding their ways of national scientific development. The success in scientific development was one of the decisive factors in winning the Cold War, which ended up with the collapse of the Soviet bloc. Inability of Soviet political and social system to find an adequate response to the challenges of technical development undermined the strength of Russian science as global competitor and led to grave consequences still experienced by the Russian Federation. Existing for years behind the Iron Curtain, the Soviet Union excluded itself from world trends of scientific development, a fact that should not be underestimated by other nations in modern world. "High isolation of the Soviet science from the world due to political reasons was responsible for weak technology transfer…", while Soviet scientists "had to rely, to a large extent, only on their own resources and achievements." [1] The worst consequences of such isolation are illustrated by failure of the Soviet Union to enter the personal computer marketplace. The Soviet policymakers resisted this science with a passion and consequently found themselves compelled to copy the Western examples, a race which Soviet science never won. [2] As shown by further historical development, world science has chosen the way different from the Soviet paradigm: global collaboration.

As any emerging market, the global science market required adequate changes in the structures of national and international science and creation of international agencies, monitoring and coordinating the efforts of global scientific community. The world's leading authorities in charge of scientific cooperation between the nations reacted to these processes by setting up new supranational bodies for coordination of research and development activities. This step may be considered as a cornerstone on the way of global scientific development and signaled a new period for world science.

As a matter of fact, the World Bank in co-operation with the United Nations, the governments of Japan, Germany and Switzerland supported the creation (1999) of the *Global Development Network*, an association of research institutes and think tanks, whose objectives are to "create, share and apply knowledge." Also, the

---

[1] "Systemic Transformation, Trade and Economic Growth", by Natalja von Westernhagen (Heidelberg: Physica-Verlag, 2002), p. 49.

[2] "Science, Technology, and Ecopolitics in the USSR", by Miron Rezun (Greenwood Publisihng, 1996), pp. 53-77.

Megascience Forum, created in 1995 under the auspices of the Organization for Economic Co-operation and Development, to serve the interest of international cooperation was reorganized as the *Global Science Forum* (GSP, 1999). The Workshop on Best Practices in International Scientific Co-operation conducted by the GSP in 2003 emphasized that "lessons learned are rarely shared. This has resulted in a lack of guidelines for policymakers planning and implementing new multinational scientific research projects."[1]

The authors, who devoted their research to the phenomenon of global knowledge stressed that "the expansion of knowledge is an expression of our global community seeking pathways for self-organization."[2] The principal repositories of global knowledge, such as universities and research institutes, in different countries of the world were affected by the restructuring processes in the world science. Globalization required fostering new approach to the strategy of research, methods and major directions.

The studies of the phenomenon of globalization define the Anglo-American[3] model as dominating and most successful response to the challenges of this universal process. It should be noted that the globalization on the whole as well as the globalization of science should not be understood as a tendency imposed[4] by certain political forces or vested interests of transnational corporations. On the contrary, different countries and social groups have to find their own ways of response to such global changes. In this connection, the German model (*Modell Deutschland*) of social economy market, including the system of publicly-funded applied research institutions, looks potentially vulnerable in adjusting to the needs of global markets.

A comprehensive analysis published by Robert Huggins Associates, one of Europe's foremost research house studying national and international competitiveness, enlists 125 world's most knowledge-competitive regions. The study proves that the location of high technology clusters in Europe continues to be concentrated in a few regions. While Europe "continues to struggle to bridge the knowledge gap to compete with the US regions," Germany's Baden-Württemberg, Bayern, and Hessen are rated as 55th, 70th, 71st in the World Knowledge Competitiveness Index 2004.[5] The most successful regions of Europe are represented by Stockholm, Sweden (15th); Uusimaa, Finland (19th), and a vast area around Paris (Île de France; 34th).

---

[1] OECD Global Science Forum. Reports 1999-2004 (Paris: Organisation For Economic Co-Operation And Development, 2004).

[2] "The Knowledge Evolution: Building Organizational Intelligence", by Verna Allee (Elsevier: 1997), p. 15.

[3] "The Tale of the Hare and the Tortoise: Globalisation and the Restructuring of the German Model", by Louise Amoore in *The Future of the German Economy: An End to the Miracle?*, op. cit.

[4] "Governing Globalization: Issues and Institutions", ed. by Deepak Nayyar (New York: Oxford University Press, 2002), p. 27.

[5] World Knowledge Competitiveness Index 2004, published by Robert Huggins Associates (London, 2005).

Other centers of knowledge in Germany according to the Index are:

City/region	Place/rating
Hamburg	75th
Berlin	87th
Nordrhein-Westfalen	97th
Bremen	98th
Niedersachsen	105th
Schleswig-Holstein	111th
Saarland	113th

Table 1: Germany's most knowledge-competitive regions (Robert Huggins Associates)

Although the World Knowledge Competitiveness Index is not based entirely on public scientific institutions, the interpretation of its results helps draw a few conclusions. It appears that the German centers of knowledge, including commercial and non-commercial sector, are not dominant neither in Europe, nor in the world, holding modest positions. However, it should not be overlooked that Germany has a strong potential for further growth as it is represented by at least 10 regions, which make up 8% of the world's global knowledge centers. For instance, Italy is represented by 5, UK by 4, France by 2, Belgium by 2 centers. Evidently, the potential of Germany should be considered as particularly strong basis for taking the lead in the world's knowledge competition.

Determined to serve the interests of national economy, the publicly-financed applied research network in Germany looks slightly different from the schemes fitting into the context of commercialized science. The model, which worked perfectly in the age of German economic miracle and secured the competitiveness of German innovations throughout the 1980s and early 1990s, is currently experiencing the pressure of globalization as much as other parts of traditional socio-economic structures. The authors of the study carried out on behalf of *Bundesministerium für Bildung und Forschung* assert that "no other country scaled down its R&D as rapidly or as vigorously as Germany did." [1] Strictly speaking, the problems of the German R&D system are not caused by the system itself which is rational and sustainable. They came as a part of the greater process of global pressure on German economy and society resulting from global processes, which, in their turn, are integral part of world historical development.

The analysis of the situation in the German applied research sector proves the fact that this potentially strong sector capable of generating most valued scientific discoveries has to go through the process of reconsideration of its methods of work. Only the interaction of business and science by the means of broad communication

---

[1] "Germany's Technological Performance", ed. by Harald Legler , Georg Licht, Alfred Spielkamp (Heidelberg, New York: Physica-Verlag, 2000), p. 103.

would be an adequate response to the challenge of time. Economic development and competitive performance are not predicated on basic research, but on the connection between basic and applied research (the R&D system), and their diffusion throughout organizations and individuals.[1]

The place of Germany as a leading power in global science and the country possessing important centers of innovations cannot be questioned at the moment, but what causes the earliest concern is the shaping of reforms in science policy. Traditional means of European protectionism cannot be considered as a panacea since the openness of the research institutions to world processes and international cooperation require to maintain a high level of competitiveness as it is the case in other leading countries. The German state has already found new ways of stimulating entrepreneurial behavior by adding extra funds to contract-winning projects, but traditional foundations of the publicly-financed R&D system remain the same.

An outstanding example among the centers of scientific and technological resources in Germany is the Fraunhofer Society, which spent decades in developing the mechanism of the knowledge transfer from basic research to applied technologies in industry. A network of 56 applied research institutes at over 40 different locations in Germany, whose operations and capital expenditure made up €1,2 billion in 2006, the Fraunhofer Society stands as a popular image of the place, where most important innovations are born. "Innovation as mission" reads the chapter in a Fraunhofer annual report and this challenging task has always been admired in the Fraunhofer research community.[2]

Strategic importance of such centers of global knowledge in Germany as the Fraunhofer Society has tremendously increased since the beginning of the globalization age. The Fraunhofer Society along with the Helmholtz Association are currently responsible for major contribution to development of national science and overwhelming majority of non-university patent applications registered in German public R&D sector.[3] As this thesis is primarily focused on the applied research and the role of communication in science, the importance of the Fraunhofer Society in the changing structure of German science should not be underestimated.

Placed in the complex and organized system of R&D in Germany and maintaining broad international contacts, the Fraunhofer Society suffers from the same problems as the system on the whole. The Fraunhofer Annual Report 2006 recorded this unfavorable trend as follows:

"Expenditure on research and development in Germany, measured as a percentage of gross domestic product, declined slightly. This has taken us even

---

[1] "The Rise of the Network Society", by Manuel Castells (Blackwell Publishing, 2000), p. 126.

[2] Fraunhofer-Gesellschaft. Annual Report 2006. A Publication of the Fraunhofer-Gesellschaft (München, 2007).

[3] "Turning Science Into Business: Patenting and Licensing at Public Research Organisations", published by the Organization for Economic Co-operation and Development (2003).

further away from the shared objective of the EU member states and the German government to raise the proportion of R&D spending to 3 percent of GDP by 2010."[1]

Critical studies of the German R&D network argue that though it may prove to be successful in some sectors, such as nuclear technology, vehicle construction or environmental research, the failures to achieve significant results in leading-edge technologies, such as information technology, are evident.[2] In the next decade, information technology, biotechnology and new materials will be dominant among the leading-edge technologies, but traditional concepts of the German R&D sector may create further difficulties in adjusting to new economic realities.[3] For instance, the increase of sophistication in automobile production in terms of adding more electronic gear and means of global navigation inevitably would lead to dependency of traditionally strong German production lines on innovations created outside the country.

The highly institutionalized system of applied research in Germany encompasses the Fraunhofer institutes and others with a strong barrier of public funding, which weakens the ability to support risky innovative projects in hi-tech area and to become competitive centers of global knowledge and competence. The German R&D sector cannot avoid the involvement in the process of globalization, but today it is difficult to define the form of its response. In general, globalization of R&D is defined as "the ability of the technology development organization to recognize and respond to technology and market signals from all strategically important locations."[4] Although desperately sought for, this response has not been definitely shaped yet. A broadly based "initiative for innovation" and "concerted effort by public administration and private enterprise to bring about a renewal"[5] are still in the process of elaboration, delayed by economic recession and changes on political scene.

The German innovation system has long been serving as a model of technological transfer for its strong capacity to produce high quality, high technology and high competitive products, but the attractiveness of this model based predominantly on abilities of research institutes is gradually fading. While percentage of national expenditures for R&D remains close to the level of other developed countries, the share of hi-tech goods in German exports fell during the 1990s and the

---

[1] Fraunhofer-Gesellschaft. Annual Report 2006, op. cit., p. 11.

[2] "The End of the Innovation Economy?", by Rebecca Harding and David Soskice in *The Future of the German Economy: An End to the Miracle?*, op. cit.

[3] "The German Innovation System", by Frieder Meyer-Krahmer in *Research and Innovation Policies in the New Global Economy*, ed. by Philippe Larédo, Philippe Mustar (Cheltenham, Northampton: Edward Elgar, 2001).

[4] "Strengthening Technology Incubation System for Creating High Technology-Based Enterprises" (United Nations Publications, 2003), p. 18.

[5] See the address of the President of the Fraunhofer Society Professor Hans-Jörg Bullinger in *Fraunhofer Magazine* (2. 2004).

German innovation system appears to be incapable of responding to global challenge.[1]

The reasons for this drawback are rooted in a wide variety of factors, but the method of technology transfer employed by the German applied research institutes leaves no doubt that only modernization of the whole approach may cure the diseases of the innovation network. What causes another reason for considerable concern is the incremental tendency of innovations, which can be characterized as "innovations of innovations" rather than revolutionary changes in particular areas of science. The researchers, who wrote about the pro and contra of the German incremental innovation system, argue that Germany has historically proved itself resilient to major shifts in techno-economic paradigms[2], but such process as globalization may lead to irreversible consequences if considered as the global change of world business and science. Globalization has already brought about such phenomena as the transfer of German industrial enterprises to the Asian markets, a step, which would be impossible in the years of economic miracle. The global shift of knowledge centers to North America and Asia has already begun and Germany is increasingly exposed to a risk of losing its leading positions. In the 1990s, the growth and employment centers have shifted to the US and Great Britain, where upwards trend in the research sector is combined with a booming economic situation.

Successful centers of knowledge in the age of global market should pursue a policy aimed at commercializing the products of their work, communicating its achievements to target groups, and sustaining itself by fostering a network of international contacts, while their ability to meet the requirements of the market will not only increase their revenues, but will also serve as a foundation for further growth and development. Can the current R&D system in Germany encourage the creation of international innovation networks and improve entrepreneurial climate in Germany's applied research institutes in general? Evaluating the potential of Germany, the researchers are pessimistic about the role of institutions of knowledge and learning, which "in the current form … do not appear able rapidly to produce and reproduce the right kinds of knowledge to make Germany a strong and competitive knowledge economy."[3] At the same time, the demands for generating more economic benefits from public support to R&D are growing.

The German innovation network still possesses a number of evident advantages and serves as an example of successful model, but only institutional and structural modernization of this system would help maintain and develop its robustness and competitiveness. If compared to other countries, Germany has highly differentiated and decentralized network of research centers, where new knowledge and technologies are constantly generated. Meyer-Krahmer distinguished six principal advantages of the German innovation system, including high-level technologies, existing markets, decentralized research system, high degree of

---

[1] "The End of the Innovation Economy?", op. cit., p. 83.

[2] "Postindustrial Germany: Services, Technological Transformation and Knowledge in Unified Germany", by Claire Annesley (Manchester: Manchester University Press, 2004), p. 91.

[3] "The German Innovation System", op. cit., p. 102.

internationalization in R&D, qualified staff, and long-term orientation. However, on the weaker side are insufficient link-up to leading-edge technology and customer-oriented strategy, failure to acquire new markets, fragmented structure, domestic orientation of technology policy (more state financing in exchange for more domestic industry contracts), decrease in investments in training and education, and the most problematic – a lack of effective incentive mechanisms for research strategies and preservation of traditional fields of innovation.

The contradictions between solid potential of the German R&D sector and negative trends in its recent development would not be overcome until the public research infrastructure becomes more competitive, more flexible and more dynamic. Improvement of the level of competitiveness in this case should be understood not as merely successful economic performance, but as technological competitiveness between the centers of global knowledge. In this relation the effectiveness of communication as necessary feature of flexibility and dynamism would play a major role for success of knowledge industry in Germany. The "new mode of production of knowledge" depends upon "innovations in the telecommunication and computer industries that will make possible the ever closer interaction of an increasing number of knowledge centers."[1]

The new techno-economic paradigm of the 21st century requires active participation of the applied research centers in creating innovations in the leading-edge technology sector, which might be realized only through institutional re-evaluation of the role of public research centers in Germany.

[1] "The New Production of Knowledge", op. cit., p. 122.

1.4 Adjustment of R&D Strategies

Global competition and socio-political demands drive the technological progress, which is based on state-of-the-art of science and technology. The cultural component which affects this process is substantially more complex both in its cause and effects as it covers aspects of successful innovation management, technological acceptance, and the efficiency of the research community. The R&D strategies in applied research require all three components to achieve appropriate, financially viable, professional and efficient results, based on excellent research.

In market-oriented industrial societies with a moderate regulative environment, such as the German model, competitive pressure drives R&D progress and the cultural context establishes its options and dynamics. These factors are affected by the difficulty in predicting the degree of governmental conditions, sometimes promoting and at times impeding R&D projects.

Inevitably, globalization leads to a coherence of markets, their products and rules. National systems, and likewise the generation and utilization of knowledge, yield to the pressure and should find the ways to adjust to new conditions in order to achieve continued success. By nature, this burden primarily applies to industrialized countries, such as Germany, with a high share in international trade of technological commodities. Thus, it is no surprise that the term *globalization* in scientific literature is interchangeable with terms like *industrialization*, *modernization* and/or *democratization*; all these processes and actions are enforced or implicated through profound societal change.[1] The consequences for globalization are exceptionally remarkable as reflected in the *Delphi'98*, an expert survey conducted by the German Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*, BMBF). This research carried out to study the global development of science and technology provides substantial evidence for an argument that the stabilization and strengthening of international R&D cooperation are the most important measures for advancement of science and technology.[2]

Key goals of applied research, namely the development of new or improved products, technologies, and services, must therefore be pursued in a continuously varying cultural, political and economic environment, that consequently requires the adjustment of strategies.

For the purposes defined in this study, there are two principal strategies for selling products, technologies and services. The strategy pursued in Germany for the last few years, shaped under conditions of the social market economy, relies on the ability to innovate and increase productivity as essential elements for the power to compete. This "high-quality" strategy, which is thought to be a key for high profits,

---

[1] "The Tale of the Hare and the Tortoise: Globalisation and the Restructuring of the German Model", op. cit., pp. 54-55.

[2] Delphi'98 - Umfrage. Studie zur globalen Entwicklung von Wissenschaft und Technik, ed. by Kerstin Cuhls and Knut Blind (Karlsruhe: Fraunhofer-Institut für System- und Innovationsforschung, 1998).

defines the current debate about Germany as a business location.[1] The argument presented by its adherents is that research and development are capable of strengthening the innovative dynamics within an economy.

The alternative strategy pursues what might be defined as a “low-cost” policy in order to maintain competitiveness. Contrary to the “high-quality” strategy, low wages, collectivization of infrastructure expenditures, and outsourcing are common policies to lower production costs. Both strategies have a major impact on the development of business locations for manufacturing and hence on the site selection for R&D.[2]

Interlinking forces between powerful R&D, high-end production and high-end marketing are obvious. These relationships lead to a medium and long-term balance of international business strength, i.e. relocation of R&D into foreign countries when the company expects better market opportunities and more favorable production conditions abroad.[3] In contrast, the relative strengths of R&D are boosted by promoting sophisticated national production structures, local supply networks, and innovative promotional activity as market leaders (by suitable regulatory procedures, for example). In this context, it is interesting to note that companies’ foreign investment into an R&D location is only a valid option when all three benefits are equally achievable.[4]

The continuing trend of globalization of research, product development and innovation is primarily motivated by the increasing significance of R&D strategies for industrial companies. The most important motives according to the work of Louise Amoore are:

- Access to key research results and talents
- Local presence, study of leading markets and adjustment to sophisticated customer segments
- Setup and continuous enhancement of R&D at locations with optimal advantage and benefits
- Monitoring and incorporation of regulatory requirements
- Support of products and distribution through local R&D capabilities

Today’s motivation and purpose of internationalized R&D is therefore not primarily the coexisting support of multiple globally displaced R&D entities (as practiced in the past), but rather the globalization of learning processes along the entire value-added chain (research, development, production, marketing/distribution,

---

[1] “The Tale of the Hare and the Tortoise: Globalisation and the Restructuring of the German Model”, op. cit., p. 56.

[2] “Globales Management von Forschung und Innovation”, ed. by Alexander Gerybadze, Frieder Meyer-Krahmer, Guido Reger (Stuttgart: Schäffer-Poeschel Verlag, 1997), p. 174 ff.

[3] Ibid., pp. 186-188.

[4] Ibid., pp. 193-194.

service, supplier and logistics networking and integration). The crucial parameter for the intensity of cross-national learning and innovation is the extent that the generation of knowledge forms as a portion of the value creation process in any company.[1]

This short-defined impression of globalization leads to the installation of centers of R&D expertise to concentrate resources and avoid duplications, while generating the background for increased competition between various innovative systems. This is therefore a mandatory requirement for R&D location development but an insufficient requirement for excellence in research and development. The latter particularly includes the presence in key markets of ground-breaking innovations. In the case of incremental innovations, for example product improvements, we are in effect dealing with the installation of local R&D capabilities to support production, sales and distribution.[2]

As discussed earlier, some authors suggest that the German social market model is less capable than American market economy in creating fundamental innovations and establishing them in the market place.[3]

The alternative argument suggests that the German business location is widely recognized as creating stable growth through high-tech products and technologies in the long run. In addition, internal competition and flexibility, which generate incremental innovations and structural adjustments, are all but exclusively based on established technologies.[4] [5]

This weakness of the German business location appears even more precarious. Potential risks include the governmental withdrawal of their financial aid (proportionally based on the gross domestic product), or their support of science and technology, and possible reluctance to entertain the risks involved with the introduction of innovations in the market place.[6]

German politicians are fully aware of this problem and take this issue seriously as demonstrated by their repeated commitment to R&D. However, even

---

[1] Ibid., p. 199.

[2] Ibid., p. 201.

[3] See “Germany In A Global Era”, by Rebecca Harding and William E. Paterson, “The End of the Innovation Economy?” by Rebecca Harding and David Soskice in *The Future of the German Economy: An End to the Miracle?*, op. cit.

[4] Ibid, p. 83 ff.

[5] The 2007 Nobel Prize for physics was awarded to Prof. Peter Grünberg (shared with Albert Fert, French scientist at Université Paris Sud) at the Jülich Research Centre for the discovery of giant magnetoresistance (GMR) which brought about a breakthrough in gigabyte hard disk drives. Today, GMR sensors are successfully marketed world-wide, but almost exclusively manufactured in the U.S.

[6] “Rethinking the Impact of Globalisation on the Nation-State: the Case of Science and Technology Policies in Germany” by Heiko Prange in *German Politics*, 12:1, 4:2003, pp. 23-42.

heavily engaged politicians do not believe that by 2010 the nation can achieve[1] what is known as the 3%-Target, an objective based on the resolutions of the European Council passed in Lisbon in 2000 and Barcelona in 2002. It was designed to make the European Union the most competitive and dynamic, knowledge-based market area in the world by 2010, requiring the spending of 3% of gross domestic product on R&D.

A report commissioned by the Federal Ministry of Education and Research (BMBF) provides a comprehensive overview of the prospects for R&D in Germany. Despite some optimistic views, the relevant data contained in the report prove the decrease of efficiency and the sagging volume of R&D in Germany. The objective of increasing essential R&D expenditure by 40% within four years is deemed phenomenal, and praised given the vision of increasing R&D expenditures to 4% and investment in education to 7% by 2020.[2]

The strikingly low rate of foreign investment in German R&D (less than 3%) is particularly noticeable when compared to other European countries, most notably UK (17.2%), France (8.8%) and Sweden (7.3%) which are in a much better position.[3]

The share of R&D expenditure of small and mid-sized German business is also relatively small despite the outstanding export share of almost 35% of the gross domestic product in 2005. In turn, the successful presence of Germany industry in international markets requires certain outsourcing of R&D, the funding of which will be removed from German business locations.[4]

On the basis of this short analysis, the consequences for German business locations and the future outlook of globalization cannot be easily predicted. In view of their economic power and domestic market volumes, Germany's ability to adapt to market conditions, global technology, and product trends (ensuring high-quality) will help to maintain the effectiveness of German business in the future. In addition, the domestic market of the EU more and more adopts the character of a home-based market. Nevertheless, the relatively small proportion of new high-tech technology and product development is a concern.[5]

In view of the increasing importance of location factors such as knowledge and innovation ability, concurrent with the reduction of R&D funding by traditional support programs, the following circumstances may evolve and have to be addressed:

---

[1] Rat der Europäischen Union, Brüssel, den 18. Mai 2006 (30.05), 7775/1/06, REV 1, Schlussfolgerungen des Vorsitzes, online edition, http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/de/ec/89030.pdf (assessed 30 November 2007).

[2] "Das fabelhafte 3%-Ziel: Perspektiven von Forschung und Entwicklung in Deutschland", ed. by Uwe Thomas, Staatssekretär im Bundesministerium für Bildung und Forschung a.D. (Berlin: Friedrich Ebert Stiftung, 2007), p. 38.

[3] Ibid., p. 23.

[4] Ibid., pp. 17, 24.

[5] "The End of the Innovation Economy?" by Rebecca Harding and David Soskice, op. cit.

- Germany as the business location looses ground and becomes less important globally
- government sponsorship of the German R&D business location is insufficient and remains below required needs
- Germany as a R&D business location is not adequately attractive for foreign investments, knowledge and skills

The most effective response to these hypotheses would be formulated if the publicly-funded research institutions assumed a substantially larger entrepreneurial initiative. This initiative should strive for excellence and relevance in particular for applied research and development.

Excellent research is predominantly defined and recognized by the scientific community. Relevant research is defined by the acknowledgment of science by those outside the scientific community and beneficiaries, who must also be willing to pay for it. Along those lines, knowledge becomes a product and R&D turns into production, which will only be successful in competitive environments, and with a clearly defined product portfolio and an efficient professional approach.

It is quite obvious that this relevance cannot be achieved when R&D is limited to pre-competitive situations. In this instance, the transfer of R&D into industry is achieved primarily through the education of scientists, so that scientific results can be transferred to industry.

Applied research and development scientists must expand their understanding of performance results for the development of marketable products and services, in particular for small and mid-sized companies that are considered to be the driving force behind German innovations, in order to receive competitive financial support for industrial projects.

However, the growing understanding of performance results should not be limited to marketable products and services. The renewal of company resources should also be considered an asset of great importance. The analysis conducted by BMBF indicates that the Germany as business location is in dire need of more R&D intensive businesses in new growing markets. [1] To achieve this goal, publicly-funded R&D requires a set of new rules applicable to innovation in management. In principle, this approach calls for an extended commitment to education, completed by certification that documents the vitality of an emerging and innovative company.

The third response to these hypotheses is related to the internationalization of research and development. Foreign talents, with cultural and technical skills are desperately needed by German companies and must be attracted by R&D organizations as part of their educational mission.

At the same time, young German scientists must be prepared for international tasks. For technical institutes, the quest must be towards international recognition and

[1] "Das fabelhafte 3%-Ziel", op. cit., p. 57.

for respected “centers of excellence”, to provide market access for small and mid-sized companies through international cooperation.

In summary, performance and results will be improved by the development of market-ready products, the establishment of viable companies and their integration into the international scientific community and by supporting local small and medium-sized business focusing on success in international markets to ultimately boost the attractiveness of German R&D locations.

Professionalization of R&D practices is another important aspect of adjusting the research strategies. While more than 90% of the development expenditures are funded by industry, over 90% of the disbursements for research are financed by public funds.[1] Through competition the government, being the most important source of funding, has to provide for the infrastructure for “scientific excellence”, which will facilitate the reformation of companies and their portfolios.[2]

To become effective, the applied research institutions, governed by public law, have to act professionally given their responsible role between R&D and the economy and society as a whole. The adoption of modern management practices, which are not in contradiction to the statutes of non-profit, publicly promoted research and development, is a substantial prerequisite. Another condition, possibly more difficult to achieve, is the willingness to assume corporate responsibility including their orientation towards performance results that are marketable, within a system that is governed by public law.

[1] Ibid., p. 58.

[2] Ibid., p. 61.

