

Artists in Industry and the Academy: Collaborative Research, Interdisciplinary Scholarship, and the Interpretation of Hybrid Forms

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Introduction

For an October 10, 1967 press conference, artist Robert Rauschenberg and engineer Billy Klüver collaboratively wrote a manifesto outlining the aims of Experiments in Art and Technology (E.A.T.).¹ The organization's co-founders expressed the "urgency... for a new awareness and sense of responsibility" regarding the relationship between art and technology. They warned that industry's failure to "generat[e] original forethought... and precipitate a mutual agreement" could result in a "cultural revolution," which would be a "waste" – the antithesis of efficient engineering. The authors asserted that it was unrealistic for art and technology to develop separately and claimed that a "civilized collaboration" between them would promote the constructive values of "variety, pleasure, ... exploration and involvement in contemporary life."

In 1966, when Klüver and Rauschenberg organized *nine evenings – theater and engineering*, the landmark event that launched E.A.T., there was greater disciplinary autonomy and insularity than exists today. John Cage, who participated in the event, claimed that, "the engineer was separate from artists and other people because of "his very highly specialized knowledge."² Similarly, Klüver observed that, as a result of their training, engineers are "locked into a very restricted way of looking at the world," which prevents them from "using their brains to change the environment, to make a more human environment, as they should."³ Over and above Klüver's specific goal of making "materials, technology and engineering available to any

contemporary artist,” E.A.T. created an institutional infrastructure to facilitate and enable communication and collaboration between artists and engineers at a time when practitioners in these disciplines had little or no access to each other either socially or professionally.⁴ Ultimately, Rauschenberg believed, the success of E.A.T. could be measured by the extent to which it had become a “redundant organization” -- in other words, that artist-engineer collaborations would have become so commonplace that E.A.T. no longer was needed to facilitate them.

To what extent has E.A.T. achieved its goals? What cultural changes and institutional formations have emerged over the last forty years that facilitate or promote interdisciplinary collaborations at the intersections of art, science, and technology (which I shall refer to as AST)? What lingering or new structural problems hinder them? The following discussion begins with a brief survey of AST collaborations in industry and the academy internationally. Next, a variety of practical and theoretical issues are considered, including the role of intermediaries who build bridges between various communities, diverging interests between those communities, questions of interpretation and evaluation of the hybrid products and the individuals and teams that create them, and career concerns facing those whose work challenges traditional disciplinary constraints. Given the growing dedication of cultural resources to engage artists and designers in science and technology research, there is great need for scholarship that analyzes case-studies, identifies best practices and working methods, and proposes models for evaluating both the hybrid products resulting from these endeavors and the contributions of the individuals engaged in them.

Interdisciplinary Research in Industry and the Academy

Taken as a whole, Europe is arguably at the forefront of AST research, with the greatest concentration of resources dedicated to it. The ZKM in Karlsruhe, the Ars Electronica Center

in Linz, V2, and the new Artists in Labs program at the HGKZ, exemplify how the European Union (EU), local governments, and advanced scientific research centers in Europe continue to provide substantial support for interdisciplinary research involving artists at full-service media art centers, museums, exhibitions, and symposia, and partnerships with industrial and academic research programs.⁵ These programs focus on providing access to transdisciplinary resources by immersing artists in labs where engineering, computing, and natural science research take place. Also funded in part by the EU, *Poetic Cubs* (Poetic Cubes) project includes artists, neuroscientists, computer scientists, and engineers at universities in Spain, England, France, and Scotland. Their interdisciplinary research explores the scientific and cultural potentials of self-organizing, self-replicating, and self-repairing systems. The Crucible Studio, a joint-project between the University of Art and Design Helsinki Media Lab and the Media Centre, Lume, researches and develops narrative forms by employing digital, non-linear and interactive media. Based in Paris, the Multimedia Art Research Centers and Electronic Laboratories (MARCEL), consists of a permanent broadband network. According to founder Don Foresta, it consists of more than “100 members in over 17 countries” and uses the Access Grid multicasting platform to enable “artistic, educational and cultural experimentation, exchange between art and science, and collaboration between art and industry.”⁶

