Picturephone and the Information Age

The Social Meaning of Failure

KENNETH LIPARTITO

> *"It can't be done Tom! It can't be done! . . . To transmit pictures over a telephone wire, so that persons cannot only see to whom they are talking, as well as hear them—well, to be frank with you, Tom, I should be sorry to see you waste your time trying to invent such a thing."*
>
> —Victor Appleton, *Tom Swift and His Photo Telephone*

At the 1964 New York World's Fair, the American Telephone and Telegraph Company (AT&T) unveiled a "new way of communicating." Picturephone, a system that transmitted the user's image and voice simultaneously over telephone lines, would "displace today's means of communication" by century's end. Following Ladybird Johnson's inaugural call (fig. 1), spectators lined up for their chance at a technology that promised to end urban congestion, render travel obsolete, and save time and energy. Physical presence could be mimicked by Picturephone's ability to convey a "feeling of proximity and intimacy with the other party."[1] Meanwhile, AT&T prepared to spend some five hundred million dollars turning its World's Fair exhibit into a commercial product for home and office.[2] At Bell Telephone

Dr. Lipartito is professor and chair, Department of History, Florida International University, Miami, Florida. His most recent book is *Investing for Middle America: John Elliott Tappan and the Origins of American Express Financial Advisors* (2001). He thanks Sheldon Hochheiser and the AT&T Archives in Warren, N.J., where much of the research for this article was conducted, and the National Science Foundation and the Office of the Provost at Florida International University for financial support of the research and writing. A number of colleagues offered invaluable suggestions and gave generously of their time in reading earlier drafts: Lara Kriegel, David Kirsch, Robert Britt Horwitz, Eric Schatzberg, W. Bernard Carlson, and Richard John.

0040-165X/03/4401-0003$8.00

1. Julius P. Molnar, "Picturephone Service: A New Way of Communicating," *Bell Laboratories Record* 47 (May/June 1969): 135. For the epigraph, see Victor Appleton, *Tom Swift and His Photo Telephone: Or, The Picture that Saved a Fortune* (New York, 1914), 1.

2. Estimates range from one hundred to five hundred million dollars spent on Pic-

FIG. 1 The inaugural call on the Mod I Picturephone, placed by Mrs. Lyndon B. Johnson in Washington, D.C., to the Picturephone center in Grand Central Terminal, New York, 1964. (Courtesy of the AT&T Archives, Warren, N.J.)

Laboratories, Picturephone's birthplace, project chief Julius Molnar waxed lyrical over the possibilities. "Rarely does an individual or an organization have an opportunity to create something of broad utility that will enrich the daily lives of everybody," he gushed.[3] As if to confirm his optimism, a few years later Picturephone appeared in Stanley Kubrick's science fiction masterpiece, *2001: A Space Odyssey*.[4]

Bell executives apparently missed the irony of product placement in a

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turephone. AT&T Archives, Warren, N.J. (hereafter ATT), box 64 10 01 10, Picturephone. A. Michael Noll, "Videophone: A Flop that Won't Die," *New York Times*, 12 January 1992, sec. 3; A. Michael Noll, "Anatomy of a Failure: Picturephone Revisited," *Telecommunications Policy*, May/June 1992, 307.

3. Molnar, "Picturephone Service."

4. In the film, NASA scientist Heywood Floyd uses a futuristic version of Picturephone (complete with Bell System logo, the monopoly still intact in 2001) to call his young daughter from the moon on her birthday. Though the technology works perfectly—full motion, full color, and a shot that is wide and deep—a fundamental connection is missing. The four year old is distracted, her mother is out, the baby-sitter is in the bathroom. When asked what she wants for her birthday, the girl responds, "a telephone." The man's closing words are "tell your mother I telephoned, and that I will telephone again tomorrow." As is often the case in films, the telephone suggests both presence and absence. Technology extends human experience, but also seems poised to erase the difference between people and machines, making humans superfluous to their own tools.