2. Development of Communication

2.1 Knowledge as Commercial Product

Development of human knowledge is as old and complex as the history itself. It has been a central subject matter for epistemology, analyzing the nature of knowledge since the time of Ancient Greece. In recent years, knowledge began to gain a new wave of attention. Increasing number of scholars in the fields of social economy, industrial organization, technology management, management strategy, organizational theory have started to theorize about knowledge management, often considering it as a real management resource and power.

The birth of a new trend in studying the role of knowledge in modern society could be observed in the business press of the 1990s, featuring such prominent authors as Peter Drucker, Alvin Toffler, James Brian Quinn, Robert Reich, leading the field. These authors in their own way attempted to transmit to the audience the idea of the arrival of a new economy and/or society. In his book *Post-Capitalist Society* (1993), Drucker, widely-cited author of numerous management-related literature, analyzed the major world transformation from the age of capitalism to the *knowledge-society* and examines the radical effects it may have on society, politics and business. Drucker argued that in the new economy knowledge is not just a resource alongside the traditional factors of production – labor, capital and land, but the only meaningful resource today. It was also Drucker who coined the phrase "knowledge workers"[1] to describe managers as knowledge executive who knows how to allocate knowledge to productive use, just as capitalist knew to invest capital to productive use.

Famous American writer and futurist Alan Toffler echoes Drucker's contention, describing the transition of knowledge from being an adjunct to money power and muscle power to being their very essence[2]. Pushing aside the agricultural era based on land ownership and industrial age when raw materials for mass production became the central resource, the last decade of the 20th century brought us to the transition to a new *information age* where information, the raw material of knowledge, is a central resource both for wealth production and military power. James Quinn went a step further by pointing out that the value of the most products and services depends on how "knowledge-based intangibles" (invisible assets) such as technological know-how, understanding of the customer, innovation and creativity can be developed [3].

The issue of a new value assigned to knowledge frequently appears on the pages of popular press of the early 21st century. In January 2006, the special edition of distribution giant, *Newsweek*, questioned the pros and contras of "The Knowledge

---

1 "Post-Capitalist Society", by Peter Drucker (Butterworth Heinemann Oxford, 1993), p. 8.

2 "Powershift: Knowledge, Wealth and Violence at the Edge of the 21 Century", by Alvin Toffler (New York: Bantam Books, 1992), p. 37.

3 "The Intelligent Enterprise: A Knowledge & Service Based Paradigm for Industry", by James B. Quinn (New York: The Free Press, 1992), p. 66.

Revolution: Why the Victory Will Go to the Smartest Nations and Companies". It was primarily focused on the knowledge-related issues[1]. In the article "The Exhausting Race for Ideas", Thomas L. Friedman, management-thinker and the Foreign Affairs Columnist for the *New York Times*, explains that one of the reason for the importance of knowledge today is that the tools being crucial to improving productivity become more and more complex with each new generation, and therefore require more and more knowledge and training to get the best out of them. Friedman believes that the societies with the most innovative scientists, universities, engineers and technology companies able to solve complex problems have enjoyed the raising standards of living then the societies without them. In an interview published in the same issue of *Newsweek*, IBM's president Irving Wladislawsky-Berger notes that science and engineering which once started up the industrial revolution have become critical in advancing the services revolution which became more sophisticated in the way they are designed, built and deployed.

In his latest book *The World Is Flat: A Brief History Of The Twenty-First Century*, Friedman describes the unplanned cascade of technological and social shifts that effectively leveled the economic world and "accidentally made Beijing, Bangalore and Bathesda next-door neighbors"[2]. As growing complexity of global markets with increasing number of consumers spins off the new industries, the appearance of new niche specialists within them, the rise of information technologies and the Internet greatly raises the value of knowledge. These factors helped transform the global competition from one that was mainly about the race for intercontinental ballistic missiles into one that is more about the race for IQs. "Now, so many previously closed societies have opened up to the world, and connected to the flat-world platform, and more and of their knowledge workers can plug and play, we are pushing out the boundaries of knowledge farther and faster. The next great breakthrough in bioscience may come from a 19-year old in Poland or Vietnam, who downloads the human genome from Google via wireless Internet. This makes for a very disruptive business environment"[3].

Considering these issues of global competition in the framework of new knowledge-based environment, the experts emphasize that the *management of knowledge* is quite complex and it is more difficult to create knowledge, measure, value and protect it, though the processes of producing knowledge from raw data are as diverse as the manufacturing processes for physical materials[4]. To win the future intelligence competition where the conflict space is global, a new strategy will be required and its success will depend on knowledge-centric advantage. A single player can hardly maintain a significant margin in global sources of information while

---

[1] See *Newsweek (Special edition)*, December 2005-February 2006 (Newsweek, Inc. The Washington Post Company).

[2] "The World Is Flat: A Brief History of the Twenty-First Century", by Thomas Friedman (New York: Farrar, Straus and Giroux, 2006).

[3] "The Exhausting Race for Ideas", by Thomas Friedman in *Newsweek (Special Edition)*, op. cit., p. 12.

[4] "Knowledge Management in the Intelligence Enterprise", by Edward Waltz (Artech House Publishers, 2005), pp. 8-10.

global sensing and networking capabilities will become a commodity with most global competitors at parity. The ability to win will depend on the ability to select and convert raw data into accurate decision – making knowledge.

The remarkable phenomenon of knowledge-economy is that information has emerged as a product in its own right. The information received as a by-product of the core business is important to the success of the enterprise. Today, the cost of information technology in an average car may be greater then the cost of the steel. Information technology, including connectivity on the information highway, is soaking up more capital than any other investment.

The new dimension and place of knowledge in society and economy is necessarily related to another important process – *knowledge transfer*, which forms a part of broader transition known as technology transfer, where "technology consists of knowledge that may be embedded in complex processes."[1]

Systematic study of technology transfer is a relatively new area which came into the limelight in the last twenty years of the 20th century. A powerful definition for knowledge transfer is: "Bridging the gap between the innovator and the exploiter of technology"[2]. In the course of this process, applied-research institutions act as associations of innovators, whose ability to manage their knowledge is a critical point for success of the entire process of knowledge transfer.

Important detail of the definition for technology transfer is given by the US National Technology Transfer Center (NTTC) and reveals another important aspect in knowledge management. In view of the NTTC experts, the process of utilizing knowledge or particular technology, expertise, know-how is carried out under conditions when such utilization was "not originally intended by the developing organization."[3] This valuable extension points out at increasing necessity not only to develop new knowledge, but also to find best solution for its application.

The emergence of a new role of knowledge leads to cardinal changes in understanding the place and role of the inventors in the knowledge-based economy. The transition is still underway. Analyzing the policies for managing intellectual property in Denmark, Sven Milthers stresses that "a large number of researcher-inventors have absolutely no intention of becoming entrepreneurs with their own start-up company" as they merely "want to have their inventions to benefit society, to get extra funding for their activities…"[4] The complexity of task of technology transfer appears not to be fully understood by many researchers as, for example, a recent survey in Ireland showed that 50% of researchers at universities were not at all

---

[1] "Technology Transfer of Federally Funded R&D: Perspectives from a Forum", by Helga Rippen, Mark Wang (Rand Corporation, 2003), p. 45.

[2] "Prospects of Integration and Development of R & D and the Innovation Potential of Black Sea Economic Co-Operation Countries", ed. by Walter Leal Filho (IOS Press, 2002), pp. 101-102.

[3] "Technology Transfer of Federally Funded R&D", op. cit., p. 5.

[4] "Turning Science Into Business", op. cit., p. 136.

(23%) or only “hardly” (27%) aware of technology transfer mechanisms at their respective institutions.[1]

The approaches proposed for creating a new class of entrepreneurs – technocratic entrepreneurs – vary from educating scientists to changing legal regulations to more intensively supporting academic spin-off companies. The increasing role of effective communication used by these technocratic entrepreneurs will be discussed in the next chapters of this study, but what appears obvious in this context is a crisis of scientific identity, a subject for further studies as research in this area is “sorely needed”.[2]

As knowledge becomes a product created by collective efforts of scientists, their new function should be extended to entrepreneurship. Any research laboratory or institute, especially those engaged in technology transfer, serves as a melting pot where fundamental concepts elaborated by theoreticians are merged with the needs of modern economy. Loose knowledge concepts and ideas would not reach its potential without direct involvement of applied research organizations in shaping the forms of a new technology and converting it from abstract schemes into ready-for-use technologies.

Though it may seem obvious that publicly-funded research organizations are key players in the technology transfer to the same extent as universities or industrial laboratories, the concept of knowledge as a product still needs to find ways for appreciation among the scientists community. Before technology transfer may become successful business in the applied research institutions, these organizations should convert from slightly interested in commercial issues think-tanks to the units with developed infrastructure of marketing and communication.

---

[1] “Survey of Academic Research in Ireland”, by Jean-Luc Bellevergue, Chris Carroll, Colin Delaney, Aidan King (Dublin: University of Dublin, College 2004).

[2] “Determinants of Scientific Entrepreneurship: An Integrative Research Agenda”, by David B. Audretsch and Doğa Kayalar-Erdem in *Handbook of Entrepreneurship Research: Disciplinary Perspectives* , ed. by Sharon A. Alvarez, Rajshree Agarwal, Olav Sorenson (New York: Springer Science, 2005), pp. 97-118.

2.2 Acceptance of Knowledge and Technologies

In the past century, science was perceived as a process of "understanding and coping with change in the natural world" expressed in "universal model… that corresponded to an instrumental practice with respect to social and economic development".[1] Traditionally, researchers pursued their academic goals, progressing in their professional careers, while research institutions strove for excellence earning their reputation in accordance with significance of achievements. As it happened on many occasions, society and economy were not always ready for immediate use of innovations because the reaction of customers even to a great invention might be relatively slow in developing. Even the most useful by today's estimation inventions, such as radio, [2] went through a number of stage of public acceptance. Third generation mobile phone technology (G3) is probably the most recent example how the forecasts on the role of a new innovation proved wrong.[3] The Age of Information defined in the previous chapter imposed more demanding requirements for the process of creating innovations. "The difficulty is to harness, in increasingly effective ways, these outputs to socially useful purposes",[4] writes Gibbons in his study discussing "new production of knowledge."

Very few inventions, no matter how good conceived and demonstrated, receive instant feedback from the market. A research based on 200 failed innovations conducted in the late 1970s by Myers and Sweezy proved that three-quarters of them were stopped at the final, most expensive stage of the production installation.[5] In other words, 85% of all innovations that failed continued to be funded beyond the relatively economical phase of assessment and initiation. The failure in implementation of these would-be technologies is related to the marketplace. As many as 27.5% of new product and process technologies were scuttled because of uncontrollable market factors. Another 26% failed because of limited sales potential and an inability to find buyers for something that was apparently developed in the public interest.

Almost thirty years later, in the early 21st century, the percentage of failed innovations remains relatively high. "Failed innovation are costly, because they consume resources that could be otherwise used, opportunities are lost, systems are inefficiently employed, and customer perceptions can be irreparably damaged."[6]

---

[1] "Innovation, Competence Building, and Social Cohesion in Europe: Towards a Learning Society", by Pedro Conceição, Manuel V. Heitor, Bengt-Åke Lundvall (Edward Elgar Publishing, 2003), p. 21.

[2] "History of Radio to 1926", by Gleason L. Archer (New York: American Historical Society 1938), p. 59.

[3] "ICT for Social Welfare: A Toolkit for Managers", by Luke Geoghegan, Jason Lever, Ian McGimpsey (Policy Press, 2004), p. 12.

[4] "Science, Technology and Governance", ed. by John de la Mothe (Routledge 2001), p. 33.

[5] "Why Innovations Fail", by Summer Myers and Eldon E. Sweezy in Technology Review (March-April 1978), pp. 41-46.

[6] "Pioneer Companies: Striving for Fast, Deep, and Broad Diffusion of Innovations", by Gary L. Simon and Hemant Rustogi in *Erfolgsfaktor Innovation*, ed. By Ralph Berndt (Berlin, Heidelberg: Springer-Verlag: 2005), p. 83.

Examining the failures of innovations, Franklin refers to a study in which 197 innovations were analyzed out of which 111 were successful, while 86 had failed[1]. A set of features essential for the successful ones implied that they:

- were moderate new to the market
- were based on known and tested technology
- allowed customers to save money
- supported existing patterns of user's behavior

Most of the objectives which make an innovation successful cannot be achieved without continuous communication with market segments and additional efforts for studying the market, including possible profits for customers and acceptance of a given innovation at psychological level defined as existing patterns of behavior. Drucker in his masterpiece of theory of innovation noted that "For all the visibility, glamour and importance of science-based innovation, it is actually the less reliable and the least predictable one".[2]

While fundamental research institutions may probably afford to organize their work around a less demanding schedule which does not lead to immediate commercialization of results, the applied-research institutions constitute a sector, where further financing and planning are dependable to a great extent on what is known as success stories. Technological success is not sufficient to win the market as it was expected at the stage of development. Concorde, Sony's Betamax, and IBM's OS/2 are examples. A supersonic jet airliner, a failed videocassette format, and unsuccessful competitor of Microsoft Windows are perfect examples how enthusiastically developed technologies died out after wasting tremendous amounts of efforts to develop and to implement it. Scholars such as Salter and Dodgson believe that despite the wide recognition of importance of innovation "in many ways 'innovation' itself needs to be better understood."[3]

The vital role of communication in assuring the innovation's success is emphasized by Jolly, who lists a number of conditions which would hardly be met without developing the concept of acceptance of knowledge by means of increasing the awareness of technology creators with the help of professional communicators. Considering commercialization chain, Jolly points out at "mobilizing the market constituents needed for gaining market acceptance and delivering the benefits of the technology". [4] He continues defining the process of technology acceptance as a progressing range of factors, each adding value to the technology as it progresses.

---

[1] "Why Innovations Fail, Hard-won Lessons for Business", by Carl Franklin (Spiro Press, 2003).

[2] "Innovation and Entrepreneurship", by Peter F. Drucker (Butterworth-Heinemann, 1986).

[3] "Think, Play, Do: Technology, Innovation and Organization", by Ammon J. Salter, Mark Dodgson, David Gann (Oxford University Press, 2005), p. 18, 26.

[4] "Commercializing New Technologies", by Vijay K. Jolly (Harvard Business School Press, 1997), p. 2.

Being proficient at only one or two of them brings down the average result or can abort the process of commercialization and acceptance.

The race for innovation acceptance inevitably led to introducing a new dimension for the role of competition. "At any one time, little or no head-to-head competition exists, but significant innovation competition exists over time. This pattern of competition is often referred to as Schumpeterian rivalry, after Joseph Schumpeter, who asserted that it is a central feature of the modern economy." [1]

Further examination of the report ordered by the European Commission which had already appeared in this study proves the existence of "potential conflict between academic achievement criteria and commercialisation activities". This conflict between a scientist's view of importance of his study or invention and its potential implementation in the market undermines the activity of an organization on the whole. Immediate consequences of underestimating market mechanisms are expressed in the analysis of technology transfer performance in the same report:

Output	**US**	**Europe**
Number of patents filed	35.8	6.2
Number of patents issued	16.8	5.8
Number of active licensing contracts	120.2	17.1
Revenue from licenses (1 000 €)	10,173	507
Number of spin-offs	2.1	1.6

Table 2: Technology Transfer Performance in EC Report

The authors justly warn that these figures should be interpreted carefully as the surveys taken as a basis for such conclusions are based on statistically not significant samples. However, they reach another important conclusion: the low number of customers per technology transfer organization indicates that European institutions "are not very outward oriented nor particularly successful in their marketing and communication strategies."[2]

According to the report, the number of active licensing contracts in European technology transfer institutions is seven times less than in the United States. At the same time, the effectiveness of these contracts is 20 times less if the revenue is taken for measurement of acceptance of the developed technologies.

[1] "Innovation Policy and the Economy", by Adam B. Jaffe, Josh Lerner, Scott Stern (MIT Press, 2004), p. 113.

[2] "Improving Institutions for the Transfer of Technology from Science to Enterprises. Expert group report. Conclusions and recommendations" (European Commission, 2004), p. 28.

The conclusions drawn in the report were challenged by a group of researchers at the United Nations University in the Netherlands headed by Hugo Hollanders and Anthony Arundel, who attempted to prove that European scientists not less entrepreneurial than their American counterparts.[1] The scientists came to what they characterized as "intriguing results." A phenomenon named in their study as the European Paradox proves that the publicly-funded research suffers from a "poor performance in the system of open science". What hides behind this definition is a network of informal communication by means of reading journal articles, attending scientific conferences and maintaining personal contacts that is not less important than formal indicators of technology transfer.

The arguments of Hollanders and Arundel should not necessarily contradict with the official European report as they apparently wanted to emphasize the importance of a tradition relying on informal contacts in scientific community of European countries. Informality has always been a part of academic environment and will probably always remain an element of scientific culture, but growing interest of civil society towards science and cautious approach with regard to some controversial R&D projects may lead to increasing the degree of transparency and weakening the influence of informal relations.

A lack of openness in communicating the innovations to the public causes grave failures in acceptance of knowledge or any particular technology. Demands for greater public participation in civil society, influenced the current status when "the public nature of science… is no longer taken for granted" and when science is "challenged publicly as not being public enough." [2]

From historical viewpoint, the age when scientific community operated under conditions emphasizing the importance of motivational factor other than economic ones has already come to an end. At the same time, the old way of public thinking among the scientists continues to exist as illustrated by the works of a major expert in changing relationship between science and society, Helga Nowotny. Some important notions such as *propertization*, a term introduced in her works to define an important trend in changing the nature of publicly-funded science, still have to be realized as new concepts. Before going public and gaining a competitive age, any scientific data, object, method or procedure should be perceived from the viewpoint of market, which would eventually decide whether a particular technology may be accepted or not.

In planning an applied-research project, scientists or professional communicators working with them would face a new challenge: they will have to predict "the least predictable" – a success of transfer technology, including *a priori* identification of features which would help their technology to find its place on the market.

---

[1] "2005 European Innovation Scoreboard - Innovation and Economic Performance", by Hugo Hollanders and Anthony Arundel (Brussels: European Commission, DG Enterprise, 2006).

[2] "The Public Nature of Science Under Assault: Politics, Markets, Science and the Law", op. cit., p. 1.

The success of an innovation realized in its acceptance at the market is influenced by a wide range of factors. Having analyzed the most prominent studies of success and failures of innovation in the works of his predecessors, Saad summarized a number of principles for acceptance of knowledge and innovations[1]:

- Innovation results more frequently from marketing than from technical activity
- Factors of failure include ignorance of customer's needs, paucity of marketing, lack of effective communication
- Factors of success include identification of a need and market research, good internal and external communication

The set of features pertaining to successful knowledge transfer suggests that in publicly-funded research a comprehensive knowledge of market will be crucial not only in promoting an innovation, but also in achieving success in finalizing the results of the applied research which may suffer from a lack of financing and even left unfinished.

The acceptance of knowledge in the form of technology will not be possible without researching the needs of customers and one of the most important features examined in the next section will be the need for good designing. Under this notion, we understand not merely a shape which technology would acquire, but proper planning of the whole process of introducing an innovation to the market, taking into consideration each and every aspect affecting its promotion.

[1] "Development Through Technology Transfer: Creating New Cultural Understanding", by Mohammed Saad (Bristol, Portland: Intellect Books, 2000), p. 29.

2.3 The Role of Communication Tools (Public Relations and Marketing) in Technology Transfer Institutions

The previous sections of this chapter focused on the issues of promoting the awareness of new state of the knowledge market and adequate response to the changing model of applied-research innovation. Such response cannot become effective in research institutions without strengthening two elements of the market tools – marketing activities and public relations strategies.

Any form of communication from fax message to business negotiations to audience-targeted publication appears in a certain form of rhetoric, in other words – in a message sent from scientists to their potential customers, partners, sponsors etc. Emphasizing the importance of rhetorical practices, Doheny-Farina argues that it "must play substantive roles in the processes of technological innovations, technology transfers, and the development of new products."[1]

The mission of any innovation and further technology transfer will not be accomplished without proper and effective use of communication tools, which serve as an informational tunnel connecting isolated continent of scientific world with all interested parties. Science as social phenomenon and technical sciences in particular were often criticized for existing as an isolated circle which is particularly reluctant for extending communication boundaries. Rethinking communicative interaction is almost impossible without achieving intensive boost in communication of science with the help of all modern tools and the use of professional communicators, who can be broadly defined as "persons participating in an event that communicates science", be it with a friend in the pub or at a large-scale public event.[2]

The Bodmer report (1985) which greatly influenced the growth of efforts targeted at better communication of science in the UK called on a scientist's "sense of duty" to communicate their work to the public. However, the abilities and willingness of considerable number of researchers to share this knowledge with the community, government and industry rarely, if ever, matches their research capability. As it is often a case, their skills in communicating science come nowhere near their skills in performing it.

A sort of justification for this imbalance is rooted in the fact that research institutions are not communication venues and their primary role is defined as discovering knowledge or transferring these discoveries into innovative technologies. It is obvious that scientists would gain positive results from following one of the most modern trends of global world: outsourcing. Unlike their industrial counterparts, they do not need to look for a smart student from India or cheap labor in China. They would rather profit from relying on the help of professionals instead of reinventing communication tools and practices. Increasingly, science

---

[1] "Rhetoric, Innovation, Technology: Case Studies of Technical Communication in Technology Transfers", by Stephen Doheny-Farina (MIT Press, 1992), p. 219.

[2] "Travelling Facts: the Social Construction, Distribution and Accumulation of Knowledge", by Caroline Baillie, Elizabeth C. Dunn, Yi Zheng (Frankfurt/Main: Campus Verlag, 2004), p. 64.

communicators are "fulfilling part of the obligation that scientific institutions have to share scientific results with the public."[1] The concept that the new communication technologies are "transforming mediated communication in the 21st century, placing demand on public relations practitioners and communication managers to adopt such technologies" should become a generally shared view to promote the success of innovations in academic environment.[2] The unique role of public relations communicators is that they can and should combine scientific accuracy with cultural relevance, fulfilling the role of "interpreters" between the scientists and target audiences of the scientific institutions. Textual and visional representation of scientific projects by product-oriented engineers is frequently limited to technical details and presented as vague concepts to the public, falling short of catching the interest of top management decision-makers, who simply need to find some common sense and simplicity in technologies, even if they are complex.

A great variety of tools are available today for science communicators for achieving their goals: media advertising, public relations development, direct mail distribution, trade shows, seminars, training, and others, but creation of innovative products requires a different approach. Exhibitions and trade shows normally impose additional costs on the publicly-funded budgets of applied-research institutions, while media advertising of the innovative products is hardly possible at a large scale as they are often offered as technical solutions and customized devices, which do not fall under a certain category of advertisement in broad sense of the word.

A group of communication tools which could constitute a powerful basis of interaction with customers and partners consists of marketing and public relations. Leaving aside the increasing demand for elaboration of consistent marketing strategies, more effective application of public relations policies may help foster cooperation in different areas of economy and society.

The nature of production of innovations involving know-how techniques and exclusive rights may not allow to disclose the very details of the products, but the goal of public relations is broader. Applied-research institutions should not ignore the value that comes from keeping high profile, maintaining positive image and associating themselves with success and competence. One may argue that this is the very instance of encroachment of purely business attitude into the sacred temple of science. A counter-argument, if one can be found, is in the changing position of science in human society. The tribe of high priests in Ancient Egypt observing the constellations would also be puzzled if they discovered that modern astronomers gain both direct and indirect profit from successful merchandising as a part of science communication agenda in the Hubble project. An overall success or failure of the whole process might be measured by the level of fine-tuned balance of positive

[1] "Organizations and Strategies in Astronomy", by André Heck (Kluwer Academic Publishers, 2003), p. 106.

[2] "Excellent Public Relations and Effective Organizations: A Study of Communication Management in Three Countries", by Larissa A. Grunig, James E. Grunig, David M. Dozier (Lawrence Erlbaum Associates, 2002), p. 216.

publicity expressed in the coverage which a company or an institution receive in the media (web, TV, print, broadcast) regarding its products or activities.[1]

Unlike numerous start-up companies, the publicly-financed applied-research institutions have one thing in common that may serve as a perfect basis for planning public relations campaigns. First, they enjoy a long record of serving public interests, which is an undoubtedly strong argument in winning positive image. Second, such institutions have normally existed for years and created a proven record of public trust to the results of their work. Some of them represent unique scientific organisms based on years of experience in promoting innovations.

Will the introduction of new methods such as public relations in innovation management be enthusiastically embraced by scientific community? Given the historical conservatism of scientists and the view commonly shared among them that the laymen should refrain from meddling in scientific process, the answer can hardly be positive. The Luddite-style response, when the 19th century English workers destroyed textile machines in futile attempt to prevent their replacement with inexpensive devices, is familiar in the study of social culture. In the 1990s some U.S. newspapers criticized hooking up schools to the Internet in the same manner as a century earlier the public were warned of the decay in morals because of publication of daily newspapers.[2]

Many studies which had appeared in the recent years emphasize the importance of a new role for public relations in scientific community or academia. "Technology transfer or commercialization units in academia and government agencies need to not only market the technology to external organizations but must also convince the creators or providers of technology that their services are valuable and effective for the transfer or commercialization of the asset."[3]

A general strategy for introducing the elements of public relations to the marketing strategies of the applied-research institutions implies continuous and targeted efforts for association of the organization's name with positive activities reaching far beyond the needs of immediate market.

Probably one of the most striking examples how an innovation created by scientific organizations was cleverly exploited by a purely commercial enterprise lies in the history of *mp3* technology. As of December 2006, a Google query placed by the author of this study for association of "mp3" and "Fraunhofer", who greatly contributed to the technology that revolutionized digital music, returned about 1.09 million results. At the same time, the search for association of "mp3" with "Apple"

---

[1] "Marketing of High-Technology Products and Innovations", by Jakki J. Mohr, Stanley F. Slater, Sanjit Sengupta (Pearson Prentice Hall, 2001, 2005) pp. 317-318.

[2] "Deconstructing Public Relations: Public Relations Criticism", by Thomas J. Mickey (Lawrence Erlbaum Associates, 2002) p. 62.

[3] "Technology Commercialization Manual: Strategy, Tactics, and Economics for Business Success", by Melvin J. DeGeeter (Med-Launch Inc., 2004), p. 354.

and "iPod" returned 122 million and 9.7 million respectively. In November 2007, the same associations make up 1.23 million, 363 million, and 292 million respectively.