Research involving art, science, and technology has received substantial support in the UK. Founded by an act of Parliament in 1997 and funded by the lottery, the National Endowment for Science, Technology and the Arts (NESTA) has made over seven-hundred awards that support interdisciplinary creativity. For over ten years, the non-profit organization Arts Catalyst has promoted dialog, research, and awareness at the intersections of art and science, including projects supported by NESTA, the European Commission, and the European Space Agency. The Arts Council England has spearheaded the “Pioneers of Art and Science”

project that supports interdisciplinary research and the production of documentary resources pertaining to it. Evolving from the CAiiA+STAR Ph.D. program that Roy Ascott initiated in 1995-6, the Planetary Collegium offers an international Ph.D. program for art and design researchers through its base at the University of Plymouth and its hubs at the HGZK and the Nuova Accademia di Belle Arti in Milan. The picture in the UK is not entirely positive: in Dublin, Arthouse Multimedia Centre closed in July 2002 and the Media Lab Europe, which supported creative invention across disciplines, closed in January 2005.

In Canada, The Banff New Media Institute, funded by a combination of federal monies and corporate partnerships, has supported many collaborations at the intersections of art and technology and also has played a leadership role in promoting meta-critical research into the field through The Beauty of Collaboration research conference (2003) and the BRIDGES consortium and conferences, resulting in informative and insightful reports. In the province of Québec, the Daniel Langlois Foundation, the Société des Arts Technologiques, and the new HEXAGRAM Institute for Research/Creation in Media Arts and Technologies (funded by a Canadian \$20 million grant shared between Concordia University and the Université de Québec à Montréal) all support various aspects of research and documentation of collaborative work. Smaller regional organizations, including the Interaccess Electronic Media Arts Centre in Toronto and the Soil Media Suite at Neutral Ground in Regina also provide important resources for research, production, and presentation of AST projects. Interdisciplinary programs at Canadian universities are drawing top artists/scholars from the US, including Diane Gromala (Simon Frasier University), Steve Mann (University of Toronto), and Chris Salter and Sha Xin Wei (Concordia University).

In Australia, the SymbioticA collaboratory was founded at the University of Western Australia at Perth and the first edition of the Biennial of Electronic Arts Perth (BEAP) took

place in 2002. The Visual Arts Board of the Australia Council has funded artist residencies in science labs and the Australian Network for Art and Technology has promoted interdisciplinary practice and collaboration since 1985. The Interactive Digital Media Matrix (iDMM) was created through a merger between the University of New South Wales and the University of Technology, Sydney. Under the leadership of Jeffrey Shaw, Director of the iCinema Centre for Interactive Cinema at UNSW, the iDMM has received several grants to support a large-scale, international research consortium that stresses interdisciplinary collaboration in new media, communications technology, cultural theory, and cognitive science.

In Japan, the Institute for Advanced Media Arts and Sciences (IAMAS), Gifu, and the Media Information Science Laboratories at the Advanced Telecommunications Research Institute (ATR), Kyoto, support interdisciplinary, collaborative research. Since 1996, the NTT InterCommunication Center (ICC), Tokyo was a leading international center for exhibition and discourse surrounding AST and created an important collection of artwork. Unfortunately, the ICC recently announced that it will close in early 2006. New programs are emerging in Singapore, China, and other areas of the Pacific Rim. At the University of Caxias do Sul, Brazil, Diana Dominguez coordinates the Artecno research group, part of the Laboratory of New Technologies in Visual Arts, which has produced many multimedia installations and developed the Pocket Cave (a NAVE, or Non-expensive Automatic Virtual Environment.)