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movie about the dehumanizing consequences of technology.[5] A short while later, however, the company's "most highly publicized new product" in a decade was being derided as "the Edsel of the Bell System."[6] Picturephone started hurtling back to earth almost as soon as it was launched. In 1964, Picturephone booths were installed in New York, Chicago, and Washington, D.C., offering the public a chance to pay sixteen to twenty-seven dollars per minute for a call. They had only seventy-one patrons in their first six months. By 1970 they were down to zero. That same year, service on customer premises debuted in Pittsburgh, with predictions of twelve million subscribers by millennium's end. But long before that AT&T had pulled the plug. It was a mercy killing. Pittsburgh had only thirty-two sets in service in 1972, and the number was falling. The only other city to offer commercial service was Chicago. Sets there peaked in 1973 at 453. Picturephone limped along through 1974, when a handful of customers were paying $87.50 per month for the service. By 1978 the only Picturephones remaining sat on desks at Bell Labs. They were quietly removed some time later.[7]

Picturephone, it would seem, is simply the story of a failure. Most accounts treat it as such. In retrospect, it seems clear that video telephony was bound to fail. It was too intrusive, crossing the boundary of privacy necessary for human communications. It was superfluous, adding little information to voice alone, especially considering its high price. Yet these explanations, which have been offered in both popular and scholarly accounts, do not quite add up to a full answer. Examined more carefully, it is not so clear that Picturephone was doomed to fail. More importantly, the very terms "success" and "failure" do not capture the full import of this story.

In what follows, I will use Picturephone to tell a somewhat different tale. This product, which consumed millions of dollars, received the full backing of the world's largest private corporation, and was conceived in millennial terms as the communications technology of the future, points us instead to the deeper cultural paradigms that shape technological change. Picturephone's story shows that failures are not inherent in hardware but constructed by contingent social conditions. It shows how even so-called failed technologies can construct technical systems. Finally, it raises trou-

5. Nor could they have been aware of the double-edged meaning of Picturephone's appearance in the Nixon White House. It was reported that several of Nixon's aides had them, but that there was none in the President's office. "Picturephone Placed in Offices of Top Aides at White House," *New York Times*, 3 December 1970.

6. "What Would Happen if We Abandoned Picturephone Service?" 14 June 1972, ATT, box 64 10 01 10, Picturephone.

7. ATT, box 64 10 02 05, Picturephone Chronology; ATT, box 64 10 01 10, Picturephone. E. A. Mainzer, "AT&T's Picturephone: The Dysfunctionality of a Functional System," ATT, box 64 10 01 02. This paper was written for a graduate seminar in United States history at New York University in 1984. It is one of the best studies of the technology ever done.

bling questions about freedom in the constitution of technological society. Failed technologies, far from being dead ends or even mere cautionary tales, may persist well beyond their material life. They may reinforce rather than undermine technological paths, even when those paths are questionable or undesirable. Failures, the story of Picturephone suggests, can echo like footfalls down corridors not taken, leading us to the present.[8]

The Problem of Failure in the History of Technology

Failure has long been recognized as having resonant and lasting effects. Usually, however, the narrative move has been to set success and failure against each other in a deterministic way, or to compact the effects of failure in some sort of evolutionary framework. Both treatments make failures into preludes for improvement and progress. Reason and functionality prevail as failures are relegated to their proper place, either the dustbin of history or the lesson book of progress. The possibility of uncertain, unintended, or undesired outcomes from failure is not considered.

This approach is most obvious in traditional Whig histories of technology. Successful technology functions well and meets social needs; failures miss these marks. Good products are accepted by consumers, while bad ones are rejected. Stories of failure are often written as "reverse Whig" histories, cautionary tales of error or hubris.[9] Studies of catastrophic accidents, such as marine disasters, airplane crashes, and bridge collapses still treat failure in this fashion.[10]

The simple Whig narrative has largely been abandoned by historians of technology in favor of social construction. Failures may result not from

8. One might argue this is to be expected, since failures teach inventors and engineers how to do better the next time. I will take up the issue of learning through failure below, and also argue that this "rational" interpretation of failure ignores the important role of technological enthusiasm and cultural projection in setting technological agendas.

9. On Whig history of technology, the classic article is Eugene Ferguson, "Toward a Discipline of the History of Technology," *Technology and Culture* 15 (1974): 13–30. Whig history is one type of functional analysis, in which social outcomes are seen to be the results of their contributions to a well-functioning society. Failures are then functional breakdowns. A major example of this approach is William Fielding Ogburn, *Social Change with Respect to Culture and Original Nature* (Gloucester, Mass., 1964). See also Toby Huff, "Theoretical Innovation in Science: The Case of William F. Ogburn," *American Journal of Sociology* 79 (September 1973): 261–77. A sophisticated attack on determinism is found in Wiebe Bijker, *Of Bicycles, Bakelite and Bulbs: Toward a Theory of Sociotechnical Change* (Cambridge, Mass., 1994), 7, 75, 124–26.