In terms of public relations, the analysis of these figures shows that Apple as producer of iPods succeeded not only in manufacturing the devices which was created by talented German scientists, but also made sure that the very meaning of the mp3 technology became firmly associated with the name of the company. Fraunhofer also developed the first mp3 player in the early 1990s, but failed to capitalize on these important inventions both in terms of marketing and public relations.[1] While the failure to capture economic profit was caused by a number of issues, the failure to gain positive publicity could hardly be explained by other reason, but the lack of proper public relations strategy. German authors agree on this view: "Eine erfolgreiche Verknüpfung von Technologie- und Marktorientierung im Innovationprozeß ist der iPod von Apple. Apple gelang es, das im Fraunhofer Institut für Integrierte Schaltungen entwickelte mp3-Komprimierungsverfahren für Musikdaten mit einem Apple-typischen, schlichten und hochwertigen Gerät sowie einem geschickten Vermarktungskonzept zum Erfolg zu führen."[2]

A growing demand for quality changes in treating public relations as vigorous tool in winning not only the public opinion, but also funds, contracts and other business opportunities is stressed by various researchers. Publishing a report on innovations in energy technology, the Organization for Economic Co-operation and Development (OECD) made a particular observation concerning Germany: "All initiatives play an important role in the initiation, coordination and administration of support measures, subsidies, demonstration projects and public relations ..." [3]

The results obtained from promoting public relations in applied research might be achieved by employing various techniques. Examining the opportunities of technology transfer in biotechnology, Evenson and Santaniello mention an interesting example how the "donation" of proprietary innovations may influence increasing positive image of an organization.[4] Regardless the details of this process, it shows that public relations might be used in a variety of forms beneficial for research units.

A key factor and direct channel for succeeding in communicating scientific ideas in the Age of Information is found in continuous extension of web presence aimed at proper representation of an organization's profile in the Internet. The creation and maintenance of a website for applied-research institution would hardly

---

[1] "Eadoption and the Knowledge Economy: Issues, Applications, Case Studies", by Paul Cunningham (IOS Press, 2004), pp. 337-338.

[2] "Technologiemanagement & Marketing: Herausforderungen eines integrierten Innovationsmanagements", ed. by Jenny Amelingmeyer, Peter E. Harland (Wiesbaden: Deutscher Universitäts-Verlag, 2005), p. 405.

[3] "Innovation in Energy Technology: Comparing National Innovation Systems at the Sectoral Level", by Organisation for Economic Co-operation and Development (OECD, 2006), p. 142.

[4] "The Regulation of Agricultural Biotechnology", by Robert Eugene Evenson, Vittorio Santaniello (CABI Publishing, 2004), p. 132.

be considered a great burden to the budget, but its use for communicating positive image and sharing business ideas sometimes looks underestimated.

Many scientific institutions still ignore the importance of general public interests, often omitting the laymen as one of the target groups. Lederbogen and Trebbe from the Free University of Berlin analyzed the way the scientific non-university based institutions present the information about their ideas and products on the Internet. The researches point out that if the websites address a certain target audience at all (only 8 from 67 of non-university research institutions actually have a specific appeal to target audience), the majority still try to appeal to the scientific community. Only a very small part of the websites addresses members of society that have no direct connection to science. Especially, the internationally renowned top-level research institutions analyzed in this article have developed highly specialized "languages" for scientific communication, which often make it impossible for non-specialists to understand the content, methods, and research process. [1]

Exclusion of general public from the targeted audiences in marketing strategies also affects other important areas – global competition and international partnership. A researcher looking for extending his/her contacts within a growing economic societies of America and Asia would be successful without using modern communication tools in delivering his/her ideas first to the public and then by means of media to the scientists and businessmen in other countries. Further studied in the next section, the issue of understanding the needs of a global customer is a real challenge for those organizations, which used to serve their regional markets.

[1] "Promoting Science on the Web. Public Relations for Scientific Organizations - Results of a Content Analysis", by Utz Lederbogen, Joachim Trebbe in *Science Communication*, 24 (3), 2003, pp. 333-352.

3. Communication as Integral Part of Technology

3.1 The Meaning of Science Communication

It has been shown in previous chapters that the role and place of communication in technology transfer entered the stage of important transition influencing acceptance of knowledge and technologies in the market. The growing potential of communication in multicultural world is evident, but still might be underestimated by the members of scientific community mostly focused on research and implementation. The value of science as the art of discovery, accumulation and transfer of knowledge may significantly increase if communicative methods are recognized and introduced into various spheres of scientific world.

If communication is valued as one of the most effective methods of fostering technical progress, the presence of communication in the process of forming knowledge and creating innovation inevitably leads to analysis of *science communication* as a complex network of social channels serving not only as mechanism for bridging a gap between scientific community and the lay public, but also as effective tool for extending scientific boundaries and gaining wide public support for important research and development.

Although the modern theory of communication focused on studying the communicative methods and systems has emerged as a scientific discipline years ago, it is barely possible to formulate a universally-acceptable definition of communication and/or science communication. Heath and Bryant (2000) studying the phenomenon of human communication theory and research admit that "hundreds of definitions have been proposed over the past 50 years, but none is entirely satisfactory."[1] The analysis of authorities induced the authors to conclusion that "interaction" lays in the core of the definition of communication. Traditionally seen as the exchange of information between human beings, communication might be defined as interaction based on commonly shared system of symbols (signs), found particularly in languages.

Science communication as relatively new field of academic knowledge with shorter historical record and currently emerging theoretical basis suffers from the lack of clearly formulated definitions and continuing state of confusion in definition of related terms. Public understanding of science, public awareness, and science communication are the most frequently found terms in the literature concerning relationship between science and society. These terms as the closest in meaning to science communication are interchangeably used by authors as synonyms.

The analysis of science communication as emerging definition would be incomplete without referring to related terms used in the past and present. Gilbert, Stocklmayer and Garnett (1999) defined it as follows. "Public awareness of science and technology may be defined as a set of attitudes, a predisposition towards science and technology, which are based on beliefs and feelings and which are manifest in a

---

[1] "Human Communication Theory and Research: Concepts, Contexts, and Challenges", by Robert L. Heath, Jennings Bryant (Mahwah, NJ: Lawrence Erlbaum Associates, 2000), p. 46.

series of skills and behavioral intentions."[1] The primary meaning of "awareness" is related to an ability to "have or show realization, perception, or knowledge" (Merriam-Webster Dictionary). In development of their concept, Stocklmayer, Gore and Bryant (2001) proposed to use the term "public awareness of science" as a better alternative to the definition of earlier coinage, "public understanding of science", since the former, in the authors' view, better reflects "the need to communicate science more effectively, to share with the public the concerns and the issues and to convey a sense of individual change."[2]

In fact, both terms are often confused in colloquial use, merge into each other, but public awareness of science appears to be more fundamental and serves as a prerequisite for more liberally understood public understanding of science: "The skills of accessing scientific and technological knowledge and a sense of ownership of that knowledge will impart a confidence to explore its ramifications. This will lead, at some time, to an *understanding* of key ideas/products and how they came about, to an evaluation of the status of scientific and technological knowledge and its significance for personal, social and economic life."[3]

As a term, public understanding of science is less abstract than its counterpart, but as a rule it is also analyzed by researchers from viewpoints of different disciplines. A canonical definition frequently cited in the literature was provided in the widely noted report compiled by the British House of Lords (2000) and entitled *Science and Society Report*. The experts involved in its compilation offered their view of public understanding of science as "understanding of scientific matters by non-experts." The report indicated that this cannot mean a comprehensive knowledge of all branches of science, but allowed a certain "understanding of the nature of the scientific methods, including the testing of hypotheses by experiment." In addition, "it may also include awareness of current scientific advances and their implications".[4]

The *Science and Society Report* was an important European benchmark in turning public understanding of science into a sort of principal definition "for all forms of outreach by the scientific community, or by others on their behalf (e.g. science writers, museums, event organisers), to the public at large, aimed at improving that understanding. It is sometimes expressed more comprehensively as 'public understanding of science, engineering and technology'."

Extending the scope of application of the term 'public understanding of science', Dierkes and von Grote (2000) understand it not as continuous interaction

---

[1] "Mental Modelling in Science and Technology Centres: What are Visitors Really Doing?", by J.K. Gilbert, S.M. Stocklmayer, and R. Garnett in *Proceedings of 'Learning Science in Informal Contexts'*, ed by S.M. Stocklmayer and T. Hardy (Canberra: Questacon, 1999).

[2] "Science Communication in Theory and Practice", ed. by Susan Stocklmayer, Michael Gore and Chris Bryant (Springer, 2001), p. 145.

[3] Ibid.

[4] Science and Society (Science and Technology Third Report), by the House of Lords (London: Her Majesty's Stationary Office, 2000).

between science and the public, but offer more proactive definition. "Contextualized within a political network, the public understanding of science emerges not as an objectively measurable index of scientific literacy but, more important, as an aggregate of what people wish to know about science in order to inform their daily choices and the ways they wish to deploy this knowledge for policy."[1] A very important detail in this evolution of the definition is that a natural desire to explore the world and gain new technical achievements is complemented with necessity to use this knowledge for forming policies affecting scientific process.

However, one of the original meanings of public understanding of science – in the context of educative mission dating back to 18th and 19th centuries – should not be completely discontinued. Considering this term from educational point of view, Hunt and Millar (2000)[2] provide a concise definition, distinguishing three main aspects:

- understanding of science content
- understanding of the methods of inquiry used in science
- understanding of science as a social enterprise

Thus, the modern definitions of public understanding of science is biased towards more effective involvement of formerly more 'passive' actor – the public in wide sense – for the purpose of understanding the content of scientific research, its processes and interacting social factors. As noted above, public awareness of science should serve as necessary criterion for better understanding, emphasizing positive attitude of any given audience towards science and readiness for development of this perception.[3]

A general approach to the process of communication between science and society has been changing throughout the end of the 20th century, demonstrating significant changes in their relationship and attitude towards each other.

The term 'public understanding of science' was formalized in the UK in 1980s "to advocate improved education in the ways of science – with a hope that the public would not be so quick to disagree with scientific understandings of, for example, risk issues"[4] accumulated in public conscience in the amount sufficient at that time for exposing mistrust towards science, scientists and results of technical progress. The degree of public trust to science was significantly undermined by a series of accidents related to nuclear waste and bovine spongiform encephalopathy (BSE), commonly known as mad-cow disease, which were largely perceived as

---

[1] "Between Understanding and Trust: The Public, Science and Technology", op. cit., p. 48.

[2] "AS Science for Public Understanding", ed. by Andrew Hunt, Robin Millar (Harcourt Heinemann, 2000).

[3] "Science Communication: A Contemporary Definition", by T.W. Burns, D.J. O'Connor and S.M. Stocklmayer in *Public Understanding of Science*, 2003, No. 12 (2), pp. 186-187.

[4] "The (co)-Production of Public Uncertainty: UK Scientific Advice on Mobile-phone Health Risk", by Jack Stilgoe in *Public Understanding of Science*, 2007, No. 16, p. 47.

results of activities of certain scientists who abandoned precautionary principles pursuing the advancements of new technologies. Raging discussions around genetically engineered foods and the usage of human embryonic stem cells serve as the most recent examples of scientific controversy. Under the given circumstances, the processes of scientific communication have been exposed to attention of political forces.

The publication of the *Royal Society Bodmer Report* (1985) urging scientists to develop new attitudes towards science communication manifested the beginning of the public understanding of science movement[1]. Encouraged by appearance of the Bodmer Report, a number of studies was carried out for the purpose of measuring the extent of scientific literacy within different social groups and prompted the emergence of what later became known as 'deficit model' of public understanding of science, which dominated the scene until early 21st century.[2]

The 'deficit model' was based on an argument that the reason behind skeptical attitude of society towards science is caused by insufficient level of scientific knowledge possessed by individuals. The adherents of this model argued that if society was not so incompetent with regards to science and elementary rules of physics, it could have shown more trust to science and subsequently developed better set of attitudes. Science as authoritative methodology and faceless society appeared as two antipodes: one was armed with priceless knowledge while the other failed to recognize the greatness of scientific progress due to ignorance and the lack of information which could be compensated with the help of mass media. Once such balance was achieved, mankind would have changed its attitude and approached critical reconsideration of the role of science as entirely beneficial.

According to the authors of 'deficit model', communication process was basically seen as one-way flow of information from science to society, overlooking the element of dynamic interaction between these two structures. This model was criticized for simplified approach to the issue of communication, for its relativity and impossibility to cover many vital aspects of relationship between science and society. The studies criticizing the lack of scientific knowledge among society members failed to address the principal concerns raised by its critics: why society should demonstrate its literacy in science and what is the advantage possessed by science over politics, arts, music and other spheres of human knowledge. Was it feasible to conduct tests to certify proficiency of individuals in various sectors of science and what sectors should be given priority? Does the extent of scientific literacy influence the trust of society and public approval with regard to ongoing studies?

In response to growing criticism and changing circumstances, the meeting of the UK Committee on the Public Understanding of Science (COPUS) in December 2002 passed a resolution concerning the 'deficit model' which admitted that the "top-

---

[1] "The Public Understanding of Science. Report of a Royal Society ad hoc Group Endorsed by the Council of the Royal Society" (London: The Royal Society, 1985).

[2] "Scientific Literacy: A Conceptual and Empirical Review", by J.D. Miller in *Daedalus*, 1983, 112(2), pp. 29-48.

down approach which COPUS currently exemplifies is no longer appropriate to the wider agenda that the science communication community is now addressing,"[1] thus sealing the fate of the old concept about science communication.

It took decades for researches to reach the conclusion that science communication is a two-way process. As a result, it was replaced with a new contextual approach known in the literature as 'trust model' which is seen as an attempt to improve the methods of communication between researchers, industry, and civil society, sometimes extending from public ignorance to loss of trust.[2] The contextual approach is based on recognition of importance of interaction between science and society, and acknowledges "particular circumstances of the recipients of scientific information and of their existing knowledge and beliefs".[3] The 'trust model' is different from 'deficit model' and appeals for active position of civil society in communication, emphasizing the importance of social context serving as a framework for such interaction.

The emergence of 'trust model' and contextual approach to science communication has signaled the beginning of transitional stage. However, the transition occurred mostly in theory. In real life, the process of discovery of science's new place in modern world and its relationship with society is still evolving. The end of the Cold War and armament race which consumed a considerable amount of scientific resources in the former Soviet bloc and in the West prompted scientists "to begin to think more broadly about other societal justifications for research and development and to begin to examine the value of science as a public enterprise".[4]

Regardless of new concepts, some conservative elements in scientific culture based on the views of exceptionality and professional expertise proved its ability to resist the changes imposed by social and economic development (see in particular Section 4.2 of this work). The reconsideration of values dominating the scene of communication between science and the lay public is still undergoing vital transition which may help the participants of this dialogue discover new ways to look upon their roles.

The most notable element in this transition is the shift from passive to active involvement of the lay public in the process of knowledge consolidation. Enlisting everyday examples of broader involvement of the public in application of scientific knowledge, van Dijk (2003) points at steadily increasing practice when the patients

---

[1] The Royal Society. (2002, December 9). "Statement on Copus by the British Association, the Royal Institution and the Royal Society." Retrieved December 5, 2007, from http://www.copus.org.uk/news_detail_091202.html

[2] "Science and Governance in Europe: Lessons from the Case of Agbiotech", by L. Levidow and C. Marris in *Science and Public Policy*, 2001, 28 (5), pp. 345-360.

[3] "Science in Public: Communication, Culture and Credibility", by Jane Gregory and Steve Miller (New York: Plenum, 1998), p. 247.

[4] "Communicating the Future. Report on the Research Roadmap Panel for Public Communication of Science and Technology in the 21 century", by Rick E. Borchelt in *Science Communication*, 23 (2), 2001, p. 209.

use the Internet to find the latest publications on the diseases they suffer from. Overwhelming majority of the patients do not have either medical service background or professional education and are exposed to the risk of misinterpretation of the medical information contained in scientific articles. Although, such attempts of self-education could hardly lead to positive results, the patients become co-constructors of knowledge because “the fact that they search for knowledge and demand interpretation should be seen as an interesting shift in a culture” where science and knowledge are no longer passively disseminated but actively negotiated.[1]

Cribb and Hartomo (2002) give their assessment of this process of cultural change within science itself as ‘democratization of science’. They argue that democratization of science is not merely desirable from a societal viewpoint but from a scientific one since “the community can bring to science many ideas and perspectives that will result in the science being more widely accepted, rapidly adopted and or commercialized… It can be a partner in the process instead of an uniformed recipient.”[2]

Encouraged by emergence of a new trend aimed at open and two-sided dialogue between science and society, some authors rushed to propose the dismissal of term ‘public understanding of science’ as “outmoded” and pointed at ‘science communication’ as more attractive alternative.[3] They argued that ‘public understanding of science’ rested upon old-fashioned concept about passive and ignorant society and benevolent science is no longer valid.

Currently, the replacement of the term ‘public understanding of science’ with more modern ‘science communication’ appears to be relevant for research purposes, but in practical application the separation of the two terms may be more desirable as long as public understanding is considered the objective of the process involving communication between science and the public. Therefore, the two terms may peacefully coexist and should not be seen as antagonistic. As communicative process evolved into what is known as ‘science communication’, the matter of understanding will remain one of the products of such interaction.

A short overview of the definition for ‘science communication’ illustrates how the subject of the present study is characterized by the scholars.

Most recently published studies[4] on the subject favor the neutral science communication as a term defining the two-way process of exchange of information

---

[1] “After the ‘Two Cultures’. Toward a ‘(Multi)cultural’ Practice of Science Communication”, by Jose van Dijck in *Science Communication*, 25 (2), 2003, p. 177-190.

[2] “A Guide To Effective Science Communication”, by Julian Cribb and Tjempaka Sari Hartomo (Melbourne: CSIRO Publishing, 2002), p. 15.

[3] Science and Society (Science and Technology Third Report), op. cit.; “After the ‘two cultures’. Toward a ‘(multi)cultural’ practice of science communication”, op. cit.

[4] “The Hands-On Guide For Science Communicators. A Step-By-Step Approach To Public Outreach”, by Lars Linberg Christensen (New York: Springer, 2007); “A Guide To Effective Science Communication”, op. cit.; “Science Communication In Theory And Practice”, op. cit.

between the two interested parties involved in interaction. In the words of Gregory and Miler (1998) "Communication is a process of negotiation: it is one of a mutual getting-to-know. Science communication is a process of generating new, mutually acceptable knowledge, attitudes and practices. It is a dynamic exchange, as disparate groups find a way of sharing a single message. Negotiation is a two-way process: if the public's needs are to be met, they must articulate what these needs are."[1]

Christensen (2007) defines the main function of science communication in the following way: "Popular science communication provides a bridge between the scientific community and the wider world, providing examples of the scientific method and success stories to the society at large and supporting the educational use of scientific products"[2].

Burns, Connor and Stocklmayer (2003) define science communication as the use of appropriate skills, media, activities and dialogue to produce one or more of the following personal responses to science[3]:

- Awareness, including familiarity with new aspects of science
- Enjoyment or other affective responses, e.g. appreciating science as entertainment or art
- Interest, as evidenced by voluntary involvement with science or its communication
- Opinions, the forming, reforming, or confirming of science related attitudes
- Understanding of science, its content, processes, and social factors

As a matter of fact, the neutral science communication definition became widely recognized in the literature for the process of communicative contact between science and the public. What more important is that science communication is developing as professional occupation involving certain education, skills and experience as may be concluded from the said definition provided above. As Treise and Weigold (2002) wittily put it, "the writings of science communication scholars suggest two dominant themes about science communication: it is important and it is not done well."[4]

The reasons for existing difficulties in embedding science communication into the structures of applied research organization are found to a certain extent in scientific culture understood as a historically formed phenomenon reflecting the character of a generic scientist who may fail to realize the necessity of communication with the lay public as the means for development of science in our age.

---

[1] "Science in Public: Communication, Culture and Credibility", op. cit., p. 247.

[2] "The Hands-On Guide For Science Communicators", op. cit., p. 3.

[3] "Science Communication: A Contemporary Definition", op. cit., p. 191.

[4] "Advancing Science Communication: A Survey of Science Communicators", by Debbie Treise and Michael F. Weigold in *Science Communication*, 23 (3), 2002, pp. 310-322.

3.2 Human Factor in Communication

Human civilization has come a long way in making technologies more complex, reaching a point where diversity and complexity of the accumulated knowledge allow us to create systems and products unimaginable even half a century ago. Endlessly improving models of cellular phones, notebooks, palm computers and other gadgets appear on the market and rapidly slip out of sight giving way to even more sophisticated devices.

Obviously, a large part of the innovations changed our life for the better, but the number of technologies which earned a safe market place with convenience of use may be relatively small. In the book *The Human Factor: Revolutionizing the Way People Live With Technology*[1] professor of engineering Kim Vicente describes an every-day example. A few years ago, Mercedes-Benz was offering a feature that lets the drivers check their oil electronically, from the driver's seat of *Mercedes-Benz E320* which seemed like a clever use of a technology. The driver did not have to leave the vehicle, pop the hood, find a rag to wipe the dipstick, lift it, reinsert the dipstick again, take a reading and reinsert it again. Electronically oil-checking from the driver's seat was supposed to solve the problem of fulfilling these innumerous operations. The problem with the innovative way of oil-checking was that its advantages in comparison with an old-fashioned way were far from being obvious for drivers. To check oil from the seat the driver had to fulfill (and remember) five operations: to turn the car off, wait for the oil to settle, turn the ignition two notches to the right, wait five seconds again and *within one second* press the odometer reset button twice. Memorizing steps appeared to be a difficult task for many.

Thus, the advantages of the innovative solution proposed by the E320 developers seem rather insignificant if compared to the old-fashioned traditional method of measurement which is barely more difficult in use than the implemented innovation. From technical point of view, the existence of such technology might be justified as a new step in improving car control functions, but from the viewpoint of usability there is no argument for its implementation because the importance of human factor in the course of creation of the technology was hardly taken into consideration. An average driver would rather check the oil as he used to do instead of memorizing the order of steps or looking up the manual for automatic oil check-up procedure sitting inside the vehicle.

Vicente asserts that the availability of ready-made technology and its positioning on the market is not a guarantee for successful interaction between customer and technology. Unfortunately, the illustrated example with oil check-up appears to be quite common in various aspects of living. Technologies are the reflection of our knowledge about the physical world and each technology is normally based on confidence in its reliability and rationality. However, a great number of technical solutions are too complex in use and most people find it difficult

[1] "The Human Factor: Revolutionizing the Way People Live with Technology", by Kim Vicente (New York: Routledge, 2004), p. 15.

to use. At times, accomplishing a simple task in everyday life involving the interaction between a human being and technology might fail. At best, it may cause irritation or, what is worse, lead to errors related to what known as "human factor".

An outstanding example of unsuccessful design or technical solution is when millions of people felt themselves confused at facing multiple options offered to customer in conversation with voice messaging system instead of conventional chat with human operator.[1] Not less painful procedure for some people is endless examining of a manual coming together with a new TV set or coffee making machine.

What seems to be an ordinary situation in everyday life resulting from the failure of rational contact between humans and technologies is another matter when it comes to industry where labor safety is a critical factor. Any lack of interaction and any malfunction of such kind may cause tragic consequences.

Shortly after the disaster at the Chernobyl Nuclear Power Plant, the International Nuclear Safety Advisory Group (INSAG) published a report titled "Summary Report on the Post-Accident Review on the Chernobyl Accident". It was submitted to a Vienna conference in 1986 putting the whole blame on improper actions of the plant personnel following the conclusion made by the Soviet experts involved into investigation.[2] More balanced assessment of the causes of disaster was presented in an update to the original INSAG report published in 1993. Critical reconsideration of the facts causing the accident carried out by a group of international experts led to official recognition that the human factor was not considered as a priority during the development of control and measurement devices responsible for displaying the data related to the conditions of reactor. Among other conclusions, it was stressed that the "type and amount of instrumentation as well as the control room layout made it difficult to detect unsafe reactor conditions".[3] Thousands of indicators on the control panel transmitted numerous data, but a lack of prioritized information and complexity of dynamics within the reactor left no chances for operators to realize the threat and to prevent further complications.

What lies beneath the surface of the situation when people lose control of machines? In opinion of Vicente, the causes of such situations have been originally laid into the foundation of principal organization of knowledge in the 17th century. Influenced by the ideas of René Descartes, the scientists involved in the process of organization of knowledge favored the reductionist approach. The concept of reductionism was introduced by Descartes in Part V of his *Discourse on Method* (first published in 1637), where he argued the world was like a machine, its pieces like clockwork mechanisms, and that the machine could be understood by taking its

---

[1] See "Things That Makes Us Smarter: Defending Human Attributes in the Machine", by Donald Norman (Cambridge, MA: Perseus Publishing, 1993), pp. 109-112.

[2] See "Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident", by International Nuclear Advisory Group (Safety Series No.75-INSAG-1, IAEA, Vienna 1986).

[3] INSAG-7, The Chernobyl Accident :Updating of INSAG-1 by International Nuclear Advisory Group (Safety Series No.75-INSAG-7, IAEA, Vienna 1992), p. 31.

pieces apart, studying them, and then putting them back together to see the larger picture.

This common approach influenced the formation of another intellectual phenomenon: a tendency to separate the knowledge into limited categories of disciplines – physics, chemistry, psychology, theology, etc. As a result, each discipline is determined to study the world from the viewpoint limited by the object of the research. On the one hand, they exist isolated from each other, but on the other contribute to the common bank of knowledge. In the past, such approach was perfectly justified and helped advancement of human knowledge and scientific thought. In our time, this specialization has some negative consequences summarized in an influential Rede Lecture of the British physicist and novelist C.P. Snow titled "The Two Cultures"[1] in 1959. Snow claimed that "intellectual life of the whole of western society is increasingly being split into two polar groups" – literally intellectuals and physical scientists. He identified a substantial gap between them and described them as two separate and even hostile cultures that live in different worlds and "have a curious distorted image of each other"[2].

At the time of delivering the speech, neither Snow, nor his opponents could not foresee the emergence of a variety of interdisciplinary fields of knowledge such as molecular biology or artificial intelligence, exceeding the boundaries of his bipolar concept of the scientific landscape severely criticized for radicalism and wide generalization. Nevertheless, one cannot dismiss the fact that it was Snow who was the first to emphasize and to discuss a significant issue of co-existence of the two different systems of views. Subsequently, his modernist concept of "two cultures" prompted the emergence of the trend known as "public understanding of science," which raised the issue of perception and understanding of science by the general public at the level of state interests.

Despite a considerable time distance separating the concept of Snow from today, his ideas are still valid in a new historical environment. A split which occurred within science notionally divided it into humanities and natural sciences as different realms of knowledge. While the humanities are focused on studying human aspects of the world, natural sciences are based on studying the universe via rules or laws of natural order and are ultimately aimed at creating technologies. For instance, human brain is in the focus of study conducted by specialists in cognitive psychology. However, this discipline does not study the *situations* occurring in the course of use of calculators, automobiles, computers and other devices by humans. In other words, the missing link is the understanding of communication between technology and human beings.[3] A similar situation occurs during the creation of an innovation product: its developers' primary concern is the product itself. It may be, for example, the capability of a device to compute as much information as possible or a strive for adding more new functions. Possible reactions from customers and simplicity of use are usually omitted from the list of priorities.