The situation in the US is marked by an absence of governmental funding and great uncertainty about other forms of institutional support. There is nothing comparable to the ZKM, Ars Electronica, V2, the Banff New Media Institute, or the ICC in the US, though organizations such as Art Science Collaborations Inc. (ASCI), Boston Cyberarts Festival (and ARTCOM program), Eyebeam Atelier, the Exploratorium, the Kitchen, and SIGGRAPH help support networking, exhibitions, residencies, and symposia. The publication in spring 2003 of

the report, *Beyond Productivity: Information Technology, Innovation, and Creativity*, sponsored by the National Research Council with support from the Rockefeller Foundation, offered hope that more governmental interest in interdisciplinary AST research would be forthcoming.⁷ However, the agenda of the January 2004 Convocation on Facilitating Interdisciplinary Research convened by the National Science Foundation in Washington, D.C. did not include any discussion of the role that artists, humanists, or even social scientists might play in collaborative research. The handful of humanists and social scientists in the audience voiced their disappointment about this elision. Although the subsequent National Academies Press publication, *Facilitating Interdisciplinary Research (2004)*, offered insightful recommendations for interdisciplinary research, including the important role of social scientists, it did not address the AST nexus specifically and its substantial bibliography included few references to literature in this field.

Prestigious, corporate-sponsored programs at Interval Research and Xerox PARC abruptly ended in 1999 and 2000 respectively. In 2000, Lucent Technologies teamed with the Brooklyn Academy of Music to develop the short-lived Arts in Multimedia (AIM) program, which resulted in several interdisciplinary projects, including *Listening Post (2001)* by Bell Laboratories research statistician Mark Hansen in collaboration with independent artist Ben Rubin. Lucent no longer sponsors such projects and Hansen left Bell in 2003 for a professorship at UCLA, where he holds a joint appointment in Statistics and Design|Media Arts. Intel is currently the most visible and generous corporate sponsor of artistic research collaborations in the US.⁸

Although corporate artist residencies and project sponsorship require broad support from within an institutional framework, often it is the vision, talent, and work of individuals that generate and hold together such programs. Max Matthews and Billy Klüver played such a role

at Bell Labs in the 1960s. From its inception in 1993, the PARC Artists In Residence program (PAIR) was spearheaded and directed by Rich Gold, whose own background bridged the arts and industry and who was able to communicate in both languages. Similarly, Intel's sponsorship of artistic research emerged from the vision and leadership of Dana Plautz, who also has an interdisciplinary background. Sara Diamond has noted that such individuals play a crucial role enabling interdisciplinary research involving artists by justifying industry's investment in them, convincing colleagues of their value, and intermediating between the interests of individuals and institutions, and between artists, engineers, and scientists.⁹ It is unclear what combination of personal and managerial qualities makes for successful intermediaries, or what conditions would lead to identifying and cultivating more of them, but such catalysts may play a vital role in the future of interdisciplinary research.

Despite their largesse, it would be naïve to imagine that industry partners invite artists into their labs for the sole purpose of research. In works such as *On Social Grease* and *Mobilization* (1975), and in his essay, "Museums: Managers of Consciousness" artist Hans Haacke poignantly revealed how supporting the arts can white-wash a company's tainted image, transforming it into a corporate good citizen. By accepting corporate sponsorship, Haacke argued, artists and cultural institutions become complicit in supporting the interests of capitalism and globalization.¹⁰ Nonetheless, it is difficult to imagine a "pure" place of operations where artists can produce and exhibit work that is autonomous from economics.¹¹ For some artists, whose practice demands access to and participation in the development of emerging technologies, there may be little option but to rely on corporate, public, or institutional partners.

At the same time, individual artists have succeeded in producing technologically complex work and alternative spaces have presented it without relying on such support. For example, in

1968, Norman White used discarded digital circuits to construct *First Tighten Up on the Drums*, an artwork that may be considered a cellular automata experiment. In 1986, after being confidently informed by engineers at the University of Toronto that *Telephonic Arm Wrestling*, a bi-directional, telematic, force-feedback device could be build for a cost of \$75,000, White and Doug Back succeeded in doing it themselves for approximately \$500 by “throwing together a bunch of junk” along with some home-made custom electronics. In 1996, Garnet Hertz, working in his garage in Saskatoon, built *Interface*, a web-based telerobotic system, one of the first such artworks³