10. See, for example, Henry Petroski, *Design Paradigms: Case Histories of Error and Judgment in Engineering* (Cambridge, 1994); James Adams, *Flying Buttresses, Entropy and O-Rings: The World of an Engineer* (Cambridge, Mass., 1991); Matthys Levy and Mario Salvadori, *Why Buildings Fall Down* (New York, 1994); Steve Casey, *Set Phasers on Stun and Other True Tales of Design, Technology and Human Error* (Santa Barbara, Calif., 1998).

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poor design or malfunction but from the resistance of social groups—residents living downwind of nuclear power plants, say. Or products may fail when complementary assets, services, or financing are unavailable. Ideological values about what is best or most modern may push innovators to pursue some lines of research and abandon others.[11] In short, the same combination of institutions and values that shapes presumably successful technologies can operate on failed ones as well. What constitutes success or failure is more a matter of social values and expectations than performance or function.

When treated as social constructs, Graeme Gooday notes, failures exhibit a high degree of "interpretative flexibility."[12] He points out that the terms success and failure are actually applied selectively and for reasons that depend on the narrative strategies of the author. For example, although most innovative efforts never bear fruit, we condemn only certain ones as failures.[13] Many so-called successful technologies, moreover, are themselves compromises among various design features and functions. It is unclear how many users a technology must have before it is a success, or whether failure is judged by market share or financial performance. Even in the expanded compass of causation of the social construction narrative, many thorny questions remain. Do niche technologies qualify as successes if they never reach a mass audience? What role does time play—how long must a technology languish before it can be dismissed as failure? If a failed technology suddenly enjoys a renaissance, what do we call it?

Such questions should warn us against assuming that failure is self-evident. Indeed, they cut at the validity of the very category failure (and success, too). Some historians have been able to preserve these categories through various narrative strategies of stability. In doing so, however, they construct an unwitting social determinism to do the work formerly done by technological determinism. Walter Vincenti, Henry Petroski, and others, for example, have treated failure as part of an evolutionary process. Here fail-

11. David Kirsch, *The Electric Vehicle and the Burden of History* (New Brunswick, N.J., 2000); Margaret Graham, *RCA and the Videodisk: The Business of Research* (New York, 1986). For more examples, see *Social Studies of Science* 22, no. 2 (1992), a special issue on failed technologies. On the role of ideology, see Eric Schatzberg, *Wings of Wood, Wings of Metal: Culture and Technical Choice in American Airplane Materials, 1914–1945* (Princeton, N.J., 1999).

12. Graeme Gooday, "Rewriting the 'Book of Blots': Critical Reflections on Histories of Technological 'Failure,'" *History and Technology* 14 (1998): 265–91; Bijker, 270. As with successful technology, what matters with a failure is not whether it "works" in either the technical or the commercial sense. Rather, what becomes accepted is thought to work, while what is rejected is deemed inherently unworkable. Acceptance is an open-ended social process.

13. Hans-Joachim Braun states that only 20 percent of R&D projects become commercial successes; "Introduction: Symposium on Failed Innovations," *Social Studies of Science* 22 (1992): 215.

ure is inserted into a narrative emphasizing selection and learning. It becomes functional to technological change, teaching designers to avoid mistakes.[14] In like manner, user-based approaches see the consumer as exerting a control over technology that can correct the misconceptions of producers. Knowledgeable consumers pick only those products that match their preferences.

Both evolutionary and user-centered models posit a collective rationality. Learning through failure moves technology toward closure, a definite form that is the outcome of improvement, redesign, or rejection.[15] Crucial here is the assumption that actors can make clear choices, even under conditions of uncertainty about the future. This assumption works only if the evolutionary path is narrow—that is, if the possible technological options are limited to a range of knowable choices. It also requires that outcomes be self-evident, that we know a failure when we see one. Suppressed are the hard cases, ambiguous outcomes, and elongated time frames noted above. As a result, evolutionary models may end up repeating, in ironic fashion, the Whig narrative of social progress. Reversing the Whig assumption that any success is a socially desirable outcome, they sometimes treat failures as socially desirable. User-centered approaches do likewise when they code the user as the average citizen rejecting ill-conceived products proffered by large corporations or centrist states.[16]

The assumptions about knowledge, learning, and behavior embedded in these progressive evolutionary accounts have been met with skepticism

14. Henry Petroski, *To Engineer Is Human: The Role of Failure in Successful Design* (New York, 1985); Walter Vincenti, *What Engineers Know and How They Know It* (Baltimore, 1990); Richard Nelson and Stanley Winter, *An Evolutionary Theory of Economic Change* (New York, 1982); Richard Nelson, "The Co-evolution of Technology, Industrial Structure and Supporting Institutions," *Industrial and Corporate Change* 3 (1994): 47–63. An excellent example of learning for the market can be found in Margaret B. W. Graham and Bettye H. Pruitt, *R&D for Industry: A Century of Technical Innovation at Alcoa* (New York, 1990), 157–80.