---

[1] "The Two Cultures", by C.P. Snow (Cambridge University Press, 1998), p. 3.

[2] Ibid., p. 4.

[3] See "Cognition in the Wild", by E. Hutchins (Cambridge, MA: MIT Press, 1995).

The authors of studies in science communication criticized the traditional approach to one-sided consideration of effects resulting from interaction between humans and machines maintained by conservative representatives of humanities and natural sciences. Many authors including Vicente argue that “Humanistic and Mechanistic world views rarely meet, as anyone who has ever set foot on a university campus knows. There are artsy Humanists and there are geeky technologists, and people tend to be educated to become one or the other”[1].

One should realize a conditional character of seemingly traditional categorization as in reality people and technology manage to *co-exist*. An ability to create technology and to be able to use is an integral part of human behavior. However, artificial and customary character of separation of scientific disciplines leads to ignoring the aspects of communications between human beings and ever increasing sophistication of technology. As humans and technology are examined not in direct connection, there is hardly a surprise that those responsible for developing innovations are people educated as natural scientists and those with background in humanities, not possessing any special knowledge, are not considered fit to contribute any useful ideas outside their specter of competence.

As a result of long-standing separation of different branches of knowledge, the technical systems developed on the basis of machine-centered approach are mostly focused on physical and mechanical properties of technology. The question how a particular technology would fit humans from psychological point of view is not always in the center of discussion and may be downplayed if additional costs are likely to arise.

The Industrial Age with mechanical technology as a sort of object of worship also heavily influenced the perception of technology as a praised value separated from humans. Norman notes that today’s “bias toward a machine-centered approach is subconscious, which makes it even more insidious: those who follow the machine-centered approach are unaware that they are doing so, simultaneously denying the claim and defending their methods as logical, obvious, and necessary”[2]. However, it should be emphasized that transition from Industrial Age to Post-Industrial Age manifested the appearance of new technologies which “shifted emphasis from trivial mechanisms as prostheses of human actions, to complex self-regulating systems as prostheses to *human intelligence*; from tools to be guided manually to systems to process information”.[3]

The difference between industrial and postindustrial periods is in the time spent for adaptation to a new technology. In the past, the process of advancement of technical knowledge developed relatively slow and people had sufficient time to get used to those products created without placing human factor among the priorities. In the last 20 years or so, the mankind found itself amidst an informational explosion

---

[1] “The Human Factor”, op. cit., p. 32.

[2] “Things That Makes Us Smarter”, op. cit., p. 9.

[3] “The Semantic Turn: A New Foundation for Design”, by Klaus Krippendorf (CRC Press 2006), p. 15.

when the markets offer increasingly sophisticated products replacing each other in fast succession.

Digital modeling allowed to speed up technical development and made it difficult for customers to keep the pace with growing capacities of devices. It might be seen as a certain paradox, but the strength of machine-centered approach is simultaneously its weakness as those engaged into creating innovations are often culpable of ignoring the needs of customer, because the level of education and technical experience possessed by an average customer is very much different from complex thinking of engineers and programmers with purely technical background.

The products created in the course of this technological race for ideas sometimes meet unfavorable response at the market and are labeled by the media as technological disasters coming under the fire of critics among experts and customers.[1]

Design Professor John Coliandro in an interview to *USA Today* identified three principle reasons for unsuccessful design of technology rejected by customers:[2]

- ignoring customer needs whose interests are not examined at all or such market study is conducted at the last stage of technology development
- designer's taste favoring installation of too many options as cheap electronics allow it
- as a rule, developing teams consist of the engineers responsible for know-how, market analysts responsible for market survey and, in very rare cases, human behavior specialists

All these seemingly different reasons have something in common: the issue of realizing the importance of each aspect of communication between human beings and technologies. So what is the difference between a technology customized for users and a technology imposing a necessity for users to get themselves adjusted to it? The author of *Non-Zero: The Logics of Human Destiny* Robert Wright described the model for development of innovations as chaotic. In his opinion, each innovation should undergo a path of natural selection among those most corresponding to human factor in order to deserve a right to be useful for customers: "Your brain may give birth to any technology but other brains will decide whether the technology thrives. The number of possible technologies is infinite and only few pass the test of affinity with human nature".[3]

---

[1] Michelle Kessler, "Designs That Made Consumers, Reviewers Cringe", *USA Today*, 31 December 2001; online edition, http://www.usatoday.com/money/retail/2001-12-31-review.htm (assessed 12 November 2007).

[2] Jim Hopkins, "When The Devil is in the Design", *USA Today*, 31 December 2001; online edition, http://www.usatoday.com/money/retail/2001-12-31-design.htm (assessed 12 November 2007).

[3] "Non-Zero: The Logic of Human Destiny", by Robert Wright (New York: Vintage Books, 2000), p. 27.

Examining the issue of communication between people and technology might require different approaches, but one unbeatable argument is that technical design should not be based purely on knowledge of physical world. The knowledge of human behavior must form a basis for broader understanding of product development. This process might be described as multidisciplinary, where "the goal is a technology that serves the user, where the technology fits the task and the complexity is that of the task and the complexity is of the task, not of the tool".[1]

Robert Logan, head of user interface design at *Thomson Consumer Electronics*, an international French electronics manufacturer and media services provider, developed a method called "the new R&D" based on multidisciplinary approach.[2] It requires communication between three groups of experts working on a product as shown below. Technical group consists of mechanic engineers, computer-aided design engineers and computer scientists, the humanists include ergonomists, marketers, physiologists and anthropologists, and artists group includes industrial and graphic designers, fine artists, photographers and new media designers.

Specialists	Technologists	Humanists	Artists
Research responsibilities	-track technological evolution -identify emerging technologies -identify synergies	-task analysis -ethnographic observation -usability testing -focus groups -participatory design	-track aesthetic evolution -identify emerging trends -research tools and techniques
Design responsibilities	-engineering to design translator -prototyping -specifications	-overall usability and ergonomics -mental models - research	-voice and personality -branding -aesthetic -bitmaps

Table 3: Multidisciplinary Approach in R&D (Robert Logan)

Emerged under the influence of global changes in science and society in the Age of Information, the pressing necessity to change the approach to technical design prompted comprehensive reconsideration of its organizational, disciplinary and research aspects in the works of scholars. Up until recent time, most of the studies on interaction of design and marketing considered the success of design from the viewpoint of its compliance with the following links of the marketing chain: product,

---

[1] "The Invisible Computer: Why Good Products Can Fail, The Personal Computer Is So Complex, And Information Appliances Are The Solution", by Donald Norman (Cambridge, MA: The MIT Press 1999), p. 67.

[2] "Research, Design and Business Strategy", by Robert Logan in *Design Management Journal*, Vol. 9, 1997, p. 35.

price, place and promotion[1]. In the last few years, this model was extended by four mandatory elements related to the prospective customer and his/her reaction to a given technology: context, connection, consumption and closure.[2]

Each of the said elements is directly bound to rational and emotional relationship with customer, his/her possible reaction to technology. Without examining all pros and cons in the context of relationship with the user, there is no chance to come up with successful design which fits customers' needs. If universally accepted, such approach would encourage confidence in a product of which "brand, packaging, environmental and information design work in harmony to provide a holistic experience of use".[3] The authors provides an excellent definition for modern design, assigning to it the role of communicator or "cultural intermediary" and "opportunistic entrepreneur" able to frame a technology in customer-oriented context.

The human factor should become an integral part of the designing process, including a variety of forms: physical, psychological, social, organizational and even political. Mechanistic approach to creating the technology does not lead to decreasing probability of human errors and cannot downplay its effect when such errors occur. Multidisciplinary approach to technology design based on the results obtained from effective science communication offers better solutions securing continuous interaction between developers and users, scientists and their customers. An assertion repeating in most works on modern design emphasizes that communication and study of user's needs have always influenced the design, but, contrary to the past, when both were omitted from designing process as mandatory elements, today they assume a leading role.

---

[1] "Marketing and Design Management", by Margarete Bruce and Rachel Cooper (International Thompson Business Press, 1997).

[2] "The Role of Design and Designers in the 21 Century", by Mike Press and Rachel Cooper (Ashgate Publishing, 2003), p. 124.

[3] Ibid., p. 123.

4. Instruments and Potential of Effective Communication

4.1 The Factors behind Development of Science Communication

A growing number of preconditions for increase of importance of communication in academic community and extending number of training programs serve as evidence of continuous development of science communication as distinguishable sector of knowledge and professional occupation. At the same time, the quality of science communication in research institutions falls short of the goals declared in public addresses and theoretical studies. Meanwhile, the actual role of communication in scientific environment is still to be defined and reassessed.

The most recent studies unequivocally place science communication in the center of interests of scientific community. Von Aretin and Wess (2005) assert that *today* it cannot be logically separated from the very community's existence: "Die Wissenschaftskommunikation ist heute aus der Scientific Community nicht mehr wegzudenken. In ihrem Rahmen werden aktuelle Informationen bereitgestellt, Medienbereiche lanciert, Kontakte zu Entscheidungsträgern und Meinungsbildern gepflegt, Publikationen veröffentlicht sowie vielfältige Veranstaltungen, Symposien, Initiativen oder Wettbewerbe durchgeführt. Sie soll auch die Forscher in die Dialoge mit der Öffentlichkeit integrieren and sie darauf vorbereiten."[1]

A document drafted by the UK Royal Society and designed for much more global strategy planning also emphasizes that science communication will be instrumental in:

- National prosperity (for example, a better trained workforce)
- Economic performance (for example, beneficial effect on innovation)
- Public policy (informing public decisions)
- Personal decisions (for example over tobacco, diet or vaccination)
- Everyday life (for example, understanding what goes on around us)
- Risk and uncertainty (concerning nuclear power or BSE)
- Contemporary thought and culture (science as a rich area of human inquiry and discovery)

Evidently, science communication went through a sort of legitimization and is widely recognized as an integral part of the initiatives of scientific community. However, a number of critical studies analyzing its current status in research institutions argue for a presence of certain setbacks in implementation of theoretical principles of science communication. The U.S.-based Research Roadmap Panel for Public Communication of Science and Technology in the Twenty-First Century was asked in 2001 to survey science communication activities at the scientific research

[1] "Wissenschaft erfolgreich kommunizieren", by Kerstin von Aretin and Günter Wess (Willey-VCH, 2005), p. 112.

institutions in the United States and abroad. It carried out an impressive research and came to certain conclusions including the following:

"The panel was struck overall by the general lack of intellectual rigor applied to science and technology communication activities, especially as contrasted with the very rigorous scientific environment in which this communication arises. Communication often remains an afterthought, a by product of scientific endeavour somehow removed from the scientific process itself and often funded by a different mechanism than the scientists who perform the research".[1]

The situation described in the panel's report of 2001 is largely persisting in various sectors of scientific community. The actual study does not purport to formulate a definite set of issues affecting the development of science communication in its new quality, but a variety of concepts will be analyzed shortly to give a taste of the issue. There are at least three principal groups of issues for consideration in the next sections:

- Development of scientific culture
- Need for dialog between scientists, journalists and public information officers
- Lack of research and institutional professionalizing

[1] "Communicating the Future: Report of the Research Roadmap Panel for Public Communication of Science and Technology in the Twenty-First Century," op. cit., pp. 196-197.

4.2 Development of Scientific Culture

Science may work miracles of technical advancement, explore the deepest depths of human psyche, push the boundaries of the bravest philosophical theories, but it itself will never cease to be an object of research, ranging from history of scientific thought to classification of academic disciplines to scientific trivia. The richness of the subject does not allow us to discern even the most significant fields of interest, but this great variety has something in common: a phenomenon known as scientific culture.

At first glance, it might be characterized solely as a set of values, practices, methods and attitudes based on the norms that exist within the scientific community.[1] Under such definition, scientific culture might be seen as having been formed within this community, serving as a code of ethics in professional relations between scientists. Some authors believed that this culture had gone a long way forming as a corporate behavioral code which is in some way incomprehensible to lay public reacting to it as a relict of what Leplin (1997) defined as "arrogance of disciplinary autonomy."[2]

The point easily overlooked in references to scientific culture is that any definition of such phenomenon would be incomplete and one-sided without realization of the role of society. It is true that scientists communicate effectively within their environment for the purposes of peer review, academic publications and discussion and this process could not be successful without a certain cultural framework.[3] However, decisive role of interaction between science and society should be stressed in definitions. In attempt to generate a universal definition for such multidimensional phenomenon Burns, O'Connor and Stocklmayer (2003) arrive to conclusion that "Science culture is an integrated societal value system that appreciates and promotes science, per se, and widespread scientific literacy, as important pursuits."[4]

Studying the ethos of modern science, Merton (1979) summarized four codes of scientific conduct[5]:

- universalism (commitment to discover universal truth)
- communism (commitment to sharing data and credit with colleagues)

---

1 "School Science and the Development of Scientific Culture: a Review of Contemporary Science Education in Africa," by Olugbemiro J. Jegede in *International Journal of Science Education* , 1997, Vol. 19 (1), pp. 1-20.

2 "A Novel Defense of Scientific Realism", by Jarrett Leplin (Oxford: Oxford University Press, 1997), p. 3.

3 "Wissenschaft erfolgreich kommunizieren", op. cit., p. 7.

4 "Science Communication: A Contemporary Definition," op. cit., p. 189.

5 "The Sociology of Science: An Episodic Memoir", by Robert K. Merton (Carbondale: Southern Illinois University Press, 1979), pp. 270 ff.

- disinterestedness (detachment from any single ideology and a willingness to follow data wherever it leads)
- skepticism (unwillingness to declare any perception to be true unless supported by empirical evidence)

It is evident that successful functioning of social mechanism built upon these principles is conditioned by specific scientific environment living according to internal standards and unwritten laws. In many ways, the principles of scientific culture contradict with the principles of human behavior in everyday life, where approximation, compromise and influence of public opinion rule the day. Some experts deliberately stress the differences between the moral of lay public and that of scientific community. Schaller and Crandall (2004) believe that "Scientists turn a relatively blind eye to matters of theft (e.g., the appropriation of one scientist's ideas by another without citation is typically treated as a trivial offense), but mete out unusually harsh punishments to peers who commit fraud (e.g., the falsification of empirical data)."[1]

The arrival of electronic communication tools and emergence of the Internet signaled not simply tremendously growing audience of lay public interested in science. The beginning of the age of information for scientific culture might be compared to arrival of Christopher Columbus's ships to the shores of America. Willingly or not, the authentic culture of the scientific world will have to go through a stage of transformation when the basics of communication with the public will have to be changed in accordance with requirements imposed by a new environment.

We may dismiss the conjecture that this new merger will replace such basic features pointed out in Merton's work as universalism and skepticism, but disinterestedness and communism might be subject to reconsideration. The term "communism" as understood in this context might be replaced with a broader notion embracing the ability to share knowledge not only with colleagues, but with the lay public. This new feature of scientific culture might be defined as *scientific communalism*, a term standing for a feature in scientific culture centered upon serving the interests of community. The term itself is not new as Merton used it and defined as "institutional conception of science as part of the public domain… linked with the imperative for communication of findings."[2]

If the said feature succeeds in establishing itself in the culture of science, it will hardly be possible without changing the attitude towards disinterestedness as broader exposure of scientific culture to the public will mean compromises. Early warning on possible consequences of wider exposure of science to public opinion is given by Nowotny (2005), who described the current status of public science as being under the assault of politics, markets and the law: "In actual controversies, the public nature of science may be contested. The charge is then raised that science is

---

[1] "The Psychological Foundations of Culture: An Introduction", by Mark Schaller, Christian S. Crandall (Lawrence Erlbaum Associates, 2004), p. 203.

[2] "Social Theory and Social Structure", by Robert K. Merton (Glencoe, Ill.: Free Press, 1957), pp. 556-558.

not public enough, because it does not sufficiently take the public interest into account as articulated and represented through the public that is engaged in the controversy." [1]

In the next decades, the relationship between scientific community and the public will be influenced by growing interest in transparency and safety of technologies as they increasingly penetrate in new spheres of human life. The more sophisticated devices, techniques and procedures come to the market, the greater is the area of common interests shared by the public and scientists. New technologies add to the growing number of public concerns and create a public demand in information from scientific circles. One of the recent examples among other public inquiry projects is the creation of the Link Mobile Telecommunications and Health Research Programme (MTHR) set up to look into the possible health impact of mobile telecommunications. The creation of such programs at the dawn of the telecommunication age was hardly conceivable and spared the scientific community from the necessity to prove their credentials. On the contrary, current trend in public attitude towards such problems as health and safety affected by scientific advancement is marked by obvious wish to facilitate a dialogue with industry and, consequently, with science.

Overwhelmed by the growing number of instances when societal needs should be fulfilled by communication about the science and technology, scientific culture found itself in a new transitional stage when even the greatest strongholds of scientific thought had to find their way to new thinking and forming a different type of academic culture.

The introduction of the Reengineering Project in the Massachusetts Institute of Technology (1993-1999) was aimed at promoting "social change in the sense of a new organizational world – a market-oriented workplace of self-empowered staff members who would fearlessly promote yet more change."[2] In other words, the management and the staff of the renowned research organization were given a daunting task of cutting annual operational expenses by $40 million U.S. Describing the effects of the reengineering on the faculty and staff, Williams (2006) notes that it aroused "considerable resistance" among the scientists who did not face any prospects for job loss, but perceived the project as a threat to "the MIT culture." Besides upsetting the balance of the organizational structure, the reengineering was seen by the employees as breaking their academic culture and demanding to be entrepreneurial. A frequently debated "resistance to change" is a proof of deep cultural controversies existing in the academic world resistant to a global shift.

Responding to increasing outside pressure, the National Aeronautics and Space Administration (NASA) embarked on a campaign of winning public approval

---

[1] "The Public Nature of Science Under Assault: Politics, Markets, Science and the Law", op. cit., p. 16.

[2] "The Unintended Consequences of Innovation: Change and Community at MIT", by Rosalind Williams in *Cultures of Technology and the Quest for Innovation*, ed. by Helga Nowotny (New York: Berghahn Books, 2006), p. 41.

of their activities and created in 1998 a panel which fixed their goals as described by Borchelt (2001)[1]:

- Informing consumers and citizens about scientific activities and products that may be useful in improving the quality of life
- Providing information for citizens to enable them to understand and participate in formation of public policies on specific issues
- Providing descriptions and explanations of scientific work

A quick analysis of these tasks may serve for proving a thesis that scientific culture is in the process of bridging a gap in establishing *public accountability* as scientists and researchers acquired a new role of "creators and managers of knowledge commodities". As active actors of commercial markets, scientists have to play in accordance with market rules because as Pickstone (2001) emphasized that "The promotion of business methods across the public sector, including universities, has created a culture of 'output', of knowledge as commodity." [2]

It is generally recognized by many researchers that cultural and public autonomy of science based on a privileged relationship of science to truth comes to an end when the society speaks back as noted by Nowotny (2005).[3] In such changing circumstances, the ethos embedded in scientific culture and ethics will inevitably pass through a major transformation, leading to emergence of new forms and methods for communicating the science to the public.

---

[1] "Communicating the Future: Report of the Research Roadmap Panel for Public Communication of Science and Technology in the Twenty-First Century," op. cit., pp. 196-197.

[2] "Ways of Knowing: A New History of Science, Technology, and Medicine", by John V. Pickstone (Chicago: University of Chicago Press, 2001), p. 195.

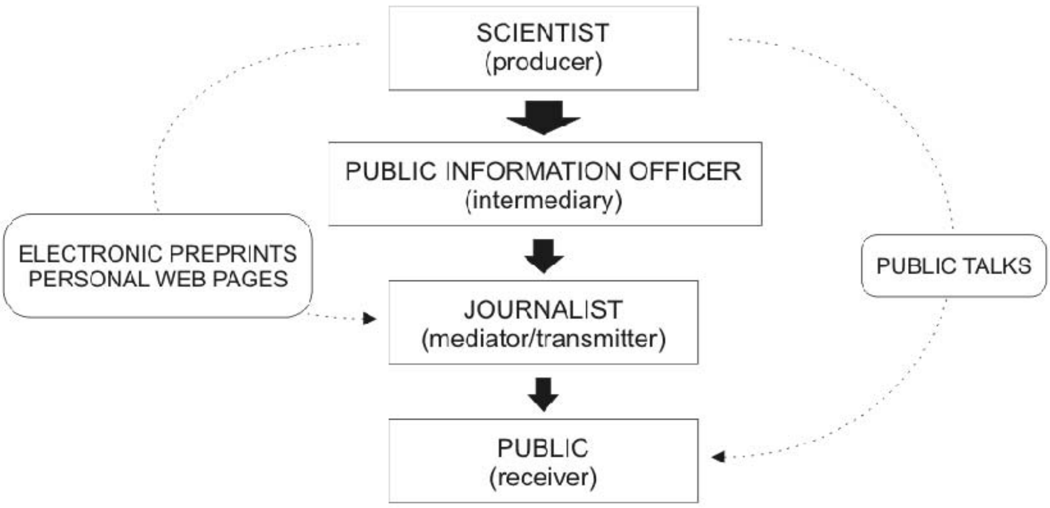
[3] "The Public Nature of Science Under Assault: Politics, Markets, Science and the Law", op. cit., p. 10.

4.3 Dialogue between Main Actors of Science Communication Process

One of the most important issues of public communication is a need for dialogue between the chief participants of the communication process:

- scientists
- journalists
- institutional public information officers (PIOs) or public relations officers, working in scientific institutions

Before the information based on the knowledge produced by scientists reaches the public, it should pass through two more participants of the communication process: journalists and institutional public officers. The model depicted below is named "linear" and based on a simple technical scheme "sender-transmitter-receiver" developed by engineers in 1940s. The linear model as recently presented by Christensen (2007)[1] identifies scientists and society as two opposite poles of communication zone where other participants are also might be given some roles (journalists and PIOs in this case).



Graph 1: Linear model (Credit: Lars Lindberg Christensen)

It should be noted that the linear model was criticized for excessive simplification of the process of communication. Some researchers observed that the linear model provides only for a general perception of the process, but it may "contribute little to an understanding of the complex communication systems in which scientists routinely engage".[2] In some cases the linear model proved to be ineffective. It happens, for example, when scientists contact journalists not relying on the advice of public information officers or when scientists deliver public lectures to

---

[1] "The Hands-on Guide for Science Communicators", op. cit., p. 8.

[2] "Science in Public: Communication, Culture and Credibility", op. cit., p. 87.

the lay public. Alternative models for news channeling are proposed in the works of Gregory and Miller (1998), and Madsen (2003).

Considering a more complex approach to the communication process, Christensen (2007), referring to the study of Madsen (2003), asserts that about 50 percent of the news related to science in European print media are based on the news releases published by scientific organizations. Therefore, one may conclude with a good rate of probability that a considerable portion of the science news reaches the recipients (general public) in accordance with the linear model.

The key issue of interaction between scientists, journalists and PIOs is that science communication as a process where all named groups are involved connects people with different social, cultural and educational background and those whose interests may lay far from each other. While professional assignments of journalists and PIOs might have much in common, the cooperation within such groups as scientists-journalists and/or scientists-PIOs may be hampered by controversy and misunderstanding. Thus, "scientists are frequently disappointed or angry about media coverage of their research, their fields or science generally. Journalists report frustration with the difficulties of describing and understanding important scientific findings and with the low levels of support provided by their news organizations for reporting on science news."[1]

On the one hand, science communication and its benefits are praised for ability to involve the professionals and working cultures historically based on completely different principles of work into a common process. On the other hand, scientists, journalists and PIOs continue to treat each other under the influence of stereotypes emerged as a result of differences in professional attitudes and cultures.

As Cribb and Hartomo (2002) put it: "To journalists, the scientific archetype is the wire-haired male boffin with the slightly-mad glint in the eye, the weird alembic and incomprehensible vocabulary. To the researcher, the stereotypical journalist is a wolverine, red in tooth and claw, jamming a foot in the lab door before ruining the scientist's reputation, before the scandalized gaze of the colleges and the world at large. Like all stereotypes, these fail the test of genuine experience yet is remarkable how many in both professions cling to them, especially those unacquainted with the other's world."[2]

The process of creating knowledge as primary objective on any scientific agenda requires more sophisticated mechanisms which should differ from simple tailoring in the interests of audiences – a task normally assigned to journalists and public information officers. Facing different professional targets, scientists, journalists and PIOs prefer to stick to varying and sometimes contradicting to each other concepts how scientific knowledge should be presented for the public. [3]

---

[1] "Advancing Science Communication", op. cit., pp. 310-322.

[2] "Sharing Knowledge. A Guide to Effective Science Communication", op. cit., p. 38.

[3] See "Sharing knowledge. A guide to Effective Science Communication", op. cit., p. 38; "The Hands-on Guide for Science Communicators", op. cit., p. 14.

In common view, scientists are knowledge makers: they are rational and treasure precise data, consider the methods of study, research process and all related details as very important, prefer to use technical definitions, value academic reputation and opinion of colleagues.

For journalists, science is an inexhaustible source for news, ear-catching and emotional. The journalists are hardly interested in details of technological process, but rather in impact on society caused by appearance of a new hi-tech gadget or another revelation from DNA study. Unlike those working in long-term scientific projects, they have to meet strict deadlines and prefer clichés and vernacular language to boring figures, common perception of an issue to highly specialized reports.

The role of public information officers which is discussed in details in one of the next chapters is ideally seen as an honest intermediary between scientists and journalists. Receiving scientific information from the scientists, a PIO has a chance to assess the potential of any piece of information to become a news release through careful selection of relevant facts and figures and keeping best possible balance between accuracy and cultural relevance for the media.

Although the role of each participant in this three-side communication seems to be quite clear and formally defined, conflicting interests and consequences should not be discarded. In November 2005, a group of experts conducted twelve qualitative open-ended in-depth interviews with public information officers from large U.S. and European governmental scientific institutions as well as scientists and journalists.[1] The issues of credibility in science communication became a focal point in this research.

As illustrated by quotations from the publication of study results, there is a few sectors of potential conflict and contradictions between these three professional occupations expressed in their own words and serving as primary source for researching such issues. The most acute issues might be defined as follows:

- Justification of science communication as important tool within scientific community

Dr. Bob Fosbury, Head of Space Telescope European Coordinating Facility in Munich: “Many astronomers live in their own crystal sphere and do not care about the outside world, which is a lack of social responsibility.”