The embrace of artistic collaborations by national and university research laboratories has played an important role in the development of AST in the US. As suggested above, one must consider the possibility that such labs also seek to enrich their public image by an association with the arts and/or to employ artists to give concrete and accessible form to the abstract and complex scientific concepts underlying their research. Such motivations are particularly germane to research that is the subject of public debate, e.g. military technology, genetic engineering, and nanotechnology; or that is a conspicuous consumer of public funds but has produced scant tangible output, e.g. particle accelerators for high energy physics.¹² These issues pertaining to corporate funding are not unique to the US context but are shared internationally.

After a wave of intense public fascination with art and technology that peaked around 1968, American universities became important centers for ongoing experimentation in this field. Founded in 1973, the Electronic Visualization Lab at the University of Illinois, Chicago has been a seedbed for interdisciplinary research, including the collaborative creation of the CAVE in 1992 by a team including artist Dan Sandin.¹³ Also in 1973, Charles Csuri founded the Computer Graphics Research Group at The Ohio State University, which later expanded in

1984 to become the Advanced Computing Center for the Arts and Design. Since 1979, the Interactive Telecommunications Program at NYU has supported research on, and development of, alternative media. The MIT Media Lab, founded in 1985 as an outgrowth of the Architecture Machine Group, is perhaps the best-known academic program for interdisciplinary invention at the nexus of technology and culture. At the University of Illinois at Urbana Champagne, Donna Cox has held a joint appointment with the School of Art and Design and the National Center for Supercomputing Applications (NCSA) since 1985, participating in myriad interdisciplinary collaborations that involve “renaissance teams.”¹⁴

Universities have played an important role in stimulating the explosive resurgence of artistic and public interest in art and technology that began in the 1990s, spurred by the availability of personal computers and user-friendly software and further buoyed by a general fascination with technology amidst the e-commerce boom. Academic institutions are increasingly recognizing the importance of interdisciplinary research and the value of art and design as a bona fide research fields that have much to contribute to science and engineering.

The University of California (UC) system is at the forefront of this wave. Leading practitioners and scholars in the arts, humanities, sciences, and engineering on the faculty include: Ken Goldberg and Greg Niemeyer at UC Berkeley; Rebecca Allen, Mark Hansen, Katherine Hayles, Erkki Huhtamo, Christian Moeller, Victoria Vesna, and Jim Gimzewski, at UCLA; Fran Dyson and Doug Kahn at UC Davis; Beatriz Da Costa, Rob Nideffer Celia Pearce, and Simon Penny at UC Irvine; George Legrady and Marcos Novak at UC Santa Barbara; Sharon Daniel, Margaret Morse, and Warren Sack at UC Santa Cruz, and Sheldon Brown, Jordan Crandall, Adriene Jenick, Natalie Jeremijenko, and Lev Manovich at UC San Diego. A wide range of centers, institutes, networks, and collaborations span multiple UC campuses, including the UC Digital Art Research Network (UC DARNet), Center for Information

Technology Research in the Interest of Society (CITRIS), Center for Research in Computing and the Arts (CRCA), California Institute of Information Technology and Telecommunications (Cal-(IT)²), and the Digital Cultures Project. Adding to the ferment, the University of Southern California (a private university unconnected with the University of California) boasts renowned faculty, including Anne Balsamo, Perry Hoberman, Marsha Kinder, and Michael Naimark, although Hoberman and Naimark only have adjunct status.

Hand in hand with the growing recognition of art and design as valuable collaborative partners in scientific and engineering research, artists have demanded a terminal degree that creates parity with other scholars who hold a Ph.D. The Planetary Collegium was perhaps the first such programs. Others have followed suit, creating a variety of models to support doctoral research involving collaboration between artists, engineers, and scientists. In responding to the demand for hybrid graduate education, they have simultaneously created hybrid scholars to supervise the education of subsequent interdisciplinary artist/scholars. Indeed, graduates of the Planetary Collegium now hold prominent positions as department heads at important institutions, including Vesna at UCLA, Seaman at RISD, and Kac at SAIC.