15. Gooday (282–84) offers a somewhat different critique of Pinch and Bijker's notion of closure and consensus among all relevant social groups. As Bijker (n. 9 above, 124–26) notes, stabilization of artifacts, or closure of the once open frame, can be assisted by using previous artifacts as arguments. For a balanced, symmetrical view of success and failure that focuses on debate over what constitutes a failure and why, see Ben Marsden, "Blowing Hot and Cold: Reports and Retorts on the Status of the Air-Engine as Success or Failure, 1830–1855," *History of Science* 36 (1998): 373–420.

16. They do so in part by not treating failed and successful technologies symmetrically. It is largely assumed that if a product succeeds, it must be well-enough designed to meet consumer needs and wants. Failures, on the other hand, are presumed to be flawed or inherently undesirable simply because they did not survive. Such tautology leaves much of the contested history of technology out. The assumption here is that people can readily distinguish failure from success. On symmetry in science, see David Bloor, *Knowledge and Social Imagery*, 2nd. ed. (Chicago, 1992), 129, 177; in technology, Wiebe Bijker, "Do Not Despair: There Is Life after Constructivism," *Science, Technology and Human Values* 18 (1993): 113–38.

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from a variety of sources. In his classic study *Normal Accidents*, Charles Perrow pointed out that complex systems are often opaque and nonlinear, making it difficult to identify the cause of breakdown.[17] Restrictions on human knowledge and certainty may thus prevent failures from teaching designers clear, objective lessons or frustrate the rationality of consumer choice. If, for example, producers lack knowledge about the probabilities of outcomes, they have no rational way to judge the chances of success of their research projects. Similarly, users may not be able to choose products that match their preferences, if preferences are unclear and unstable when products are still in development.[18] Narrow-track evolutionary models assume that actors can match their subjective desires to a known menu of options. Technology on the wide track confronts actors with too many choices, too many options, and an uncertain future. With such ambiguity and uncertainty, technology cannot be shaped by rational knowledge and a clear distillation of experience alone.[19]

Instead, I would argue, choices and decisions about technology must rely on some projected model or paradigm. When confronted with a truly new technology that had not been an option before, consumers must find some way to match the unexpected with previous experience. When decid-

17. Charles Perrow, *Normal Accidents: Living with High Risk Technologies* (New York, 1984). For a more recent treatment of risk, see Carlo C. Jaeger et al., *Risk, Uncertainty, and Rational Action* (London, 2001). Similar issues are tackled with respect to commercial technology in Edward Tenner, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences* (New York, 1996). See also Dietrich Dörner, *The Logic of Failure: Why Things Go Wrong and What We Can Do to Make Them Right* (New York, 1996).

18. Perrow's analysis proceeds from a discussion of the "technical" limits of rationality in complex systems to a discussion of the culturally specific (and variable) meanings of rationality; see Perrow, 304–52. A similar approach to technology choice and diffusion more generally can be found in Kristine Bruland, "Resistance to New Technology in Scandinavia: An Historical Perspective," in *Resistance to New Technology: Nuclear Power, Information Technology, and Biotechnology*, ed. Martin Bauer (Cambridge, 1995), 126–27. On the role of uncertainty in the market and how that upsets notions that market outcomes are rational and functional, see Richard Nelson, "Research on Productivity, Growth and Productivity Differences: Dead Ends and New Departures," *Journal of Economic Literature* 19 (September 1981): 1046; Giovanni Dosi and Richard Nelson, "An Introduction to Evolutionary Theories in Economics," *Journal of Evolutionary Economics* 4 (1994): 153–72.