Prof. Andre Heck, Astronomer at Strasbourg observatory in France: “Idealistic astronomers should be reminded about their social responsibility because the society has paid for their education and their salary is frequently covered by taxpayers money.”

[1] “Credibility of Science Communication: An Exploratory Study of Press Releases in Astronomy”, by Lars H. Nielsen, Nanna T. Jørgensen, et al. (Roskilde: University of Roskilde, 2005).

Dr. Robert Hurt, visualization scientist for the Spitzer Space Telescope, part of NASA's "Great Observatory" program: "If the science community looses credibility with the general public we face a significant danger of loss of interest and loss of ability of communicating important things they need to know."

Dirk Lorenzen, senior science reporter for German Public Radio and major newspapers, member of the executive board of the German Association of Science Journalists, Degree in astrophysics: "We need a shift in the attitude towards science communication – it is not only the problem of a PR people but also of the scientists."

Critical opinions of scientists with regard to importance of science communication collected in the course of interviewing support the thesis of ongoing reconsideration of communicative functions, although these opinions should not be seen as shared by the overwhelming majority of scientists. Stocklmayer, Gore and Bryant point out that "the idea that their science might be accessible to a lay public is still abhorrent to many western scientists who seek certainty and absolute truth."[1]

- Problem of realizing the benefits of media exposure

Lorenzen: "Good science communication has to appeal to the public and needs a human touch that most scientists don't like".

Govert Schilling, science correspondent, writes for Dutch, American and British magazines and newspapers such as "Science" and "New Scientist": "Scientists do not understand why it is important to make simplifications, but it is the simplification that helps you to get message across".

Megan Watzke, press officer of the Chandra X-ray Observatory, one of the NASA's great observatories: "If you want your story (scientific story) to make it into TV, you must have simple punch lines".

Catching attention of the mass media is another issue appearing in the cited case study which should be taken into consideration by any scholar if he wants to develop positive attitude towards science communication and counts on positive response from the press. One should realize that "in a nutshell, the simplified and easily digestible science news story – comprising a lead, body and tail – is the antithesis of the highly detailed and impenetrable scientific journal article."[2] Regardless their professional affiliation and the type of medium they represent, journalists work for their audiences within the boundaries of the laws of journalism based on intuitive search of sensations, stories appealing for human senses, and commonly accepted language. Due to a number of differences in approaches for pursuing professional goals, journalists and scientists encounter difficulties in understanding each other's working environment. Regretfully, acquaintance with the environment of their vis-à-vis happens after conflicting situations occur. However,

---

[1] "Science Communication in Theory and Practice", op. cit., p. xii.

[2] "Science Journalism: the Inside Story", by P. Spinks in *Science Communication in Theory and Practice*, op. cit., p.163.

the presence of a slightest perception about journalism and its environment in a scientist's mind and vice versa may help avoiding mutual distrust.

- Problem of combination of scientific accuracy and cultural relevance in the work of PIOs

Ray Willard, Public Information Manager for the Space Telescope Science Institute: "The scientist does not understand what the public comprehend and find interesting, and needs to accept what the public affairs professionals bring to the table".

Dr. Peter Edmonds, outreach scientist for the Chandra X-ray Observatory: "Good science communication is a compromise – it must remain accurate and interesting at the same time."

Megan Watzke, press officer of the Chandra X-ray Observatory: "You end up walking a line, because you want to be as interesting and provocative as possible without being wrong".

Acting as an intermediary between scientists and journalists, PIOs should be able to find a proper compromise when required. On the one hand, a PIO representing scientific organization defends its interests, but on the other hand he/she should not forget about the public interests. A news release written as scientific article may end up sitting in garbage can if it fails to make a story. Collaborating with scientists, PIOs should assess not only the accuracy of reports being submitted to the public, but also the combination of cultural references for public consumption of the information.

In summarizing the essence of issues related to the dialogue between scientific community and lay public facilitated by public information service, it may be noted that the boundaries of "crystal sphere" surrounding each interested party should not only be extended, but a certain extent of merger might be considered as beneficial. This requirement necessarily leads to re-evaluation of professional qualities relevant to position of PIOs as they should not act merely as a shuttle conveying information to media outlets. Their more important function at this stage of development of science communication in educating their partners in dialogue so that both sides in this informational exchange would recognize the values of the other and appreciate the efforts invested into both scientific research and media coverage.

4.4 Academic Research and Professionalism in Science Communication

Growing demand for qualified professionals in communicating science to the public cannot be presently satisfied for a number of reasons. The Research Roadmap Panel mentioned in the beginning of this chapter comes to conclusion that the degree of influence of institutional public information officers on setting up contacts between journalists, scientist and other audiences is not sufficiently studied. In 1995, Nelkin argued that 25 years ago those involved in science communication filled in positions mostly occasionally, although the current tendency is increasing numbers of professional science communicators.[1] Learning the skills of scientific communicators normally was on the job experience and prospects for professional advancement were rather limited. Starting from 2000, the appearance of graduate programs on science communication in UK, United States and Australia manifested the beginning of professionalization and created a basis for choosing science communication as professional occupation.

Despite the increasing number of educational programs in the United States and UK which have been created in the past five years, the degree of trust to science communicators within scientific community remains relatively low. In view of Christensen many scientific organizations in Europe have "not even reached a stage where communication efforts are evaluated rigorously."[2]

Germany and other European countries were slow in supporting science communication.[3] Some German experts insist on necessity of forming theoretical and research base for science communication: "In Deutschland fehlt eine wissenschaftliche Begleitung und Fundierung der Wissenschaftskomunikation. …Es wurden Erfahrungen gemacht in den letzten Jahren und es wurde bereits sehr viel ausgelöst. Jetzt ist es an der Zeit, dies wissenschaftlich zu reflektieren. Es gibt fast keine Forschung über Wissenschaftskommunikation. Auch Evalution gehört dazu. Es ist aber auch festzustellen, dass immer wieder die gleichen Leute auftauchen und auch, dass in Deutschland der Kreis der jenigen, die sich aktiv mit der Wissenschaftskommunikation auseinandersetzen, bspw. Teilnehmende an PUSH-Symposien, noch viel zu klein ist."[4]

---

[1] "Selling Science: How the Press Covers Science and Technology", by D. Nelkin (New York: Freeman 1995).

[2] "The Hands-on Guide for Science Communicators", op. cit., p. 174.

[3] "Public Communication of Science and Technology. German and European Perspectives", by Ekkehard Winter in *Science Communication*, 25(3), 2004, pp. 288-293.

[4] "Status Quo und Herausforderungen der Wissenschaftskommunikation in Deutschland: Bericht zur Expertenbefragung im Rahmen der Evalution des Jahrs der Technik 2004," by Melanie Borgmann and Cornelia Keller-Ebert (Köln, 2005), p. 91.

5. Expert Interviews

5.1 Introduction

Currently, science communication is in active phase of its development both as theoretical discipline and applied professional field. Unlike many traditional neighbor disciplines such as psychology, journalism, and public relations, science communication is not clearly perceived as a necessary tool for development of science at multinational level. The usage of marketing and public relations practices as effective tools for promoting products and boosting sales by commercial organizations is reasonably justified and clearly understandable. At the same time, the usage of science communication in scientific non-commercials institutions is largely dependent on acquiring research contracts from their partners in industry. Besides the purpose of building positive public image, it includes a sort of educational mission when achieving scientific literacy is also at stake. In this case, the size of the audience targeted by scientific communicators should inevitably grow, including new groups of interests.

This combination of educatory function of science communication and purely practical use of communication in order to receive funding, raising awareness of a scientific project, and attracting public interest, makes it, on the one hand, very distinctive field of knowledge, and, on the other, a volatile and probably controversial set of views. At first glance, the benefits of developing scientific communications at more professional level do not appear to be visible for everyone interested in the topic as its objectives within a given research organization may become a subject of hot debates.

Difficulties in understanding of science communication and its objectives are also related to the fact that communicative process and expected results depend to a certain extent on the specifics of a scientific institution and those in charge of it, on those who participate in the process, act as initiators and/or participants. A very wide range of organizations may act as originators of scientific communication process: industry lab, museum of science, planetarium, state-budgeted institutions for theoretical and applied research, universities, etc. All these institutions involved in daily science communications have a few things in common: they have to maintain a clearly-recognized public image which may become a decisive factor in winning not only funds but a certain portion of trust from the lay public becoming increasingly involved in scientific matters.

The combination of public relations campaign with elements of marketing and the methods of purely educational purpose may vary from one case to another. If a planetary may choose, for example, students as a potential audience of their communication initiatives, an applied-research institute will inevitably have to deal with the target groups representing those organizations which play the most significant role in forming the institute's budget by allocating state funds or placing research orders.

If science communication is defined as the process of two-way communication between a scientific institution and its target groups, on which such institution depends (government, industry, public, media), the success in building the strategy of such communication is largely related to the actions of two important groups, representing what is known as "human factor" in each case. The first is composed of those directly involved in fundamental decision-making process, their understanding of changing environment in which science is developing today, and their understanding of the importance of science communication. The second group is the people who communicate on daily basis – directly and constantly – the public communication/information officers employed by scientific organizations.

5.2 Objectives of the Expert Poll

The objectives of the expert poll conducted as a part of the present study might be summarized as follows:

- to prove the hypotheses presented in theoretical part of this work (Chapters 1, 2, 3, 4);
- to compare the opinions of decision-makers with regard to their understanding of the tasks of science communication and necessity of strategic development;
- to compare the opinions of the Fraunhofer executives and PIOs with those of other institutions concerning communication;
- to provide an overview of the most important issues and goals of science communication which may form a part of business strategy of a publicly funded applied-research institute;

Cribb and Hartomo (2002) asserted that "those who invest in knowledge generation ought to invest equally in the other phases of knowledge continuum"[1]. It necessarily means that the efforts put into creating innovations should match the efforts invested into communicating these innovations. However, any decision on distribution of such efforts is taken by those responsible for running a scientific institution. Therefore, the opinion of decision-makers with regard to forming the strategies of public communications seems to be crucial for this study since they act both as managers and scientists who represent the interests of scientific community on the whole. Another crucial opinion is that of the public information officers – the people in the very center of communication process who, nevertheless, are largely dependent on the decision-makers.

An offside remark should be made to exclude a question whether the managers of scientific organizations and public information officers are the sole participants of the multistage process of communication (see Section 4.3). Besides scientists and PIOs, the media plays one of the key roles and the factor of credibility in science communications was perfectly assessed by Nilsen, Jørgensen, et al. (2005) in a recently published online study[2]. Since we focused more on the methods of science communications in applied-research institutions, it appeared to be more

---

[1] "A Guide To Effective Science Communication", op. cit., p. 12.

[2] "Credibility of Science Communication: An Exploratory Study of Press Releases in Astronomy", op. cit..

consistent to conduct the poll with the two groups directly involved in this internal process, although it should be pointed out that the issues of communications with the media frequently appeared on the surface of discussions with poll participants.

5.3 Method of Qualitative Approach

The method of qualitative approach was selected for interviewing the experts because it provided us with better means of concentration on the opinions of the interviewees about in-depth specifics of communication in scientific organizations. This method also allowed to make comprehensive assessment of the issues concerning science communication, including personal attitudes of the interviewees to science communication, status of science communication in scientific and other organizations represented by the interviewees, and to discuss the most interesting points and details which could have hardly been revealed if quantitative method was used instead.

5.4 List of Discussed Issues

Each interview was based on a fixed list of questions (see Section 5.8) which was sent to each participant along with request for granting the interview. The questionnaire structure composed of predominantly open-type questions allowed to receive comprehensive and reasonably substantiated answers from each respondent. The following section includes the list of the most effectively discussed issues relevant to the objectives of the present study.

- The Essence of Science Communication
- New Approach to Representation of Scientific Knowledge
- Objectives of Science Communication
- Influence of Globalization
- External Communication
- Internal Communication
- Management Support and Understanding of the Objectives
- Instruments of Science Communication

5.5 Interviews and Interviewees

The interviews with nine participants of the poll have been conducted in November and December 2007. There were eight face-to-face interviews and one interview was conducted on the telephone.

The poll participants might be generally divided into two groups by their scope of responsibility and the type of expertise:

- Managers of reputable publicly-funded scientific organizations who are also scientists, and high officials of the state and/or industrial organizations directly involved into knowledge transfer and scientific communication by the nature of their job (decision-making process in research and development)

- Information officers working for applied and fundamental research institutions

It should be noted that the selection of the poll participants in the first group was not based on their extraordinary qualities as science communications experts. The limitations in making such choice arise from the fact that the qualities of successful manager of a scientific unit do not necessarily match the expertise in science communications. On the other hand, it would be incorrect to select the candidates whose opinions would help build idealistic picture of developing field of science communications as integral part of modern scientific community. A far more important target was to document the actual views of the participants on the role of science communication in publicly-financed institutions, their assessment of its potential and related issues.

Special credit should be given to the study supervisor, Prof. Dr. Michael Kröning, Director of the Fraunhofer Institute for Nondestructive Testing, who tremendously helped organize the interviews with the first group of the pollees. Given his vast experience on the matters of science communication, he kindly agreed to appear as one of the interviewees. A general set of criteria for selection of the first group included:

- significant experience in the sphere of applied science;
- professional affiliation with the organizations which serve as outlets for informational streams related to science communication;
- top managerial position within their organizations related to decision-making involving science, innovations, education, international cooperation;

The criteria for selection of participants of the poll in the second group were based on their excellent skills as science communicators and profound record of work in this field as well as the importance of the organization they work for in terms of its relevance to informational streams related to science communication.

The following table includes personal information on the participants of the expert poll in alphabetical order.

Name/Title	**Organization**	**Position**
Broeck, Renilde van den	European Organization for Nuclear Research (CERN), Geneve, Switzerland	Press Officer
Christensen, Lars Lindberg (Dr.)	Hubble European Space Agency Information Centre, Garching bei Munich, Germany	Press Officer/Head
Gillies, James (Dr.)	European Organization for Nuclear Research (CERN), Geneve, Switzerland	Press Officer

Heinz, Karsten	Federal Ministry of Education and Research (BMBF), Bonn, Germany	Senior Government Adviser
Kröning, Michael (Prof. Dr.)	Fraunhofer Institute for Nondestructive Testing, Saarbrücken, Germany	Director
Lehman, Ronald F. (Dr.)	Center for Global Security Research at Lawrence Livermore National Laboratory, California, U.S.	Director
Linneweber, Volker (Prof. Dr.)	University of Saarland, Saarbrücken, Germany	President
Miller, Franz	Fraunhofer Society Head Office, Munich, Germany	Press Office Head
Netzmann, Eckhard	Fraunhofer Society Curatorium, Berlin, Germany	Member

Table 4: List of Expert Poll Participants

Most of the interviews was conducted in English, while German was used for three interviews according to the preferences of the participants.

5.6 Expert Poll Analysis

5.6.1. The Essence of Science Communication

Providing an analysis of the state of science communication in various research institutions, Borchelt (2001) opposed it to public relations, branding, and marketing as "other pressures at work in scientific enterprise – commercialization, economic competition, and dwindling resources – are dictating the nature and scope of science communication…"[1] He argued that it might become inconsistent with the goals of educative function of science communication and that the methods of commercial promotion can hardly serve as replacement for "good science communication."

Taking into consideration the arguments presented in the current study, one may, however, argue that science communication should include both educational and market-oriented approach, not contradicting but supplementing each other. It was all the more crucial to find out the opinion of the interviewees with regard to this dilemma, whether PR and marketing are elements of science communication or one should strictly differentiate between those two.

[1] "Communicating the Future. Report on the Research Roadmap Panel for Public Communication of Science and Technology in the 21 century", op. cit., p. 209.

It was generally agreed that science communication is integral part in the work of any organization connected with science, but as conjectured each participant offered his/her own view for details of this issue.

Science communication historically emerged as a tool for filling in an informational vacuum existing between the public and scientific community and was originally designed for educational purposes. In some cases, it served the purpose of defending scientists and their activities from hostile and often unjustified attitude of different social groups developed under impression that science might be harmful to people. By educating the members of the lay public and maintaining contacts with mass media, science creates favorable public opinion and the educational element is and will be an important part of communicative agenda.

> [Broeck]: “Science communication means bringing across scientific topics to the lay people. For me, science communication is a philanthropic thing.”

> [Miller]: “Wir machen nicht Marketing, unsere Ziel ist nicht (F/E-Ergebnissen - *Author*) jetzt zu verkaufen, sondern damit Image zu machen. Ich will nur Bekanntheit erreichen”.

Growing commercialization of science, however, compelled scientific organizations to extend the boundaries of understanding its communicative mission because educative functions are no longer matching the agenda of their work.

> [Lehman]: “The point I would emphasize most about science communication is that it’s more than one direction. Often we think of science communication as a scientific community explaining to a non-scientific community the implications of its science. But in fact, often the science and technology community exist in a complex real world and need to understand that world better in order to understand what science and technology can do to contribute. We do a lot of science that works so wonderful in a laboratory but would have great difficulty working well out in the real world.”

Most participants in their assessment of science communication defined it as academic discipline and professional occupation where educational elements and market-oriented approach are merged into a new entity.

> [Kröning]: “Science communication is all what we communicate to the outside, including the market; we cannot exclude the market, for sure.”

> [Christensen]: “Science communication is a very broad thing. First of all, this is information about the results. Raising awareness of the organization, raising awareness of the organization’s goal. Some people, for example, the scientists could see this more as a PR, others, like management more – as an information task. You can label it in a different way. Marketing belongs also to this. If it not visible to your

> customers whether they get the product for free or they actually have to pay for it makes smaller difference."

According to Christensen, in terms of its educational value the public understanding of science still becomes "the highest, the purest goal and everyone agrees it is necessary."

> [Christensen]: "It is something difficult to get the funding for (…). It is very morally *defensive* to (promote - *Author*) education with science communication, when it is less looked upon the sales issues. But I think science communication is about it all. It depends on where you put the emphasis on."

Despite the recognition of necessity for advancement of market elements in science communication, many respondents were cautious with regard to excessive application of the market model which may undermine the credibility of scientific institutions.

> [Lehman]: "There are two great risks… in science communications, particularly, for publicly-funded institutions. The first is that if you become so promoted on selling yourselves that you're not being honest, you loose integrity. And the second is that if you're constantly chasing after social or political trends and not staying focused on science and technology. (…) The important part of science communications is staying within your limits of integrity and expertise."

Lehman made a brilliant comparison of a science manager obsessed with marketing and promotion to the hero of English folklore, the Vicar of Bray, who fundamentally changed his principles to remain in ecclesiastical office.

> [Lehman]: "If we become like the Vicar of Bray, constantly changing who we are, (…) we will loose our credibility."

If summarized, the meaning of science communication for the poll participants is embodied in changing nature of this discipline where elements of educational background are rapidly loosing ground under the pressure of globalization and commercialization to market tools aimed at better representation of research products, development of multinational scientific projects, and promoting positive image of research organization.

5.6.2. New Approach to Representation of Scientific Knowledge

The arguments discussed in Sections 2.1, 2.2, and 2.3 of this study meet verbal evidence collected in the course of the interviews. The experts agreed that scientific knowledge should be better represented.

> [Gillies]: "What makes science communication a topic on its own is that we are translating complex issues into the language understandable for the lay person."

Beyond any doubts, scientific knowledge has its own great value, but when supplied as a commercial product (please see Section 2.1) it often lacks what might be characterized as “attractive wrapping”. Kröning and Heinz defend this argument as follows:

> [Heinz]: “Today, the scientific presentation without modern look will fail. You have to sell a nice puppet. The new challenge in this sense is to entertain the audience.”
>
> [Kröning]: “When you consider science as a product you have to present it in a nice way so that everybody could understand and appreciate what you are presenting. Maybe some people will be impressed when you write long mathematical equations on the blackboard, but very often the audience doesn’t want to know the details, very often they want to know the effects, the impact of what you are presenting, the reasons why you present this, the features of what they can take advantage of.”

Linneweber is stressing that the attraction of financing often depends on the image of organization which is created in the process of communicating science.

> [Linneweber]: “Forschungsförderung ist nicht unmittelbar abhängig von Wissenschaftskommunikation, aber mittelbar schon. Wenn Sie ein Forschungsprojekt beantragen, wird das abhängig gemacht ob das läuft von der fachlichen Merkmal, aber wir wissen anderseits, dass das Renommee von unglaublichen Bedeutung ist. Deswegen wir müssen in positiver Weise mit unsere Ergebnisse angeben. Jeder möchte gerne in positiver Entität arbeiten. Wir müssen unseren Erfolg nicht verstecken”.

5.6.3. Objectives of Science Communication

As rightly stressed by Heinz, “science communication never exists for its own purpose. It always exists to make things better, faster, cheaper or to have a benchmark.” Discussing the meaning of science communication, the experts provided overview of the objectives which, in their opinion, may be achieved by means of effective communication. Their summarized opinion is presented in the following sub-sections:

- Winning the funding for research

The motivation of a scientific institution for reassessment and quality improvement of internal and external communication remains largely dependent on the fact that it serves as a powerful tool for winning funds, one of the principal preconditions for carrying out a research project. As a matter of fact, this statement is more valid in application to applied research organizations which rely on industrial and governmental contracts as one of the main sources for revenues.

> [Kröning]: “Winning the funding is essential for applied research. For it certainly you should do your best and part of that is science communication.”

Speaking of applied research institutes, some experts believe that the reduction of state funding and changes of basic conditions for running scientific organization are the most effective tools for increasing the status and role of communication in such types of organizations.

> [Netzmann]: “Die Tendenz heute ist eindeutlich, dass wissenschaftliche Erkenntnisse feilgeboten werden müssen, man muss sie darstellen und es wird immer mehr daran gearbeitet, weil möglicherweise auch staatliche Zuschüsse weniger werden”.

> [Linneweber] “We realize that universities and also major research institutions can not be financed only from the public funds, sponsors are becoming of relevance and sponsors only support institutions presenting themselves in a nice way. That’s why the emphasis on science communication is important”.

> [Heinz]: “Once you change one condition under which scientists work, it will automatically change the way they communicate. (…) If you have a contract limited to 2-3 years, you are in a completely different situation than if you had a long-term contract or life contract, it completely determines your thinking and view of the world”.

- Understanding and responding to the demands of different audiences: industry partners, media, government, lay people etc.

While market may stand as an abstract category, the audience behind it is composed of actual groups and each of them may be more or less sensible to particular tools of communication. It might be either booklet or news releases (Christensen) or presentation of a given technology for the public (Kröning), but the most important aspect of this two-way process is awareness of the market demands and flexibility in reacting to changing environment.

> [Christensen]: “It is very important to understand the demands of the market because if you give them a press release and they want a podcast it means you are failing in your objectives. The market can combine different things at different times of the year depending on your skill set at a given time.”

> [Christensen]: “It may be impractical to produce certain things… at this particular time and at a later time it might be some other products which would give you maximum, the optimized output for the amount of manpower and funding. So, flexibility and responding are the key words.”

> [Kröning]: "Effective responding to the market demands is also in the hands of science communication. To sense market demands, when you want to get industrial contracts, you have to know what they would like to get. When you don't sense the market demands what can you offer to the industry?"

- Encouraging the use of marketing tools in science communication

According to Christensen the role of science communication in practical application is developing "from education to the branding, PR and marketing aspects". At the same time he stressed that "in terms of science communication applied research has more of a marketing function, than (receiving) pure information".

> [Christensen]: "If we develop a strategy for an applied research institution we would be focusing on the different types of markets. Sort of focusing less on education, less on lay people, focusing more on paying customers, focusing more on industry, collaboration partners that we would have. We would be showing things in a slightly more polished way then we do now."

Kröning also marked the value of marketing but added that publicly funded institutions of applied research are still not prepared for integration of marketing into scientific environment and that "the marketing experts are not recognized in the scientific community."

- Facilitating Public Understanding of Science

Almost all interviewees supported the idea that increase in the quality of scientific literacy and educational activities leading to better public understanding of science is a worthy goal in itself. Kröning believes that the existing public opinion about a particular technology is formed in the circumstances when this technology is accepted or rejected by the market and is capable for "influencing the need for R&D in a specific sector". Thus, the public support for any scientific idea becomes a vital argument in decision-making related to R&D.

The power of public mandate for carrying out research and development is seen by the experts as a prerequisite for successful functioning of science.

> [Gillies]: "We are completely related on public funds. It is something like moral obligation to communicate back to those people who are paying taxes. (…) All of the evidence shows that it is always better being open, to communicate as openly and honestly and as you can."

The success in receiving such mandate is obviously dependent on the level of literacy dominating various strata of society and promotion of educational element in communicating science remains on the agenda.

> [Lehman]: "The pre-condition for greater scientific communications is not only the establishment and the process of communication, but the development of scientific literacy in the audience with which you're going to deal."

Speaking of difficulties in promoting scientific literacy, Christensen notes that long-term education projects leading to public understanding of science "is something which is difficult to get the funding for. Only those with very altruistic understanding of goal will fund people's changing perception of science. It is much more easier to win the funding if you promise the scientists that science communication, for example, will help win the funding for them."

- Attracting qualified professionals to research organizations

If decrease in the number of people choosing science as their professional occupation is considered a potentially negative tendency for national well-being, science communication may act as a tool for attracting young talented people to become researchers.

[Christensen]: "One known reason is to attract right type of personality to carry the core goals of the organization, this is just obvious. Without science communication there is nobody who knows about organization, you won't get people you need for the next decade to produce the excellence, create the growth or the revenue, whatever it is."

5.6.4. Influence of Globalization

The conjectures about the tangible influence of globalization on scientific institutions and the need for intensifying communication appearing in Sections 1.2 and 1.3 are supported and developed by the participants of the expert poll. They emphasized that the rapid movement of capitals and human resources and its increasing mobility shape the whole process as two-way.

Lehman described two patterns in the changing nature of globalization. The former pattern is characteristic of a model where talented people rushed to the "technology magnets", such as Silicon Valley in California, to fill in lucrative positions in dot-com companies, adding to the business values of there locations. However, the new pattern proves that things can move in the other way, too. Taking as an example the movement of human resources from India to Silicon Valley in the past, Lehman develops the concept of two-way globalization by describing this new pattern which emerged after the crisis of the dot-com bubble at stock markets when Indian IT programmers and engineers lost their jobs, but preferred to return home instead of looking for other opportunities of employment in the U.S.:

> [Lehman]: "They took the money back to India to invest in engineers and programmers and scientists in India! But they didn't go home simple to stay home. They kept headquarters or a major operation in Silicon Valley. So, now they're half-way around the world. They're true 24-hour companies with their contingent in California and

> contingent, say, in Bangalore or Hyderabad. (…) What has changed in globalization in the last ten years is probably that it's money and talent moving both directions in the much more flexible way. (…) It's the beginning of the more balanced two-way globalization."