As in industry, visionary individuals have played an important role in catalyzing the creation of these programs. At the moment, I know of only a handful of such pioneering PhD programs: the Digital Media program at Georgia Tech's School of Literature, Communication, & Culture;¹⁵ Media, Art, and Technology program at UC Santa Barbara; and right here: the Digital Arts and Experimental Media (DX Arts) program directed by Richard Karpen and Shawn Brixey at the University of Washington. Whether you know it or not, you are part of a very select group of pioneering faculty and students. I believe, moreover, that these programs and those who take part in them are engaged in a historically significant process of cultural

transformation that can be compared to what took place at the Bauhaus and the MIT Media Lab.

Other notable US graduate programs include the Arts Computation Engineering program directed by Penny at UC Irvine, which has proposed a Ph.D. program, and the Arts, Media, and Engineering program chaired by Thanassis Rikakis at Arizona State University, which also aspires to create its own Ph.D. program. The Design | Media Arts program chaired by Vesna at UCLA, the Art and Technology program led by Ken Rinaldo at The Ohio State University, the Digital Media MFA program at RISD directed by Bill Seaman, and the Art and Technology Program chaired by Eduardo Kac at the School of the Art Institute of Chicago all encourage interdisciplinary research leading to the MFA degree. The recent creation of the Center for New Media at UC Berkeley, the current construction of the Experimental Media and Performing Arts Center at Rensselaer Polytechnic Institute, and the recent emergence of the Art|Sci Center at UCLA spearheaded by Vesna and Gimzewski further indicate a dedication to interdisciplinary research involving artists at US universities. While Europe may lead in terms of the existence of established production facilities and exhibition venues, the US seems to be leading the way with respect to academic programs.

Concluding Reflections: Criticism, History, and Interdisciplinary Collaboration

Although 18th and 19th century aesthetic theories asserted the autonomy of art, the development by artists of one-point perspective, anatomy, photography, and virtual reality attest to the deeply intermingled histories of art, science, and technology. Moreover, throughout history, artists have created and utilized technology to envision the future, not just of art, but of culture and society in general. Unfortunately, the history of art has neglected to incorporate this visionary conjunction of art and technology into its canon in any systematic

way. Just as the insights afforded by diverse methodologies, ranging from feminist theory to Marxism to post-structuralism, have resulted in substantial revisions of the art historical canon, so the history of art must be revised in a way that explicitly addresses interactions between art, engineering, and science. This revision will be required not just because it corrects an obvious omission but because contemporary artists are increasingly employing science and technology as artistic media and students are increasingly being trained to use them as standard materials and techniques. As their work enters mainstream artistic practice and becomes embraced by galleries, museums, and other cultural institutions, the need for contextualizing it within a larger history will demand the production of that narrative. The growing number of scholarly publications in the field suggests that this process already has begun. Again, I refer you to my online bibliography.¹⁶

The initial growth of graduate programs that support advanced research involving interdisciplinary collaboration resulted from the pioneering efforts of visionary artists, engineers, scientists, other scholars, and administrators. Its current expansion is being fueled in part by market demand from students who believe that an interdisciplinary education will best prepare them for the creative challenges of the present and future. To serve this demand, the greatest number of new faculty-hires in art departments at US universities are in the interdisciplinary field of media art. University administrators are coming to recognize that multimedia development is a growth area both for the education market as well as for global economic markets, and that corporate and foundation support of graduate research in this area can provide substantial external funding. Leading contemporary artists in the US are now directing interdisciplinary graduate programs at major US research institutions they are now training a new generation of hybrid practitioners, some of whom have already entered the professoriate.¹⁷ As the number of such hybrid practitioners increases, their impact on the

centrality of technology and science in the practice of art and design (and vice-versa) also will force a reconsideration of the canons of art history and the histories of science and technology. Ideally, such work will create new forms and structures of meaning that expand the languages of art, design, engineering, and science, and that open up new vistas of creativity and invention.