As a result, globalization turns science communication into the tool of outsourcing. The more mobile and rapid the movement of talent and capital, the more important the communication is.

One of the gravest issues for publicly-funded scientific organizations is that they are compelled to compete at information market not only with each other, but with business companies where investments into public relation/marketing are much higher.

> [Christensen]: "It is a competition in a global media market place where often other players are big commercial companies ... (…) They can do so much more with that type of financial backing that they have a completely different level that you see in science communication."

[Miller]: "PR ist ein Kampf um die Aufmerksamkeit der Menschen. Dieser Kampf ist härter geworden. Vor 10-15 Jahren könnte man noch leichter Aufmerksamkeit gewinnen. Heute sind die Medien sind sehr stark vom Bild, von Emotionalität, von Personalisierung geprägt. Die Werbung ist sehr aggressiv geworden. Das wirkt sich auch auf andere Bereiche aus, auch auf die Forschungs-PR. Es ist für die Forschungs-PR schwieriger geworden, sich durchzusetzen. Früher war es leichter. Vor 10-15 Jahren, wurde eine gute Pressemitteilung überall dankend angenommen."

5.6.5. External Communication

- Science – Industry Communication

It is known that the transfer of technology into industry is one of the most effective ways for science, and applied science in particular, to implement the innovations developed in laboratories. At first glance, industry and science, the areas with high concentration of resources and knowledge, are mutually dependant and should be capable of better understanding of each other's needs. On the contrary, communication conflicts between these two are typical and are related to the search of compromise between excellence and relevance in research, produced by the scientific institutions.

Moving on a long course of looking for innovations of the best quality, scientists sometimes neglect the appeals of industry for effective and feasible solutions. In many cases, industry looks not for outstanding quality, but for the solution where the balance of quality, costs and customizable features would help conquer the market.

Describing his personal experience with the failure of external communication, Lehman takes an example of a Cincinnati-based company (U.S.) which approached an industrial lab with request to help improve the quality of their equipment. It was brought to the lab and was inspected by the scientists, whose verdict was that the technical solution was very poor. The inspecting team offered a set of ground-breaking improvements which were rejected by the company to dismay of the scientists:

> [Lehman]: "It was one of those culture shock things. Our guys couldn't believe how dumb this company was. (…) They thought we were absolute idiots. Because our fixes were so expensive, so unusable in the commercial market that we had no idea what their world is like."

He described the situation of the failed communication as "a form of science communications in which you had two really excellent groups of people with very different worlds, and we were trying to figure out how to communicate between the two, because they obviously did not understand each other's problems."

Netzmann made some more valuable comments in support of the thesis formulated by Lehman:

> [Netzmann]: "Ja, es gibt eine solche Diskrepanz zwischen der persönlichen Einschätzung und der Relevanz am realen Markt. Weil natürlich der Wissenschaftler, der eine klare Aufgabenstellung von der Industrie hat, immer sein Ergebnis als ein in sich gekapselt sehen wird und ihm deshalb eine höhere Bedeutung beimißt als z. B. ich als Endbenutzer aus der Industrie".

➢ Science – Media Communication

The roots of the difficulties experienced by many scientists when communicating their science to the media and fearing horrible distortions committed by journalists who rarely have technical education and/or background are to be sought in natural psychological differences dominating the spheres of their professional activities.

Assessing their chances for improvement of relevant qualities, Heinz thinks that "the best combination is when scientists combine excellence in research and communication". There are few individuals in each scientific community able to transform complicated ideas into something ready for media consumption, but this perfect balance of research talent and communicative skills is rather an exception.

Stocklmayer, Gore and Bryant (2001) trust that the reasons for the lack of communicative skills among scientists are to be found in the very nature of scientific community as the scientists "grew up in a world of certainties, entrained into science at an early age, secure in the knowledge that there were facts to be discovered and that, once discovered, these facts would immediately be accepted by the public." They continue by arguing that scientists do not reject the fact that science communication might useful, but they spend years to become experts in a given field and "find it difficult to imagine that it can be understood by someone who has not put in the same effort."[1]

Being highly intellectual people, scientists admit that communication of their achievements might serve positive purposes, but they attempt to avoid contacts with the media to prevent unpleasant consequences.

> [Broeck]: "Scientists still have this kind of contempt for the media, they can not accept it. They can contact with the media but they easily become frustrated."

As a result, the information supplied by scientists and appearing in the digested format may seem unacceptable for the members of scientific community.

> [Broeck]: "Scientists consider communication as something which really does make sense but they awfully don't like the end product in the media. Scientists have so much to say, often very difficult things to explain and for them to see their science in a format which is very popular, on radio or TV, to see the difficult work of 10 years reduced to a couple of sentences or simple 500-words article is sometimes a big shock."

Some authors also point out that in the scientific community it is often considered to be unserious and not modest when scientists put emphasis not only on research but also on communication of the research results to the lay public. Linneweber believes that fighting this stereotype is one of the tasks of science communication:

> [Linneweber]: "Es gibt keine Korrelation zwischen öffentliche Bekanntheit einer Person und seiner Reputation im Fach. Und das ist eine Sache, mit der die Wissenschaftskommunikation zu kämpfen hat, weil sie für die öffentliche Reputation sorgt und nicht für die Fach-Reputation."

Miller also pointed out that despite the fact that science in Germany has been relatively successful in avoiding the ferocity of criticism since 1990s and that the public realized the benefits of understanding instead of criticizing, German scientists still feel themselves uncomfortable in dealing with the press inclined to simplifications.

On the other hand, Gillies notes that "scientists are becoming more and more realistic in terms of what is possible and what is not. Especially the younger generations of scientists on the whole are becoming more and more enthusiastic about communication, understanding what to do so that audiences understand them."

---

[1] "Science Communication in Theory and Practice", op. cit, p. xii.

- Science – Government Communication

Normally relying on governmental financing to a greater or lesser extent, scientific institutions frequently face the situation where the approval of a project application and subsequent funding strongly depend on the ability to compete with other organizations seeking the funds. Cribb and Hartomo (2002) stress that "the key to an effective partnership between science and politics is for scientists and their managers to develop a better insight into the way the political mind and process works, and then deliver their research findings according to its needs."[1]

A survey conducted among Australian politicians[2] in 2001 revealed that only 14% of the Members of Parliament consider the results of communication with scientists as successful. 42% assessed these regular contacts as neutral, and 40% as unsuccessful. Among the reasons of unsuccessful communication with scientists the following were mentioned:

- Inconclusive data on benefits vs. costs (projects)
- Lack of personal contacts
- A belief shared by scientists that the government should provide funds
- Poor communication of scientific ideas in the media

On the one hand, the interviewees confirm this opinion appealing for importance of understanding the interest of the government:

> [Heinz]: "Pursuing a scientific career nowadays (…), you have to speak the language of your partners no matter how difficult it might be. You have to speak the language of the industry, you have to speak the language of the media, and the language of the bureaucrats, because our language is different from the language the scientists got used to."

> [Kröning]: "Maybe it is even more important than the scientific quality, when you can communicate what you are doing in the right way. (…) Very often those writing project proposal, for example for the government don't think about finding the right wording so that people reading it, evaluating it could be satisfied. That's also a skill of science communication – just to imagine what is this person thinking, what does this person want to hear."

At the same time, the lack of scientific and technical literacy among state officials might prevent even the most successful science communicator from reaching her/his goal.

---

[1] "Sharing Knowledge. A Guide to Effective Science Communication", op. cit, p. 68.

[2] "Expectations for Science: Survey of Federal and State Politicians", by Market Attitude Research Services (Sydney, 2001).

> [Lehman]: "I would argue (…) that one of our problems is that particularly in governments but also in many segments of industry, there is not a lot of technical literacy. (…) I think that's a significant problem. I think it's worse in governments. They often don't understand. (…) One of the communications problem is that things change so rapidly and the language is so complex and difficult that it's hard for policy-makers in governments to stay up the speed."

5.6.6. Internal Communication

➢ Scientist to PIO Communication

Due to peculiarities of scientific culture being closed by its nature (see Section 4.2) and differences in professional occupations of scientists and PIOs (Section 4.3), the issues of communication occurring in scientific institutions while contacting external target audiences, as described in the case study (Chapter 6), also affect the situation at internal level. The experts praised the role of PIOs in facilitating the two-way communication between PIOs and scientists within research organizations.

> [Christensen]: "Internal communication is also something which is overlooked in scientific institutions. As a public information officer you need to have your internal links, strengthened through internal communication. The employees in your organization need to have a certain instinctive knowledge that they can go to your office and have answers or assistance. It should be a win-win situation when they bring good ease to you, you will bring the ease to them."

As noted above, one of the most difficult objectives on the agenda of PIOs is the search for the right balance between scientific accuracy and cultural relevance. In actual practice, the search for such compromise often leads to controversies involving both parties. The information officers are largely dependant on scientists with regard to creating an information product. Normally, the latter have greater expertise in the subject and are particularly sensible to inaccuracies. All public information officers participating in the poll (Miller, Gillies, van den Broeck, Christensen) insisted on maintaining continuous dialogue with scientists, involving discussions over the most difficult sections which may happen at any stage of the product development, for instance, at editing texts of newsletters and writing press releases.

At the same time, PIOs noted that some degree of insistence should be applied on their behalf to avoid the loss of original targets and noncompliance with the strategy of science communication.

> [Christensen]: "If you have an overall goal in science communication, like a web-page, everyone should respect that this goal should not be lost off side, in bureaucratic means, in power struggles between different groups."

The degree of authority exercised by a PIO is directly related to the degree of appreciation of science communication in the scientific institutions. Answering the questions during the poll, the officers regretted the lack of appreciation of their work expressed, for example, in insufficient financing.

> [Miller]: "Es ist nach wie vor so, dass die Wissenschaftseinrichtungen sagen: Unsere Aufgabe ist Wissenschaft. Wir stellen Wissenschaftler ein, dann brauchen wir noch ein bisschen Verwaltung, aber PR (…) Es ist schon sehr ärgerlich, ich habe nur so viele Stellen und jetzt muss ich eine dafür PR opfern. So betrachten die Wissenschaftler das."

> [Gillies]: "Within this organization we have a budget of 70 million. It is a big budget but all goes into research. Anything which is not research is squeezed. Taking some away from research for anything else (i.e. PR, - *Author*) is still regretful sometimes. We have to fight that."

> [Christensen]: "What people complain most is the lack of funding. You need to have the funding for those highly skilled professionals to work in a science communication office. That is still lacking a lot in Europe, the recognition of profession is still not quite there."

The appreciation of the efforts on managing science communication is also related to the level of professionalism of the officers. Some experts, especially those in charge of research organizations expressed their disappointment over the lack of professional skills (Lehman) and warned about a sort of brain-drain resulting from competition with more powerful commercial organizations (Kröning).

> [Lehman]: "The public information officers are (…) not always so polished in either writing or speaking or their ability to understand the concepts and make them simple. I think it's actually a very serious problem."

> [Kröning]: "Concerning the lack of professional attitude; there are professionals but the public institutes cannot hire the best – they can earn much more in the industry."

- Scientist to Scientist Communication

According to Linneweber:

> [Linneweber]: "Wissenschaftskommunikation ist nicht nur die Brücke zwischen Experten und Laien, aber zwischen Experten und Experten aus unterschiedlichen Gebiete. Hier brauchen wir Toleranz und die Bereitschaft diese Unterschiedlichkeiten zu akzeptieren".

The application of public relations instruments is capable of influencing and shaping internal culture of communication between the employees of research organizations. This function of public relations is difficult to formalize as it belongs to long-term objectives and partially exceeds the business area affected by marketing and PR. Nevertheless, the public relations tools might be particularly effective in directing corporate activities, organizing workshops and training sessions, and serving as an intermediary between various social groups inside and outside research institution.

> [Kröning]: The worst enemy of a scientist is his neighbor. Because scientists are often vain by nature they don't invite their colleges to share, to discuss, but the paradox is that great ideas are created by exchange of ideas. When you are busy with a certain scientific problem for a long time, you create barriers of thinking in your head which you can hardly overcome. You need another fresh type of thinking which can make you free from these 'walls' inside of your mind. For that reason you need a dynamic exchange of ideas. Usually the scientific institutes try to overcome these barriers organizing internal formal meetings. We need instruments not only for formalization of these procedures but also – as a task of science communication – to make scientists talk with each other on their own behalf."

- Other Aspects of Communication

All participants of the poll engaged into public information management think that besides their function of mediators between scientists and external audiences, they have to hold media relation trainings for scientists.

> [Gillies]: "We are communicating complex science in a way the people understand. Another part of it is how to train scientists to answer the questions about the universe."

> [Miller]: "Wir wollen die Wissenschaftler von Anfang an daran gewöhnen, dass sie in den Medien verständlich und klar reden können. Deswegen machen wir Schulungen, wir üben mit den Wissenschaftlern."

Positive experience of involvement of a PIO into strategic projects such as *European PR-Office for NASA/ESA Hubble Space Telescope*, is represented in the poll by Christensen, who is simultaneously a member of the International Astronomical Union press office and is actively involved into different projects, for instance, the International Year of Astronomy, stating as one of its objectives increasing scientific awareness among the general public through the communication of scientific results in astronomy.

Active participation in the large communication projects helps forming positive public image of the organization employing the expert and influences the formulation of long-terms objectives of science communication within the sphere of science promoted by expert's work. A particularly impressing achievement of the *European PR-Office for NASA/ESA Hubble Space Telescope* headed by Christensen, which may serve as a model for many other PR departments of European scientific organizations, is the self-identification as an operating unit, which includes clear understanding of its mission, objectives of communication and prospects for development within the framework of the NASA/ESA Hubble Space Telescope Project. The mission and objectives are described with distinctive precision, including among others the following functions:[1]

- to maintain its position as one of the world's science communication powerhouses especially within the areas of visual science communication and innovative information management.
- to serve the community of astronomers, journalists, teachers and laypeople with the best possible science communication products, as efficiently as possible, and adapt our strategies to suit the needs of the target group whenever needed.

Objectives, development strategy, vision of the role in raising public awareness of the Hubble project, achievements of the department in promoting innovative approaches to science communication, for example, web maintenance strategy, are accessible at the project's website in details. At such approach, any visitor, either student, journalist or scientist, interested into cooperation will be able to receive the information not only concerning the current projects and its benchmarks, but also about the people engaged into communicating the outstanding results of this research to the public.

It should be particularly noted that in contrast to traditional commercial PR in large industrial companies where public relations officers, marketing and advertisement experts are given far more influential role to keep the company's high profile at the market, those engaged into public communications in scientific organizations, heavily relying on state funding and largely independent of communication quality, are normally overshadowed by the discoveries of their colleagues – researchers. If this observation is taken into consideration, it would be probably correct to conjecture that the perception of their mission and pivotal role in communicating science to the public should enable the communicators to strengthen their professional status and to increase the level of transparency of a scientific organization.

5.6.7. Management Support and Understanding of the Objectives

Professionalization of science communication and reconsideration of its place within a research organization are still in the process of dynamic development as noted in the report on the Research Roadmap Panel for Public Communication of Science and Technology which made an interesting observation that it is a current practice that public affairs or communication executives may belong to one of the few non-Ph.D. top managers who ideally should report to the head of the

---

[1] "The European Homepage For The NASA/ESA Hubble Space Telescope – Internal. Vision, Mission, Goals & Deliverables." Retrieved February 2, 2008, from http://www.spacetelescope.org/about_us/heic/mission.html.

organization to speak with authority.[1] Since public relations is one of the professional occupations which often requires quickness of decision-making and flexibility, especially under stress circumstances, the supervisors responsible for this business unit should be given definite opportunity to discuss all matters with chief executives at earliest convenience. The poll participants stressed the importance of executive support and availability of effective channels for communication with the top management, including the delegation of authority for direct contacts and board discussions.

> [Gillies]: "I think it is very important that we have a direct line with the senior management."

> [Christensen]: "It is absolutely important to have this direct connection to the supervisor. Things run on a time scale of minutes. Sometimes it should be very quick turn-around to management. If your manager is travelling all the time, inaccessible or sitting in another country it is not a big problem, today we have internet, phone and Skype but in reality it does influence a lot. (…) So, we emphasize that we need a completely efficient operation with some degree of autonomy and strong support from the management."

5.6.8. Instruments of Science Communication

➢ Innovative Tools

Overwhelming majority of the poll participants admitted that they use a wide range of instruments and tools of science communication for pursuing professional objectives. It includes mostly traditional methods such as news releases, press kits, booklets, and other means which form the basis of public relations practices. Strikingly new opportunities are offered by the use of the Internet. The experts described the following items as most effective and innovative means of electronic communications available for PIOs:

- video releases
- subscription for exclusive information via websites
- podcasts
- e-commerce/merchandizing

➢ Blogging

Gaining in popularity Internet blogs make substantial contribution to science communication. There is a number of specialized blogs primarily focused on communication of science to the lay public in easily understandable form.

---

[1] "Communicating the Future: Report of the Research Roadmap Panel for Public Communication of Science and Technology in the Twenty-First Century," op. cit., p. 206.

A particular type of blogs which serve as an outstanding example of innovative methods is the ones whose authors are the employees of scientific organizations. CERN public information officers, Gillies and Broeck, admitted that in their daily work besides monitoring mainstream press they have to monitor blogs because a lot of the CERN employees are running their own blogs.

> [Gillies]: "The reason we are doing this is that we are getting feedback from the journalists who read something on the blog. In the mainstream media there is some kind of quality control in terms of editorial process but in the blogs there isn't any, sometimes there is a lot of pure fiction."

Gillies and Broeck also marked an interesting fact. Normally, prior to the publication, a scientific paper follows a clearly defined path. First, the collaboration should be agreed on paper, then the peer review is carried out. After the completion of these procedures the article is accepted and published in a scientific journal with a chance being picked up by the media. In 2006, two CERN collaborators on the same scientific project discussed the preliminary results of their research in the blogs. A journalist who visited the blogs wrote a story which subsequently appeared in *New Scientist Magazine*, missing the whole peer review process and failing to negotiate any approval from the CERN PIOs.

> [Broeck]: "So we just try to keep an eye on blogs, to be ahead of it. I think blogging is trend now and I'm convinced that in the future more and more scientific discoveries will be coming to the media directly."

Thus, on the one hand, the blogs as fully independent form of electronic publishing are making the task of PIOs in controlling information more difficult, but on the other hand, as Broeck puts it they offer "extremely good feedback which let us sense what's going on within the organization."

- Role of Statistics

The assessment of influence of science communication on the targeted audiences is difficult to measure in case of printed media, but the electronic outlets provide more opportunities.

[Christensen]: "Sometimes the scientists respond very well if you can put a graph in front of them and say: we do certain things in certain way because of the factors which are illustrated in a graph. If you show them the numbers of people you can reach with the given product, it is easier to convince them".

The experts described the following effective ways of collecting statistics, which help evaluate the results of communication:

- Search engine ratings
- Statistics related to RSS (Really Simple Syndication) feeds
- Website visitor logging

- News subscription and distribution

5.7 Conclusions

Returning to the objectives of the interviews, a set of closing remarks is given below as a result of analysis.

The first objective was to prove the hypotheses developed in the previous parts of this study (Chapters 1-4) and the interview analysis allows to make a conclusion that the opinions collected in the course of the poll justify the principal conjectures put forward in earlier parts. Thanks to the mixture of factors, including globalization as the strongest socio-economic and political tendency, science communication is turning into an instrument of two-sided dialogue between scientific community and civil society, slowly departing from the original concept of education and bridging a gap between the two.

The poll results prove that the development of basic strategy of communication largely depends on the status of a given organization and may employ a wide range of instruments from educational initiatives to public relations activities to outsourcing and marketing. The experts positively reacted to the hypothesis about the necessity of development of a new approach to the representation of scientific knowledge and to communication strategy on the whole.

The basic features of the new approach to science communication might be summarized as follows:

- Search for a balance in combination of long-term strategical objectives (public education for better understanding of science, initiatives for increasing scientific literacy, efficient human resources policy for increasing professionalism) and tactical objectives (forming positive public image with PR methods, securing finance packages, industrial orders).
- Combination of cultural relevance and scientific accuracy in the process of communication.
- Participation of PIOs not only in external communication, but also in the processes of forming new elements of scientific culture within organizations. A special role in the communication strategy of the applied-research institutes should be assigned to the contacts with industry and governmental agencies authorizing financing packages because the lack of understanding of each others' needs appears, in the opinion of experts, quite frequently.
- Self-identification of Communication Departments; increasing the level of transparency in the communication strategies developed by such departments; emphasis on the importance of PIOs in the dialogue between science and society; positioning Communication Departments as independent units authorized to take part in executive decisions and to have their own budgets.
- Sufficient support of Communication Departments at the executive level.

- Encouragement of dialogue between the participants of communication process (PIOs, government, media, industry, lay public, etc.) by means of trainings, workshops and other interactive meetings.
- Extension of the number of web-related communication tools (content management applications, video releases, podcasts, blogs, forums, e-commerce, and others); analysis of web-related communication statistics as a tool for assessment of effectiveness of communication strategy).

The second objective of the poll was formulated as analysis and comparison of the opinions of the decision-makers and PIOs with regard to the issues discussed in the questionnaire.

Although the executives are usually not involved into daily communication of science and their working schedules are quite tight, we observed high level of competence and genuine interest to the issues of science communication expressed by top managers during the interviews. As a sign of changing nature of science communication, the discussion of the definition and meaning of this term normally preceded the interviews conducted with the executive group. The differences in the opinion of the decision-makers concerning its place and role perfectly reflect the viewpoint that science communication, as academic discipline and professional occupation in Germany, for instance, is in the transition process and still has to find its niche unlike many related disciplines.

Analyzing the degree of understanding of goals and objectives of science communication by public information department of the Fraunhofer headquarters and comparing it with the opinion of their colleagues working for CERN and NASA/ESA Hubble Space Telescope project and their methods of work, we anticipated more active involvement into science communication on behalf of the Fraunhofer Society as a network of applied research institutes whose scientific achievements stand closer to practical application. Therefore, it would have been plausible to conjecture that the results of applied research may be communicated more effectively than the concepts developed by fundamental studies. However, the analysis of the interviews proves that the approach to science communication at basic-research organization is distinctive for better understanding of the goals of science communication, development strategy and creativity, and higher level of development of communication culture.

One may conjecture that such state of things are necessarily related to a greater exposure of CERN and Hubble Project to internationalization. As traditional international organizations sharing democratic internal culture of communication which has been forming for decades, and as the institutions originally designed for international cooperation maintaining contacts all over the world, they have already found their way to advance to a higher level of science communication.

The last but not least objective of the poll was the formulation of the principal goals of science communication in practical application for applied research institutions which may be defined as follows:

winning the funding for research;

understanding and responding to the demands of market participants: industry, partners, media, government, lay people;

encouraging the use of marketing tools in science communication;

facilitating public understanding of science;

attracting qualified professionals to research organizations;

A particularly important observation was made by the poll participants with regard to the nature of science communication as symbiosis of elements of scientific research, public relations, and marketing, serving as intermediary between the interests of scientific community and other interested parties. All the named elements, although being not present *per se* in a communication strategy of research organization, constitute the basis for such communication. Needless to say, the use of marketing elements in non-profit organizations searching for extension of their present status is hampered by legal regulations and other obstacles.

Therefore, the assertion of Christensen that the focus of science communication in practical application is shifting from the efforts for better understanding of science by the lay public to converting it into a mixture of public relations, branding and marketing used for the benefit of science, is correct, but the advancement in marketing still lags behind. The demand for more active use of marketing is confirmed in the interviews, but mostly on theoretical level as it largely remains an alien concept for scientific culture. A hypothesis on transformation of knowledge into commercial product (see Section 2.1) suggests that the change in approach to representation of this product may result in further adaptation of marketing for the use by public research institutions, but at current stage it only entered the transition stage.

Summarizing the opinions of all experts, the following factors might be identified as affecting the development of science communication:

- Underestimation of communication importance
- Insufficient financing
- Lack of qualified professionals
- Insufficient executive support
- Deficiencies in professional qualities of PIOs
- Competition with industrial R&D (brain drain)

The factors mentioned in the interviews by PIOs speak in favor of greater integration of science communication in research institutions and better support on behalf of the management. An opinion described mostly by those whose competence lies with decision-making process suggests that the poor professional qualities of communication officers and employment of skilled professionals by industrial companies stand as a negative factor dividing the two groups in their daily work. Unless this controversy is not resolved, the chances for constructive dialogue are at odds, but correct understanding of the place of science communication in modern research organizations by top executives in state bodies and science may help overcome this difficulty.

5.8 Original Questionnaire as Distributed to the Poll Participants

Keywords: publicly-funded research, applied research, science communication, globalization, commercialization, public information officers, scientists, market-driven R&D, technology transfer

1. Influence of Globalization on Science Communication

1.1. What is your personal engagement in science communication?

1.2. Why do you think it is gaining importance today?

1.3. How would you measure the influence of globalization on the applied research institutions?

1.4. What are the changes in presenting scientific knowledge with regard to such factors as globalization and democratization of science? Do you observe any new trends in today's science communication? Please expand on it if your answer is positive.

2. The Role of Applied Research

2.1. How would you evaluate the role of applied research institutions within the scientific community?

2.2. Would you agree with the statement that there is a certain conflict between the scientists' perception of his/her research value and the real market potential of this research or technology? If yes, what are the reasons of this contradiction?

2.3. Does market competition exist between publicly-funded organizations?

3. Science Communication: Objectives

3.1. How would you define the main objectives of science communication for an applied research institution when reaching outside target audiences:

- winning the funding
- effective responding to market demands
- ensuring market acceptance of technical inventions
- ensuring successful technology transfer
- public understanding of science
- expanding the boundaries of transparency of scientific institutions
- building positive outlook of scientific institution
- attraction of the scientific staff to the institute (resource management)
- other objectives?

How these objectives may vary depending on research orientation: fundamental or applied?

3.2. How would you define the main objectives of science communication at the internal level: within a given institution, within scientific community?

3.3. Do public relations and marketing form a part of science communications or one should strictly differentiate between science communication and public relations/marketing?

4. Organization and Tools for Effective Science Communication

4.1. "Communication [in the publicly-funded scientific institutions] often remains an afterthought, a by-product of scientific endeavor somehow removed from the scientific process itself". Do you agree with this statement?

4.2. Which factors (combination of factors) on the following list hinder the development of science communication in the publicly-funded research institutions?

- conservative and closed character of the scientific culture itself
- lack of theoretical research within this relatively new field of study
- lack of professional attitude to science communication among public information officers
- lack of acknowledgement of science communication in the publicly funded institutions
- lack of dialogue between scientists, journalists and public information officers in terms of common agreement upon representation of scientific knowledge due to the difference of their professional backgrounds
- other factors?

4.3. What are the typical communication problems arising on daily basis in the process of communicating science to the public depending on the target group:

- scientists
- management
- industry
- government
- journalists
- general public

4.4. Optional question for a) members of scientific community, b) management, c) industry, d) media:

Do you experience any problems in relationship with your colleagues responsible for managing public relations?

5. Tools in Science Communication

5.1. Which tools of science communication contribute most in your opinion to the understanding of sophisticated scientific information and which still remain underestimated in the scientific community? Please make some examples.

- internet, print materials, conferences, exhibitions, merchandizing, visits, others?

6. Science Communication: General

6.1. What are the necessary conditions for further development of science communication?

6. Case Study: A Fraunhofer Institute – Transition to Effective Science Communication

6.1 General Remarks

Locale: Fraunhofer Institute for Nondestructive Testing, Saarbrücken, Germany (original name: Fraunhofer Institut Zerstörungsfreie Prüfverfahren).

6.1.1. Purpose of the Case Study

As the final part of this thesis, the case study is intended to illustrate the development of science communication in an applied-research organization moving towards more openness and deeper involvement into marketing and international scientific alliances. The hypotheses presented in this study are generally supported by the observations of changing strategies and practices of the Fraunhofer Institute for Nondestructive Testing, a leading German scientific organization.

The analysis and comments contained in this part have been elaborated as a result of the interviews with the Institute's management and employees and personal experience of the author as well as critical reconsideration of existing policies and strategies, including the tools for science communication and prospects for its development.

6.1.2. Brief General Characteristics of the Institute

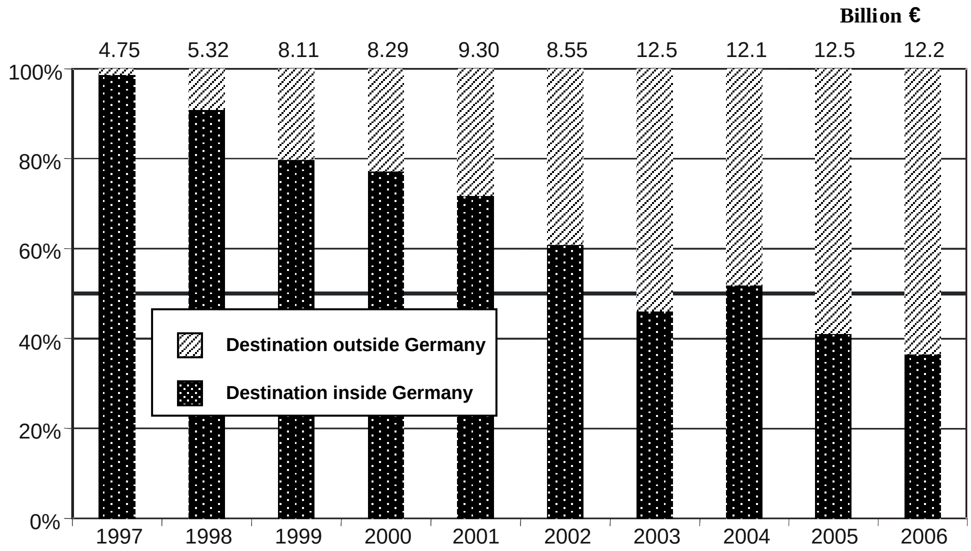
Fraunhofer Institute for Non-Destructive Testing (original name in German: *Fraunhofer Institut Zerstörungsfreie Prüfverfahren*; commonly accepted abbreviation: IZFP) with its head office in Saarbrücken, Germany, is one of 56 research institutes belonging to the Fraunhofer Society (original name in German: *Fraunhofer-Gesellschaft*), focusing on applied research. IZFP creates innovative technologies in the field of nondestructive testing (NDT), an advanced method used to examine materials and systems without destroying or damaging them. The Institute was established in 1972 as a part of the Fraunhofer and has been operating an affiliate branch in Dresden since 1992.

Employing more than 300 people, IZFP develops techniques and builds devices for industrial inspection, helping assure quality and safety standards in automotive industry, oil and gas supply, transportation, aerospace and other areas. It has an impressive record of applying tomography, ultrasonic, electromagnetic, and laser methods for data evaluation and documentation. An important part of the Institute's competence is a wide range of services, which includes evaluating new inspection procedures, staff training, and executing on-site inspection and tests. The expertise of IZFP is enriched by experience of guest scientists, graduates and PhD students from different parts of the world, contributing to every aspect of extensive research and development.

As an applied research organization, IZFP normally relies on funding coming from revenues generated by accomplishing orders for national industry and entering into partnerships with foreign organizations. The products developed by IZFP are promoted in the market with the help of transfer firms, such as Q NET, a growth-oriented network of companies engaged in nondestructive testing and condition monitoring in Europe, America and Asia.

6.1.3. Analysis of Changing Strategies

As new trends at national and international markets require different approach to management of knowledge, IZFP moves towards a new model of relationship with its customers. Originally created for serving the interests of national industry by fulfilling research contracts and providing quality services, the Institute found itself increasingly involved into international cooperation as proven by the following statistics.



Graph 2: IZFP industrial turnover 1997-2006

In 1997, the revenues received by IZFP including its Dresden-based branch from industrial contracts made € 4.75 million with almost 98 percent of the revenues coming from national contracts and services. In 2006, the revenues in industry more than doubled reaching up to € 12.2 million. However, less than 40 percent out of this amount was cashed from the contracts in Germany, while the greater share was earned by entering new markets.

The broadening of international contacts and successful appearance at new global markets inevitably raised the issue of science communication and its reassessment within the Institute. A unique role of IZFP at the national market continues to be an important part of the Institute's strategy, but the growing share of international segment in IZFP's products and services require to amend the strategy towards increasing the role of public relations and marketing as elements of corporate culture and strategic goals for better science communication.

6.2 Current Structure and Tools of Communication

6.2.1. Place and Role of an Applied-Research Institute in Modern Knowledge-Based Economy

Traditionally cautious attitude of the scientific community with regard to any forms of commercialization is a well-known phenomenon dating back to the 20th century when a lot of large scientific associations in Europe and North America were established. IZFP, as a part of the Fraunhofer Society, was chartered as a non-profit organization and most of the time was seen as a knowledge center responsible for solving the technical problems and offering innovative solutions for the giants of German industry such as Siemens and Deutsche Bahn as well as traditional German *Mittelstand*, small and medium-sized enterprises (SME). In 2004, for instance, the orders from large industrial companies made up 59 percent, dropping down to 14 percent in 2006. The percentage of revenues generated by SME, on the contrary, increased up to 48 percent in 2006 as compared to 22 percent in 2004. Such tendency supports the hypothesis on diversification of the organization's activities at the innovation market. The number of orders over € 500,000 has grown from 7 in 2004 to 12 in 2006 that illustrates new opportunities.

Fulfilling contractual obligations required neither active marketing efforts, nor the steps for intensifying communication process. Gradually, the demand for summarized information on the activities of the Institute materialized in the annual report published in 1996 (*Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren. Leistungen und Ergebnisse. Jahresbericht 1996*). In the same year, the first website was launched in German and English where the objective of the organization was defined as "to improve the safety of technical products and services," and the organization was positioned as "partner of industry".

Deepening involvement into European and world globalization processes brought about the response to market demands in the form of contacts, people and information exchange, but strategic planning of science communication in IZFP is still in the transitional process. One of the greatest obstacles for accelerating this process is a certain lack of understanding with regard to commercialization of knowledge and disagreement over the goals the Institute should pursue. Remaining an integral part of the German national industry – science mechanism and enjoying the status of non-profit organization, IZFP is still gaining considerable profit from contracted research and services. This traditional placement of services and focusing on immediate concerns of research and development impede the achievement of general consensus as to what is the role of IZFP in global science. Although the management of the Institute invested significant efforts in diversification of its activities and encouraging the quest for innovation, the culture of research and technology remains largely unaffected. The threat to long existing relationships and the mode of work is perceived as disturbing long-standing patterns. A natural reaction to invasion of commercialization and globalization in scientist environment is to protect the status of excellence center without cardinal changes in strategic thinking. Many scientists who never dreamed of becoming entrepreneurs are upset with the idea of taking additional burden for promoting their innovations at the market and, what is even more difficult, to compete with their colleagues not only for funds, but also for public recognition of their research projects becoming increasingly dependant on financing and good presentation with clear final results.

6.2.2. Labor Relations

Under present conditions when industry often has to explore newly emerged markets in search for technological solutions, the ability to be more dynamic, mobile, communication-prone, and familiarized with different business and social cultures is the prerequisite for becoming successful not only in commercial terms, but also in achieving scientific results. The labor hierarchy created for IZFP in the 1970s and going through transition at current stage is a good basis for further development, although the lack of some qualities necessary for successful competition is a hindering factor.

One of the most difficult task the management has to deal with is finding the proper ways for motivation of staff to be more active and communicative at internal level. The years of largely passive attitude towards the values of marketing left its strain. Protected from loosing their jobs by long term contracts and given the tasks of resolving a technical issue or conducting a study on orders from industry, the staff is not easily motivated for changing their working habits and "agents of change" are not the one to recruit at any time. The change in the paradigm of knowledge creation and use still remains a theoretical notion as opposed to everyday tasks assigned to particular managers, scientists or technicians.

As many non-business enterprises existing with the support of public funding, IZFP inherited quite fluid structure of reporting and accountability. The need for more aggressive marketing presence might be generally shared, but as a non-profit organization the Institute is compelled to find the ways for product marketing via transfer companies. Chartered as business units, they act as agents for fostering successful partnerships mostly outside Germany. IZFP was successful in setting up branches of its transfer firm in the United States, Russia, India, and China, that function as independent units active in marketing, but this solution would be in a far better match if joined the forces with those responsible for science communication in the Institute. Since any marketing campaign carried out by a transfer company needs backing in terms of information and coordination, the setting up of a business unit responsible for marketing, maintaining public image, and, as a result, for science communication appears to be expedient.

Besides raising various issues such as budgeting, the redistribution of responsibility and changes in current working positions for improvement of the communication process should meet another important criterion which is related to fundamental reconsideration of the objectives and place of science communication in a publicly-funded applied research institute. It would have been incorrect to define the current status of science communication in IZFP as inexistent, but what it definitely lacks is organization basis and a new attitude. As long as the circumstances permitted, communication has remained an offside effect of research and development process for years and the role of this presently important function was underestimated. Accordingly, communication and external communication in particular was seen as the exchange of ideas with peers and routine dialogue with partners. The notions of proactive communication (marketing) and the communication aimed at extending economic and cultural relations (public relations) were relegated to marginal functions of those in charge of the scientific projects. While it might have been successful in parts, a common strategy has so far failed in implementation.

The place of science communication in labor relations in the age of information cannot and should not be degraded to providing simple informational services to the projects. Science communication should be recognized as a part of strategic management and be given a vote in deciding over the priorities of the Institute's development. It would necessarily mean a departure from the old concept of the working structure and might provoke further tensions in labor relations, but winning over conservative tendencies may pay off in the nearest future as global economy will require more input from the scientists and particularly from those engaged in the last pre-market development, i.e. applied science.

6.2.3. Commonly Shared Vision

The progress in improvement the quality of science communication at IZFP cannot be reached because of some factors affecting the acceptance of new strategic vision by the staff members and key managers. The duality of IZFP's position as semi-independent unit and as a part of a broader network of Fraunhofer institutions is in the core of many decisions taken by the Institute's management. As reforms within the Fraunhofer Society cannot be implemented without substantial backing from the government and public involvement, any attempts of the member institutes to pursue too radical policies would be undermining the authority of the headquarters. Accordingly, unless the central board supports such tendency in principle, any strategies going beyond the current framework are at risk of failure. The reforming of such large organization would eventually lead to further decentralization, but as of now there is little to support the concept of fully autonomous institutes.

Since the drive for deeper involvement into marketing processes is neither actively encouraged, nor denounced in any way by the central authorities, the achievement of commonly shared vision on science communication remains a difficult task. Every opinion not favoring the transformation of scientists into entrepreneurs is well backed by the fact that the corporate culture should not be sacrificed to keep pace with globalization and commercialization, the tendencies leaving people in doubt with regard to their true goals and values.

Facing this complex situation, the Institute's management is compelled to look for a fine balance between its dual position and new realities. It does not allow to form a clearer vision with transparent objectives and appealing slogans to help the staff translate vague statements into plain directions and assignments. The lack of strength in messages in combination with corporate thinking and scientific culture cannot facilitate the removal of ambiguity whether science communication and its elements are a result of wishful thinking or pressing need for successful improvement of the organization.

Torn between the usual world of scientist and new role which might be assigned to them, the staff draws a line between the expectations of administration and everyday duties that leads to uneasy compromise and half-hearted loyalty.

6.2.4. Low Profile in the Information Market

The place of IZFP at the informational market is in direct relation with the quality of communication tools and working assignments resulting from current strategies. Apart from routine participation at conferences and business meetings, the informational policy of the organization might be characterized as modest. Normally, there are 5 to 7 press releases issued annually, although only half of them is meant to boost reader's interest with the remainder dedicated to the events illustrating corporate life and, subsequently, lacking in the power of messages.

The website of IZFP (www.izfp.fhg.de) maybe not a masterpiece from the technical point of view and design decision, but it contains sufficient volume of technical information. Complicated navigation, deficiencies in international version (English), and some inconsistency in selection of bilingual material adds to the issues of science communication.

Weak informational policy remains the Achilles' heel not only outside the organization, but also within. So far, the creation of position of public information officer, albeit the setting up of an informational department, has failed to appear on the agenda and this situation could hardly be tolerated given the increasing volume of information coming in and out of the Institute.

6.2.5. Coordination Center

A certain increase of the volume of informational streams is a relatively new phenomenon being observed for the past five to seven years. The Institute is striving towards formation of networks with global centers of scientific, educational and technical excellence. Collaborative research, exchange of faculty, outreach programs, measurement science and technology workshops are only a few items on the agenda. Geographical specter of the Institute's cooperation outside the EU includes:

North America

- Iowa State University, US
- Southwest Research Institute, Texas, US
- University of Texas System, US
- Electric Power Research Institute NDE Center, Charlotte, North Carolina, US

South America

- Pontifícia Universidade Católica do Rio de Janeiro, Brazil
- Centro de Avaliação Não Destrutiva (CAND), Brazil
- Comision Nacional de Energia Atomica, Argentine

Asia

- Indian Institute of Technology, Chennai, India
- Indira Gandhi Centre for Atomic Research, Kalpakkam, India
- Academy of Railways, People's Republic of China

- National University, Taipei, Taiwan

Russia and NIS

- Bauman Moscow State Technical University, Russia
- Flerov Laboratory of Nuclear Reactions, Dubna, Russia
- Khabarovsk University, Russia
- Tomsk Polytechnic University, Russia
- Yekaterinburg Polytechnic University, Russia
- Minsk Institute of Applied Physics, Belarus
- Moscow Power Energy Institute, Russia
- Cherkasy State Technological University, Ukraine
- Eurasian National University, Astana, Kazakhstan
- Kyrgyz-Russian (Slavonic) University, Bishkek, Kyrgyzstan
- Institute of Physics, Academy of Sciences, Bishkek, Kyrgyzstan
- Issyk-Kul State University, Karakol, Kyrgyzstan

The Institute has been successful in forming partnership alliances aimed at acquiring resources and market access. In 2004, the International Scientific Laboratory for Laser-Optical Diagnostics (ISL LOD) was organized and supported by the International Science and Technology Center (ISTC) and funded by the European Union program. It may serve as a model for international science cooperation implemented thanks to strategic cooperation between IZFP and the Stepanov Institute of Physics of the Belarusian Academy of Science.

The access to international markets is organized by means of three different strategies and supported by local experts affiliated with IZFP's transfer companies (Q NET). When possible, the IZFP prefers the "two-and-two" model – cooperation between a German company and a local company and its local research institution (university, research institute, and/or research laboratory).

To achieve long-term sustainable access to the market, the IZFP and the local research institution normally agree on joint Ph. D. education with the goal of familiarizing foreign partner with IZFP technologies and procedures. This practice has proved to be successful in effective engagement of foreign experts into the Institute's projects. The payoff of pursuing this strategy is that the IZFP managed to negotiate some key agreements providing access to the Chinese railway market.

The second strategy is targeted at securing direct engagement of IZFP scientists and managers into assisting foreign companies and professional organizations in development of NDT solutions. As an example, the Brazilian Center for NDT (Centro de Avaliação Não Destrutiva - CAND) was established with the support of the IZFP. Through the cooperation with CAND, the IZFP will be contracted by Brazilian companies to develop NDT systems and devices meeting local requirements and specifics.

The third strategy takes advantage of the international engagement of the Fraunhofer Society and its internationally renowned brand. Fraunhofer has established representative offices worldwide to serve as intermediaries for providing services of the Fraunhofer institutes. The IZFP, for example, supported the setting up of the Moscow-based Fraunhofer office in the Russian Federation and, as a return of investment, is now looking forward to receiving contacts from Russian automotive and pipeline industry.

This impressive portfolio of cooperation with institutions, and alliances with industry justifies the necessity of organizing a joint coordination center responsible for daily activities in international cooperation, planning and routing the communication streams. Currently, the burden of communication is largely placed on the Institute's management, executive secretary's office, and project managers, but a common coordination center where all aspects of partnership is analyzed would be a quality breakthrough in organizational sense and in terms of professionalism.

6.2.6. Insufficient Element of Marketing

The power of research and development should probably be not limited by current demands of economy, but applied science cannot operate in the same mode as fundamental studies requiring long-term commitment and risky investments. The innovations created by IZFP are applied in various sectors of industry and are traded at multi-billion market of NDT devices and services.

The incremental tendency of innovations created by the German applied science and criticized by some authors (see Section 1.3) has common roots in the nature of business relations and socio-economic status as illustrated by the example of IZFP. A process known as "contract acquisition" forms a central part in the budget of the Institute and is generally understood as activities targeted at collecting orders for research and development placed by industrial companies with IZFP. The process of acquisition might be characterized as identification of prospective customers experiencing difficulties in technological process or looking for quality improvements of their operations. If some distant analogies with medicine could be drawn, the organization acts as a reputable medical center where patients come with their problems and receive treatment. In addition, a network of personal contacts and reputation as the center of NDT excellence contribute to income part of the budget. As noted above, a network of transfer companies helps accomplish marketing assignments by order processing.

This complicated marketing system might form a sustainable environment for the Institute, but the greatest deficiency in such policy is a proactive marketing. There is a little chance that an industrial company would come looking for a ground-breaking innovation revolutionizing the market because it would imply long-terms investments and vague prospects. At the same time, the execution of contracts brings the opportunity to create some byproducts – new technical solutions which the Institute is able to offer to the market, although these new technologies should come a long way to win the appraisal of customers.

What proactive marketing policy within the framework of science communication would bring is the better identification of projects which have more chances to be successful at the market. It might be a difficult task to compete with industrial labs, but certain knowledge of trends and goal-oriented strategy would definitely boost R&D processes within IZFP.

All these complex tasks could hardly be accomplished without professionals with strong communicative skills and intercultural experience – the qualities which are difficult to find in the same person responsible for planning scientific part of the project. If the division of labor has played a crucial role and is considered a hallmark of industrial capitalism, the division of communicative and research tasks would certainly benefit the organization in the age of information.

6.2.7. Complicated Policies for Promoting Innovations

The whole issue of promoting innovations and benefiting from it is undoubtedly related to a set of formal regulations and laws dating back to the mid-20th century. The centralized system of transforming inventions into patents with the help of the Fraunhofer Patent Center (*Fraunhofer Patentstelle*) does not look particularly successful. Compelled to be dependant on industrial contracts in Germany, the institutes use every opportunity to maintain positive relationship with their customers, including cheap access rights to innovations.[1]

A reasonable alternative for promoting innovations at the market is the transfer companies. While being generally successful in generating additional profit for the Institute, such companies exist semi-independently and could not be fully integrated into the structure of the organization. The most crucial negotiations concerning the promotion of innovations still remain the prerogative of the Institute which is responsible, as a publicly-funded organization, for observing the regulations imposed by national legislation.

Transfer companies stay in direct daily contact with the parent organization, but it is effectively excluded from internal structure. Science communication in the form studied in the current thesis can hardly be applied at full scale as the transfer firm is mostly interested into finding optimal solutions for implementing the business agreements reached by the Institute. At such companies, marketing might be given a priority and proper development, but other vital elements of science communication such as public relations, press contacts, direct advertisement are still by-products of knowledge transfer, not a principal strategy. In addition to the duality of IZFP's position as a part of the Fraunhofer network and an independent center of knowledge, additional complexity is caused by splitting communication tasks between the parent institute and its representatives.

6.2.8. Improvement of Communicational Tools and Skills at National and International Level

International and intercultural contacts of IZFP continue to grow. Needless to say how much efforts should be put into developing a professional team which would be able to build up the current range and strength of partnership. As noted above, a

---

[1] "Turning Science Into Business", op. cit., p. 178.

certain disadvantage resulting from the existing *status quo* of labor relations is the shortage of professionals in communication aggravated by general deficiencies in educational programs and vague concepts on the objectives of science communication as independent filed of professional occupation. Qualified professionals with good communicative and interpersonal skills prefer to work for industrial companies not only due to far better compensation plans. The idea of powerful and independent science communication unit reporting directly to the Institute's executive is probably too bold an idea for the public consciousness of scientific organizations.

6.3 Prospects for Improvement

6.3.1. Adjustment of Current Communication Strategies

According to official statistics, the German contract research market was worth of € 62 billion in 2004. The share of the Fraunhofer Society's institutions was estimated at about € 1.07 billion or slightly less than 2 percent.[1] Obviously, the potential of national and international R&D market is tremendous and each institute contributing to the 2-percent share might increase if more active knowledge transfer policy is pursued.

At current stage, the introduction of new policies may be successful only as a result of changes in scientific community and abandoning the concept of the ivory tower mentality, a synonym of intellectual isolation dating back to the French poetry of the 19th century. Since knowledge became a product in its own right, the centers of knowledge, including IZFP, will not be able to find successful ways of knowledge transfer unless business responsibility, financing and market awareness are considered as priorities in strategic thinking. However, any strategy will remain on paper if the working community is unprepared for a cultural shift. The principal objectives for development of scientific culture at IZFP consist of:

- Efficiency
- Relevance
- Flexibility
- Creativity

The old paradigm described as "public mandate" in Section 1.1 of this study featured such elements as scientific development/education, pre-competitive R&D, personality-influenced knowledge transfer (*Wissenstransfer über Köpfe*), and maintaining positive public image in local community. A new strategy in combination with the paradigm change offers a different set of priorities: market success, innovative competitive products, jobs for talented scientists, and globalization. If the former concept would suit for description of a state agency structure, the new gives hope for forming competitive teams.

---

[1] Bundesbericht Forschung 2004, Stifterverband Wissenschaftsstatistik, Angaben d. Forschungsinstitutionen, Statistisches Bundesamt.

The implementation of such strategies will require considering an extensive agenda of communication objectives, both internal and external.

6.3.2. Public Information Department as Effective Channel for Information Streams and Implementation of Public Relations/Communication Strategy

The most effective organizational response to the challenges of the new strategy is the creation of a department for managing information streams, contacting mass media, researching market and fostering a positive public image of IZFP as a corporate citizen and reliable partner. As more and more concerns affect the public in terms of environment awareness activities, transparency of operations, human rights, and other areas, effective management of public interest towards the organization will become a key to success.

Besides routine targets of public relations campaigns and marketing initiatives, the science communication agenda should feature professionalization to support the transition to a new corporate identity. The current distribution of communication assignments falling on the employees incidentally involved into a project or negotiation process serves one-time purposes without far-sight vision. As further involvement into globalization process will increase the number of challenges, any disorganized arrangement will negatively affect the implementation of scientific projects, particularly those of international character where intercultural and interpersonal skills, ability to use languages and knowledge of different cultures may become crucial.

6.3.3. Adjustment of Policies for Decision-Making and Reporting Related to Science Communication

An indispensable condition for steady progress in reforming science communication at IZFP is the appreciation of its values in executive thinking. It is not sufficient to recognize the importance of communication and provide those responsible for its development with funds and general support. Regardless the future organizational structure of public relations and marketing units, science communication should become a factor in decision making related to strategic alliances and funding of research projects.

Efficiency and relevance of the current projects carried out by IZFP personnel are barely measured only by their prospects to hit the market targets. In the future, a fine balance between the values of long-term bids and industry-oriented solutions will not be possible to reach without proper knowledge about the market demands and each decision involving funds should be scrutinized to assess possible gains and losses.

As long as science communication exists as a tool serving occasional interest from partners and the public, it will remain affordable, but ineffective element modestly contributing to general performance of the Institute.

6.3.4. Development of Effective Tools for Internal Communication, Promotion of New Values for Successful Cooperation in Global Environment

Besides marketing communication and external communication (public relations), there is a field usually seen as most difficult to manage. This field is internal communication within the Institute's scientific community. Organizationally, IZFP is divided into seven business units (*Geschäftsfelder*), four science units (*Bereich Wissenschaft*), four technical units (*Bereich Technik*), and the Dresden branch office. Currently, the principal functions of science communication are distributed between top executives, executive secretariat, and unit managers. The set of tools for corporate communication includes weekly meetings, annual strategy workshops, modest use of the Intranet, and computerized business system for tracing contract operations.

Despite the existing hierarchy, the analysis of opinions proves that communication is more or less effective on vertical level (top management – manager – employee), but definitely lags on horizontal level (between different units, between employees of the same field). The important role of personal contacts and influence of scientific authorities are hardly a surprising factor given the nature of scientific community where informal leadership based on professional qualities should never be discarded.

The formulation of agenda for internal communication is probably the most difficult part as historically grounded communication lines within the organization should be preserved and incorporated into a new set of cultural values as described above. A certain element of encouraging internal competition between the units and departments and merit-based recruitment and promotion may play positive role in developing the interest to intensifying communicative efforts. Another important aspect is the creation of a new corporative identity and the improvement of team work. Certainly, the definition of *team* should be fundamentally reconsidered to replace isolated scientific/technical team with corporate teamwork. Effective management of human resources, including greater mobility of personnel, employment of graduated professionals, and expatriate experts may drastically improve the situation in internal communications.

6.3.5. Development of Information Policies and Tools

Formal changes in information management would be incomplete without developing an efficient code of policies which should reflect increasing responsibility and certain restrictions for information disclosure. Retaining its status as primarily scientific organization and center of excellence, IZFP will, nevertheless, have to comply with business ethics, although such transformation could hardly be carried out without persistent efforts.