In order to understand the evolving relationship between art and technology in contemporary art (and vice-versa) one must grapple with the complex processes and products that sustain and result from these collaborations. Scholarship in this arena may require an interdisciplinary approach that joins together humanistic methods of interpretation with social science methods of analysis. One might imagine a historian or critic simultaneously acting as ethnographer and consultant, or collaborating with social scientists to undertake research. Despite the wealth of interdisciplinary research being undertaken, and despite the general recognition that there are substantial challenges to collaboration across disciplines, there is scant metacritical research that studies best practices, working methods, and contextual supports and hinderances. It is unclear, for example, to what extent models of interdisciplinary collaboration currently employed in industry can be applied to AST research at universities. If the academy is serious about interdisciplinary collaboration, then it must dedicate resources to study these issues and to develop guidelines, training methodologies, and project management techniques that will help fulfill the promise of interdisciplinarity. As recent scholarship produced by psychologist Brigitte Steinheider and artist Legrady suggests, collaborations between artists and engineers and scientists furnish a valuable test-bed for such research, while interdisciplinary analysis offers an insightful approach to its evaluation.¹⁸

Artists, designers, scientists, and engineers who collaborate together must, on some level, share or develop a common language, negotiate mutually rewarding goals, establish clear communication and effective knowledge sharing, and develop a scheme for project coordination

and management.¹⁹ The need for shared languages and goals raises many questions, not only for the collaborators, but for cultural critics and historians who wish to analyze and comment on them. If a goal of these collaborations is the creation of hybrid forms, what have been referred to as “boundary objects,” that transcend the disciplinary limits of any single field, then the evaluative methods particular to a given discipline may not offer adequate measures of success or failure. New methods for ascertaining the value of the new hybrid outcomes of interdisciplinary collaboration must be developed just as new methods for teaching, cultivating, and recognizing the value of hybrid scholars must emerge. Perhaps even new forms of critical and/or historical exegesis and means of publication and distribution must be developed to articulate and convey the meaning and significance of evolving forms of interdisciplinary creation.

On a philosophical level, if the fruits of hybrid research are not strictly science, or engineering, or art, then one must wonder about the epistemological and ontological status of these hybrid forms: what exactly are they? What new knowledge do they produce or enable? What is their function in the world? On a practical level, the future sustainability of hybrid research depends on answering these questions, because the academic careers of scholars whose work fuses disciplines will be cut short if their contributions are not recognized and rewarded within the university. In order to pursue interdisciplinary collaboration as a full-time career, Klüver was forced to quit a lucrative and secure job at Bell Labs and rely on philanthropic sources to fund E.A.T. and provide for his livelihood. If universities are unable to adopt appropriate methods for evaluating and granting tenure to interdisciplinary professors, they will create a disincentive for future scholars to pursue interdisciplinary work, disrupt the ability of existing interdisciplinary faculty to mentor future hybrid researchers, and prevent the ascension of interdisciplinary faculty to positions of power and authority in academe, where

they can influence infrastructural change and facilitate the creation of new forms of invention, knowledge, and meaning.

First presented in abridged form at Cyberart Bilbao in May 2004. An earlier version of this essay appears in *Leonardo* 38:5 (2005): 415-18 as part of a special section of papers drawn from the panel, "Artists in Industry and the Academy: Interdisciplinary Research Collaborations," chaired by the author at the 2004 annual conference of the College Art Association. Reprint forthcoming in Jill Scott, ed., *Artists in Labs*. Vienna: Springer. This version was delivered as a lecture for the DX Arts program at the University of Washington, Seattle, January 25, 2006.

¹ Julie Martin, correspondence with the author, March 2, 2005. The statement was reprinted in *E.A.T. News* 1:3 (November 1, 1967): 5.

² Experiments in Art and Technology, "Trailer Introducing Ten Documentary Films from *9 evenings: theatre & engineering, October 13-23, 1966*." VHS. Author's transcription of Cage's oral statement.

³ Billy Klüver, Interview with the author, September 19, 1997.

⁴ *E.A.T. News* 1:1 (January 15, 1967); 2.

⁵ Jeffrey Shaw, who, as Director of Visual Media at the ZKM, helped gain EU funding, has noted that "enlightened administrator" is not an oxymoron in the European context; rather, visionary administrators in Brussels recognize the broad and important implications of supporting the intersections of culture and technology, particularly of an international nature. (Jeffrey Shaw, Interview with the author, November 24, 2002, Karlsruhe.)

⁶ "About MARCEL: Arts Electric Interviews Don Foresta," February 4, 2005. <<http://www.arts-electric.org/articles/050204.foresta.html>>.

⁷ Other notable US reports include: Century, Michael. (1999). *Pathways to Innovation and Culture*, Centre for Research on Canadian Cultural Industries and Institutions / Next Century Consultants; Harris, Craig, ed. (1999) *Art and Innovation: The Xerox PARC Artist in Residence Program*. Cambridge: MIT Press; Jennings, Pamela (2000). "New Media Arts/New Funding Models"; Naimark, Michael (2003). *Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability*"; and Lizbeth Goodman and Katherine Milton, eds. (ND). *A Guide to Good Practice in Collaborative Working Methods and New Media Tools Creation*, AHDS Guides to Good Practice <http://www.ahds.ac.uk/creating/guides/new-media-tools/>

⁸ See D. Plautz, "New Ideas Emerge When Collaboration Occurs" *Leonardo* vol 38 no 4 (2005): 302-9.

⁹ S. Diamond, "Degrees of Freedom—Models of Corporate Relationship: When Should 'Hands-Off' Be 'Hands-On,' When 'Hands-On,' 'Hands-Off? Paper delivered at the panel, "Artists in Industry and the Academy: Interdisciplinary Research Collaborations," 2004 College Art Association Annual Conference, Seattle. .

¹⁰ H. Haacke, "Museums, Managers of Consciousness, in Rosalyn Deutsche, et al., *Hans Haacke: Unfinished Business*, ed. Brian Wallis (New York and Cambridge, Mass.: New Museum and MIT Press, 1985): 60-73.

¹¹ E. Shanken, "The House that Jack Built: Jack Burnham's Concept of Software as a Metaphor for Art," *Leonardo Electronic Almanac* 6:10 (November, 1998) <<http://mitpress.mit.edu/e-journals/LEA/ARTICLES/jack.html>>

¹² I am grateful to Jill Scott for an enlightening discussion of these matters, Zürich, May 6, 2004.

¹³ Other collaborators included Carolina Cruz-Neira, Tom DeFanti, Robert Kenyon, and John Hart.

¹⁴ See D. Cox, "Renaissance Teams and Scientific Visualization: A Convergence of Art and Science", *Collaboration in Computer Graphics Education, SIGGRAPH '88 Educator's Workshop Proceedings*, (New York: ACM, 1988): 81 – 104.

¹⁵ Interdisciplinary faculty includes Philip Auslander, Jay David Bolter, Michael Matteas, and Eugene Thacker Diane Gromala continues in an adjunct role at Georgia Tech, despite her appointment in 2005 at Simon Fraser University in Vancouver, Canada. Similarly, Sha Xin Wei also formerly at Georgia Tech, recently was appointed to a position at Concordia.

¹⁶ See http://artextra.com/biblio_interdisciplinary.html

¹⁷ For example, Rob Nideffer, Associate Professor of Studio Art and Information and Computer Science at UC Irvine earned a Ph.D. in Sociology with an interactive CD-ROM dissertation, perhaps the first of its kind. He fulfilled his thesis requirements for an MFA in Studio Art with an online artist's book, a hard-copy book of code, a special issue of the online journal *Speed*, and a physical installation.

¹⁸ B. Steinheider and G. Legrady, "Interdisciplinary Collaboration in Digital Media Arts: A Psychological Perspective on the Production Process" *Leonardo* 37:4 (2004): 315-21.

¹⁹ *Ibid.*