Nowadays, the most valuable tool in successful presentation of any organization for partners and the public is the Internet. The unique position of IZFP as reputable knowledge center in Germany and Europe is the starting point for extending the virtual presence. The scope of present study does not allow to enlist all possible improvements required for promoting IZFP in this capacity, but the agenda on web presence should definitely include transition from informational web site to customer-oriented portal, introduction of content management, technical improvements, and attractive design.

The targets for content improvement will definitely feature optimization from user's point of view, correct positioning of products and services, dynamic engine, and extended internationalization depending on the markets at which IZFP would be successful (possibly China, Russia). A good portion of web content should be dedicated to press kits available for journalists interested in NDT or the Institute. The improvement of the corporate website and Intranet should be implemented in combination with using other web resources.

Besides using such powerful tool as the Internet, science communicators will have to secure the consolidation of information resources from the viewpoint of consistency and relevance to the Institute's objectives. Each instance of inconsistency resulting either from verbal contacts or distribution of information materials created *ad hoc* and/or not in compliance with the existing policies may spoil the organized efforts. It is not rare at IZFP that a unit or department develops print-out materials for their own purposes but such approach would eventually undermine collective efforts as what is seen as a positive action from departmental point of view may be seen in different light from corporate. In addition to the perils of inconsistency affecting public image, some minor issues such as corporate design, distribution priorities, and efficiency of statements should also be taken into consideration.

6.3.6. New Information Environment – Extension of Existing Tools and Introduction of New Forms of Communication

The Institute is working with a number of audiences and certain priority is given for the current and prospective customers as a sector directly contributing to revenues. Unfortunately, the absence of clear strategy in communication does not allow to improve prioritizing process and selection of audiences. Some very important groups, such as media, are practically not covered, although positive experience of other institutions may serve as a blueprint for feeding public interest. Preparation of press kits, consistency in news release practices, registration of the interested journalists at the corporate website with access to some exclusive materials are only a few measures to begin with. Expansion of the Institute's international interests will have to meet even more pressing requirements in preparation and distribution of materials in different languages.

The main objective of applying these new tools and methods is the creation of a new information environment which should help sending strong message to partners, media and the public. A good portion of work should be focused on strategic separation of audiences and choosing appropriate methods of communication. A definite accomplishment for IZFP as a transparent scientific organization with high profile in its professional field would be the achievement of interactivity as opposed to static method of handling occasional inquires. The more quality information appears on paper or in electronic form, the greater the chances for identifying useful contacts.

The involvement of expatriate specialists both as a part of the Institute's human resources and partners in outreach programs will put additional emphasis on the quality of materials distributed to the interested parties. The study of foreign business culture and ethics should be seen as a powerful tool in winning the sympathies for partnership. As IZFP continues to be engaged into educational projects with other countries, the study of communication practices is a factor for succeeding in reaching audiences.

6.3.7. Relationship with Mass Media

As an organization still researching the opportunities for marketing its projects at newly emerged markets, IZFP has limited chances to make headlines even in local press. About 50 percent of its contractual orders are carried out on conditions of confidentiality because many customers prefer not to disclose it due to safety and security concerns. Nevertheless, it does not mean that the Institute should dismiss any strategy pointing at this direction. While pursuing hyperactive media policy would definitely ruin the reputation of a reverend scientific stronghold, the underestimation of contacts with the press may backlash with a lack of factual basis for building positive public image which becomes an important factor in dealing with partners.

The policy of IZFP with regards to both print and electronic media might be generally formulated as transition to communicating science in the language comprehensible for lay public and on condition of permanent availability of facts sheets and other materials. The more complicated the tasks assigned to IZFP personnel, the more amount of work should rest with the team of the Institute's communicators. As journalists are particularly prone to misreading the facts for the sake of a sensation or because of the lack of scientific background in the field of nondestructive testing, the preparation of all materials should preferably be completed on-site. This approach would serve at least two significant purposes. First, the scientists and project leaders would be able to come to terms with communicators with regard to facts and statements that is hardly possible when contacting press directly. Second, the communicating team will be allowed to prepare most of the material beforehand, to have it approved and to make it worth of a story in newspaper column or article.

The Internet offers a great variety of sources which might be used by a journalist foe writing her/his material. Indirect sources serve the purpose when the website of the organization featuring in the story is either missing or only sporadically updated. In order to avoid the vacuum of *official* information, a fair portion of communication efforts should be focused on a) researching the trends in covering nondestructive testing, and b) supplying the demand in information with the help of press kits which may include various documents from news releases to video presentations. Displaying the information on the Institute at popularly visited resources such as Wikipedia and Knol, logging and analyzing press contacts via the official website may positively affect the quality of media relations. When contacted directly, public information officer should be able at least to provide a hard copy document or a link to resource where the information requested by journalist is stored. To be able to launch such mechanism, the Institute's information base should be analyzed and converted into most appropriate formats, both in terms of language and media. Elaboration of update schedule may also become a turning point in creating quick-response mechanism. If not neglected, strategic work with the press may pay off by adding useful contacts and extending the basis of potential customers.

6.3.8. Analysis of Market Information

The completion of science communication strategy for IZFP cannot be achieved without introducing some key elements of marketing and market analysis to help the Institute's executives to identify the most prospective directions in research and development. It would have been inexpedient to apply full-scale marketing approach to a scientific organization, but more aggressive market approach may ensure the identification of the most prospective research projects. At this point, the direct involvement of scientists and PIOs into market research should be seen as another important aspect of balancing between business approach and realization of scientific potential. The experience of a PIO in technical field and his/her involvement into research will be a crucial point as it may often be a case when scientists cannot present their great ideas in the most attractive form and this is where the PIO should take over and win the funding for the promising projects even if the market is not ready for its immediate consumption.

The introduction of market tools should be carried out cautiously and in constant consultations with the project leaders as the exclusion of the valuable projects from working agenda due to the lack of insight on behalf of PIOs would harm the reputation of the institution and strip it of possible industry contracts. If needed, the participation of third-party consultants on market research may be beneficial and provide additional expertise.

Conclusions

The examination of objectives and tools of science communication presented in this thesis leads to conclusion that in relatively short period of time this field of knowledge and professional occupation substantially departed from its original educational function and arrived to the point of becoming an instrument of mutual understanding between science and society. The present work shows that this kind of communication is still in active phase of transition and it would be premature to foresee in what direction it may develop, but what stands beyond any doubt is the relevance of this phenomenon, both theoretically and professionally, to the success of innovations and knowledge transfer.

The multidisciplinary nature of science communication absorbed a number of distinctive features from different areas of knowledge which preceded its emergence. It ensures flexibility and availability of tools needed for exercising the function of a binding link.

Complexity and outstanding character of communication in scientific community are conditioned by the whole nature of research process and sophisticated structure of scientist culture. The analysis of theoretical and empirical data carried out in this study proves that the position occupied by science communication cannot be filled in with other forms of management of internal and external communication: journalism, public relations, and marketing at least in the publicly-funded research institutions in Germany. A cautious extension of this statement in the form of conjecture might be valid for other national centers of knowledge as well. Only a combination of elements from different sources of knowledge and thoughtful insight into the objectives and results of scientific research may bring success to communicative efforts.

The strategy of communication in scientific organizations normally exceeds the patterns existing for regular agenda of public relations, marketing or even educational initiatives. Its complexity directly depends on the complexity of economic, political, social and cultural relations between modern science and society at various levels. As a result, science communication is being formed largely as a mixture of different approaches to information management.

Among other conclusions, it should be emphasized that the sources of information for scientific communication and direct involvement of scientists into the dialogue add to the complexity of the tasks. The search for a fine balance between scientific accuracy and general comprehensibility of the communicated material will always be the greatest challenge for science communicators since they have to take into account the interests of different groups of people whose educational and professional backgrounds may significantly differ from each other.

Any medium of information exchange created for a scientific organization from news release to website to fact sheet will be the result of compromise solution suiting the interests of two or more audiences: thinking by rational categories scientists and emotional journalists, the researchers proud for their ground-breaking achievements and industry managers demanding to adapt the brave new technologies to their business plans, comfortably operating with formulas scholars and the lay people lacking any talent in mathematics and physics.

The matching conclusions drawn from the related literature, interview statements and practical observations in current thesis demonstrate the increasing exposure of science to global markets and commercialization. Consequently, science adopts new features where communication is the key point for successful innovations. Some organizations are more successful in their communication practices, some are struggling to develop new approach. A particular situation as described for a German applied science network, Fraunhofer Society, is a part of more complicated process of adaptation of various nations to globalization and its consequences. In this case, the scientific community finds itself exposed not only to the public, but to a new dimension of partnership involving cultural, linguistic and social challenges.

The entrepreneurial skills of scientists might be a subject of another dissertation, but the impact of communication on its development is evidently proven in this thesis. The abilities pertinent to successful entrepreneurship cannot be improved without overcoming the barriers between scientific community and the rest of the world, and without changing the nature of scientific culture. One of the principal conclusions of this study is that science communication may assume even more important function of extending the boundaries of scientific interests and merging the experience and achievements of researchers from different cultures as research projects are becoming more complex and demanding in terms of finance and technical expertise.

The implementation of any communication agenda in a research institution will be necessarily tied with the level of professionalism demonstrated by those responsible for this process. This study supports the thesis that science communication as a professional occupation lacks definite self-identification and ongoing discussion about its role and position should help reach some reconciliation in this regard. In application to Germany, the non-commercial character of publicly-funded science indirectly downplays communication initiatives, but the apparent need for some fundamental changes in organizational context may put science communication in a far more advantageous position in the future. Even if economic factors are excluded from consideration, the intensification of global information flow suggests that the efficient management of information should become integral part of any research network.

A new paradigm of world development based on access to information and its rational distribution is the driving force for development of increasingly complex communication tools and science should definitely benefit from further involvement into communication process.

Selected Bibliography

Afuah, A. (2003). Innovation Management: Strategies, Implementation, and Profits. Oxford: Oxford University Press.

Albaum, G. S. and Smith, S. M. (2005). Fundamentals of Marketing Research. Thousand Oaks, Calif.: Sage Publications.

Alvarez, S. A., Agarwal, R. and Sorenson, O., eds. (2005). Handbook of Entrepreneurship Research: Disciplinary Perspectives. New York: Springer Science.

Amelingmeyer, J. and Harland, P. E., eds. (2005). Technologiemanagement & Marketing: Herausforderungen eines integrierten Innovationsmanagements. Wiesbaden: Deutscher Universitäts-Verlag.

Annesley, C. (2004). Postindustrial Germany: Services, Technological Transformation and Knowledge in Unified Germany. Manchester: Manchester University Press.

Archer, G. L. (1938). History of Radio to 1926. New York: American Historical Society.

von Aretin, K. and Wess, G. (2005). Wissenschaft erfolgreich kommunizieren. Willey-VCH.

Audretsch, D. B. (1999). "Is the German Economic Model Still Viable?" Wirtschaftspolitische Blätter, 46 (3), 276-285.

Baillie, C., Dunn, E. C. and Yi Zheng (2004). Travelling Facts: the Social Construction, Distribution and Accumulation of Knowledge. Frankfurt/Main: Campus Verlag.

Bardhan, A. D., Jaffee, D. M. and Kroll, C. A. (2003). Globalization and a High-tech Economy: California, the United States and Beyond. Kluwer Academic Publishers.

Beck, S., Klobes, F. and Scherrer, C. (2005). Surviving Globalization? Perspectives for the German Economic Model. Dordrecht: Springer.

Bellevergue, J.-L., Carroll, C., Delaney, C., et al. (2004). Survey of Academic Research in Ireland. Dublin: University of Dublin College.

Berndt, R., ed. (2005). Erfolgsfaktor Innovation. Berlin, Heidelberg: Springer-Verlag.

Borchelt, R. E. (2001). "Communicating the Future. Report on the Research Roadmap Panel for Public Communication of Science and Technology in the 21 century." Science Communication, 23 (2), 209.

Borgmann, M. and Keller-Ebert, C. (2005). Status Quo und Herausforderungen der Wissenschaftskommunikation in Deutschland: Bericht zur Expertenbefragung im Rahmen der Evalution des Jahrs der Technik 2004. Köln.

Bruce, M. and Cooper, R. (1997). Marketing and Design Management. International Thompson Business Press.

Burns, T. W., O'Connor, D. J. and Stocklmayer, S. M. (2003). "Science Communication: A Contemporary Definition." Public Understanding of Science, 12 (2), 186-187.

Castells, M. (2000). The Rise of the Network Society. Blackwell Publishing.

Christensen, L. L. (2007). The Hands-On Guide For Science Communicators. A Step-By-Step Approach To Public Outreach. New York: Springer.

Conceição, P., Heitor, M. V. and Lundvall, B.-Å. (2003). Innovation, Competence Building, and Social Cohesion in Europe: Towards a Learning Society. Edward Elgar Publishing.

Cribb, J. and Hartomo, T. S. (2002). Sharing Knowledge. A Guide To Effective Science Communication. Melbourne: CSIRO Publishing.

Cuhls, K. and Blind, K., eds. (1998). Delphi'98 - Umfrage. Studie zur globalen Entwicklung von Wissenschaft und Technik. Karlsruhe: Fraunhofer-Institut für System- und Innovationsforschung.

Cunningham, P. (2004). Eadoption and the Knowledge Economy: Issues, Applications, Case Studies. IOS Press.

de la Mothe, J., ed. (2001). Science, Technology and Governance. Routledge.

DeGeeter, M. J. (2004). Technology Commercialization Manual: Strategy, Tactics, and Economics for Business Success. Med-Launch Inc.

Descartes, R. (2006). A Discourse on Method. Assistedreadingbooks.com Inc.

Dierkes, M. and von Grote, C. (2000). Between Understanding and Trust: The Public, Science and Technology London, New York: Routledge.

Doheny-Farina, S. (1992). Rhetoric, Innovation, Technology: Case Studies of Technical Communication in Technology Transfers. Cambridge, MA: MIT Press.

Drucker, P. (1993). Post-Capitalist Society. Oxford: Butterworth Heinemann.

Drucker, P. F. (1986). Innovation and Entrepreneurship. Butterworth-Heinemann.

Edler, J., Döhrn, R. and Rothgang, M. (2003). Internationalisierung industrieller Forschung und grenzüberschreitendes Wissensmanagement. Heidelberg: Springer.

European Commission (2004). Improving Institutions for the Transfer of Technology from Science to Enterprises. Expert group report. Conclusions and recommendations. European Commission.

Evenson, R. E. and Santaniello, V. (2004). The Regulation of Agricultural Biotechnology. CABI Publishing.

Filho, W. L., ed. (2002). Prospects of Integration and Development of R & D and the Innovation Potential of Black Sea Economic Co-Operation Countries. IOS Press.

Franklin, C. (2003). Why Innovations Fail, Hard-won Lessons for Business. Spiro Press.

Fraunhofer-Gesellschaft (2007). Fraunhofer-Gesellschaft. Annual Report 2006. München.

Friedman, T. (2006). The World Is Flat: A Brief History of the Twenty-First Century. New York: Farrar, Straus and Giroux.

Geoghegan, L., Lever, J. and McGimpsey, I. (2004). ICT for Social Welfare: A Toolkit for Managers. Policy Press.

Gerhards, J. and Schäfer, M. S. (2006). Die Herstellung einer öffentlichen Hegemonie: Humangenomforschung in der deutschen und der US-amerikanischen Presse. Wiesbaden: VS Verlag für Sozialwissenschaften.

Gerybadze, A., Meyer-Krahmer, F. and Reger, G., eds. (1997). Globales Management von Forschung und Innovation. Stuttgart: Schäffer-Poeschel Verlag.

Gibbons, M., Nowotny, H., Limoges, C., et al. (1994). The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies. Sage Publications.

Gibbons, M. and Wittrock, B., eds. (1985). Science as a Commodity: Threats to the Open Community of Scholars. Longman.

Gilbert, J. K., Stocklmayer, S. M. and Garnett, R. (1999). Mental Modelling in Science and Technology Centres: What are Visitors Really Doing? in Proceedings of 'Learning Science in Informal Contexts'. Gilbert, J. K., Stocklmayer, S. M. and Garnett, R., eds. Canberra: Questacon.

Gregory, J. and Miller, S. (1998). Science in Public: Communication, Culture and Credibility. New York: Plenum.

Grunig, L. A., Grunig, J. E. and Dozier, D. M. (2002). Excellent Public Relations and Effective Organizations: A Study of Communication Management in Three Countries. Mahwah, NJ: Lawrence Erlbaum Associates.

Harding, R. and Paterson, W. E., eds. (2000). The Future of the German Economy: An End to the Miracle? Manchester: Manchester University Press.

Heath, R. L. and Bryant, J. (2000). Human Communication Theory and Research: Concepts, Contexts, and Challenges. Mahwah, NJ: Lawrence Erlbaum Associates.

Heck, A. (2003). Organizations and Strategies in Astronomy. Kluwer Academic Publishers.

Hollanders, H. and Arundel, A. (2006). 2005 European Innovation Scoreboard - Innovation and Economic Performance. Brussels: European Commission, DG Enterprise.

Hopkins, J. (2001, December 31). "When The Devil is in the Design." USA Today. Retrieved November 12, 2007, from http://www.usatoday.com/money/retail/2001-12-31-design.htm.

House of Lords (2000). Science and Society (Science and Technology Third Report). London: Her Majesty's Stationary Office.

Hunt, A. and Millar, R., eds. (2000). AS Science for Public Understanding. Harcourt Heinemann.

Hutchins, E. (1995). Cognition in the Wild. Cambridge, MA: MIT Press.

International Nuclear Advisory Group (1986). Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident. Vienna: IAEA.

International Nuclear Advisory Group (1992). INSAG-7, The Chernobyl Accident: Updating of INSAG-1. Vienna: IAEA.

Jaffe, A. B., Lerner, J. and Stern, S. (2004). Innovation Policy and the Economy. Cambridge, MA: MIT Press.

Jahnke, J. (2005). Deutschland global? Mit falschen Rezepten in die Globalisierung. Norderstedt: Books on Demand.

Jasanoff, S. (2005). Designs on Nature: Science and Democracy in Europe and the United States. Princeton, NJ: Princeton University Press.

Jasanoff, S., Petersen, J. C., Pinch, T., et al., eds. (2001). Handbook of Science and Technology Studies. SAGE Publications.

Jegede, O. J. (1997). “School Science and the Development of Scientific Culture: a Review of Contemporary Science Education in Africa.” International Journal of Science Education, 19 (1), 1-20.

Jolly, V. K. (1997). Commercializing New Technologies: Getting From Mind to Market. Harvard Business School Press.

Kessler, M. (2001, December 31). "Designs That Made Consumers, Reviewers Cringe." USA Today. Retrieved December 12, 2007, from http://www.usatoday.com/money/retail/2001-12-31-review.htm.

Kozmetsky, G., Williams, F. and Williams, V. (2004). New Wealth: Commercialization of Science and Technology for Business and Economic Development. Westport: Praeger.

Krippendorf, K. (2006). The Semantic Turn: A New Foundation for Design. CRC Press.

Larédo, P. and Mustar, P., eds. (2001). Research and Innovation Policies in the New Global Economy. Cheltenham, Northampton: Edward Elgar.

Lederbogen, U. and Trebbe, J. (2003). "Promoting Science on the Web. Public Relations for Scientific Organizations - Results of a Content Analysis." Science Communication, 24 (3).

Legler, H., Licht, G. and Spielkamp, A., eds. (2000). Germany's Technological Performance. Heidelberg, New York: Physica-Verlag.

Leplin, J. (1997) A Novel Defense of Scientific Realism. Oxford: Oxford University Press.

Levidow, L. and Marris, C. (2001). "Science and Governance in Europe: Lessons from the Case of Agbiotech." Science and Public Policy, 28 (5), 345-360.

Logan, R. (1997). "Research, Design and Business Strategy." Design Management Journal, 9, 34-39.

Madsen, C. (2003). Astronomy and Space Science in the European Print Media. In A. Heck and C. Madsen (Eds.), Astronomy Communication. Dordrecht; Boston: Kluwer Academic.

Market Attitude Research Services (2001). Expectations for Science: Survey of Federal and State Politicians (Preliminary results). Sydney.

Merton, R. K. (1957). Social Theory and Social Structure. Glencoe, Ill.: Free Press.

Merton, R. K. (1979). The Sociology of Science: An Episodic Memoir. Carbondale: Southern Illinois University Press.

Mickey, T. J. (2002). Deconstructing Public Relations: Public Relations Criticism. Mahwah, NJ: Lawrence Erlbaum Associates.

Miller, J. D. (1983). "Scientific Literacy: A Conceptual and Empirical Review." Daedalus, 112 (2), 29-48.

Mohr, J. J., Slater, S. F. and Sengupta, S. (2005). Marketing of High-Technology Products and Innovations. Pearson Prentice Hall.

Myers, S. and Sweezy, E. E. (1978). "Why Innovations Fail." Technology Review, 76, 41-46.

National Academy (1997). Technology Transfer Systems in the United States and Germany. National Academies Press.

National Academy of Engineering (2003). The Impact of Academic Research on Industrial Performance. N. A. Press.

Newsweek (December 2005-February 2006). Special edition, Newsweek, Inc. The Washington Post Company

Nielsen, L. H., Jørgensen, N. T., Jantzen, K., et al. (2005). Credibility of Science Communication: An Exploratory Study of Press Releases in Astronomy. Roskilde.

Norman, D. (1993). Things That Makes Us Smarter: Defending Human Attributes in the Machine. Cambridge, MA: Perseus Publishing.

Norman, D. (1999). The Invisible Computer: Why Good Products Can Fail, The Personal Computer is So Complex, and Information Appliances are the Solution. Cambridge, MA: MIT Press.

Nowotny, H. (2005). The Public Nature of Science Under Assault: Politics, Markets, Science and the Law. Berlin: Springer.

Nowotny, H. (2006). Cultures of Technology and the Quest for Innovation. New York, Oxford: Bergham Books.

Organisation for Economic Co-operation and Development (2006). Innovation in Energy Technology: Comparing National Innovation Systems at the Sectoral Level. OECD.

Organization for Economic Co-operation and Development (2003). Turning Science Into Business: Patenting and Licensing at Public Research Organisations. OECD.

Pickstone, J. (2001). Ways of Knowing: A New History of Science, Technology, and Medicine. Chicago: University of Chicago Press.

Press, M. and Cooper, R. (2003). The Role of Design and Designers in the 21 Century. Ashgate Publishing.

Quinn, J. B. (1992). The Intelligent Enterprise: A Knowledge & Service Based Paradigm for Industry. New York: The Free Press.

Rat der Europäischen Union. (2006, May 18). "Schlussfolgerungen des Vorsitzes (7775/1/06, REV 1)." Retrieved November 30, 2007, from http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/de/ec/89030.pdf.

Rezun, M. (1996). Science, Technology, and Ecopolitics in the USSR. Greenwood Publisihng.

Rippen, H. and Wang, M. (2003). Technology Transfer of Federally Funded R&D: Perspectives from a Forum. Rand Corporation.

Saad, M. (2000). Development Through Technology Transfer: Creating New Cultural Understanding. Bristol, Portland: Intellect Books.

Salter, A. J., Dodgson, M. and Gann, D. (2005). Think, Play, Do: Technology, Innovation and Organization. Oxford: Oxford University Press.

Schaller, M. and Crandall, C. (2004). The Psychological Foundations of Culture: An Introduction. Mahwah, N.J.: Lawrence Erlbaum Associates.

Snow, C. P. (1998). The Two Cultures. Cambridge: Cambridge University Press.

Spinks, P. (2001). Science Journalism: the Inside Story. In S. Stocklmayer, M. Gore, and C. Bryant (Eds.), Science Communication in Theory and Practice. Berlin: Springer.

Stiglitz, J. E. (2002). Globalization and its Discontents. London: Penguin.

Stilgoe, J. (2007). "The (co)-Production of Public Uncertainty: UK Scientific Advice on Mobile-phone Health Risk." Public Understanding of Science, 16, 47.

Stocklmayer, S., Gore, M. and Bryant, C., eds. (2001). Science Communication in Theory and Practice. Berlin: Springer.

Stocklmayer, S. M. and Hardy, T., eds. (1999). Proceedings of 'Learning Science in Informal Contexts'. Canberra: Questacon.

Sung-Jo Park and Hirowatari, S., eds. (2002). Strategies Towards Globalization: European and Japanese Perspectives. Berlin: Freie Universität Berlin - Institute for East Asia Studies.

The Royal Society (1985). The Public Understanding of Science. Report of a Royal Society ad hoc Group Endorsed by the Council of the Royal Society. London:

The Royal Society.

The Royal Society. (2002, December 9). "Statement on Copus by the British Association, the Royal Institution and the Royal Society." Retrieved December 5, 2007, from http://www.copus.org.uk/news_detail_091202.html.

Thomas, U., ed. (2007). Das fabelhafte 3%-Ziel: Perspektiven von Forschung und Entwicklung in Deutschland. Berlin: Friedrich Ebert Stiftung.

Toffler, A. (1992). Powershift: Knowledge, Wealth and Violence at the Edge of the 21 Century. New York: Bantam Books.

Treise, D. and Weigold, M. F. (2002). "Advancing Science Communication: A Survey of Science Communicators." Science Communication, 23 (3), 310-322.

United Nations (2003). Strengthening Technology Incubation System for Creating High Technology-Based Enterprises. United Nations Publications.

United Nations (2005). Globalization of R&D and Developing Countries. Proceedings of the Expert Meeting Geneva 24-26 January 2005. New York, Geneva: United Nations.

van Dijck, J. (2003). "After the 'Two Cultures'. Toward a '(Multi)cultural' Practice of Science Communication." Science Communication, 25 (2), 177-190.

Ventura, A. K. and Ramsay, A. (2003). A Natural Scientist and a Social Scientist Explore the Dilemma of Science. Kingston: Ian Randle Publishers.

Vicente, K. (2004). The Human Factor: Revolutionizing the Way People Live with Technology. New York: Routledge.

Waltz, E. (2005). Knowledge Management in the Intelligence Enterprise. Artech House Publishers.

von Westernhagen, N. (2002). Systemic Transformation, Trade and Economic Growth. Heidelberg: Physica-Verlag.

Williams, R. (2006). The Unintended Consequences of Innovation: Change and Community at MIT. In H. Nowotny (Ed.), Cultures of Technology and the Quest for Innovation (pp. 39-51). New York: Berghahn Books.

Wright, R. (2000). Non-Zero: The Logic of Human Destiny. New York: Vintage Books.