19. The strongest critique along these lines is to be found in G. Dosi and M. Edigi, "Substantive and Procedural Uncertainty: An Exploration of Economic Behaviors in Changing Environments," *Journal of Evolutionary Economics* 1 (1991): 145–68. They examine both strong substantive uncertainty, where agents lack sufficient information about possible outcomes, and procedural uncertainty, where agents lack the knowledge and ability to make clear, rational choices. The first corresponds to an ambiguous and open-ended technological world, in which outcomes are not self-evident and preferences and desires are themselves undergoing continual revision. The second corresponds to the problems brought about by too many options, unclear lessons, and opaque connections between behaviors and outcomes. In both cases the stability of the terms "success" and "failure" come into question.

ing which research ventures to pursue, innovators must start from existing knowledge and project forward. In both cases, ideas about technology and culturally specific frameworks of meaning come into play. Users and producers base their choices on what they think might happen, or how they feel about images of technology not yet brought to closure. These ideas may be irrational or nonrational, the result of assumptions, passions, and enthusiasms. Or they may result from power struggles among contending actors to lay claim to the technological future.[20] In either case, what matters is more the meaning a technology can convey than the functions it can initially perform.

In this model of technology, failures have a new role to play. They contribute to the construction of the frameworks of meaning that guide decisions in an open-ended technological world. They fit into a narrative about technology that helps to shape the range of choices we can make. In contrast to evolutionary, learning, or user-centered approaches, however, failures cannot be safely dismissed as lessons learned or mistakes avoided. Instead, as active parts of the technological narrative, they may in ironic fashion extend the vision that gave them temporary life.

Rosalind Williams has recently argued that we need a way to explain how even socially constructed technologies can still drive outcomes in unintended or undesired ways. She asks us to consider the "ensembles" of technological artifacts that can "reshape language, time, space and consciousness through technological means." In a different vein, John Staudenmaier has argued that no technology ever leaves us quite the same as before, imposing costs and constraints on certain aspects of social life or on certain groups.[21] Both are pointing us toward the ways in which technologies become so tightly integrated with society as to form systems that organize existence, materially and mentally. Williams and Staudenmaier were speaking about the "nonfailures" we commonly study, but, as I shall argue, failures have similar consequences and perform similar acts, even as they disappear from view. Socially constructed failures are also socially resonant, and they shape our options for the future. Indeed, because failures are in fact the more common technological experience, they may be more impor-

20. I follow here suggestions in John Staudenmaier, "Henry Ford's Relationship to 'Fordism': Ambiguity as a Modality of Technological Resistance," in Bauer, 147–51. Dosi and Edigi, 153–64, make similar suggestions about the need for representations, interpretations, rules, and routines as a way of dealing with such uncertainty. Simple problem-solving behavior and rational choice will not work under conditions of strong uncertainty or ambiguity. On framing, see Naomi Lamoreaux, "Reframing the Past: Thoughts about Business Leadership and Decision Making under Uncertainty," *Enterprise and Society* 2 (December 2001): 632–59.

21. Rosalind Williams, "'All That is Solid Melts into Air': Historians of Technology in the Information Revolution," *Technology and Culture* 41 (2000): 665. John Staudenmaier, "The Politics of Successful Technologies," in *In Context: History and the History of Technology*, ed. Stephen H. Cutcliffe and Robert C. Post (Bethlehem, Pa., 1989).

tant in this regard than those artifacts we treat as successes. Through a form of technological ideology, failures are able to exert a mystifying influence on the present.

Explaining Picturephone

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The stories told about Picturephone neatly recapitulate the different stages in the historiography of failure. Initially, debate centered around Picturephone's technical performance. Engineers at AT&T (as well as engineering-minded supporters ever since) argued that the technology "worked," at least in the narrow technical sense. Signals traveled down twisted pairs of copper wire fast enough to produce a black-and-white image of 250 active lines at thirty frames per second, not far off broadcast television quality. Occupying a frequency range of 1 megahertz (about a quarter of television's bandwidth) the image was of sufficient quality for head and shoulder shots of the speakers, with some distortion in sudden movements. Equipment consisted of a 5-inch screen, camera, loudspeaker, and cathode-ray tube, all integrated into a desktop display unit fashioned by noted industrial designer Henry Dreyfuss.[22]

Greater controversy arises when this technical performance is measured against consumer expectations and demands. Most explanations of Picturephone's fate, in fact, center on the "consumption junction." In 1964 as today, most premises were served by a single copper-wire loop, or circuit, incapable of carrying sufficient information for full-motion video. Picturephone required two additional circuits for the video signal, while the existing loop handled audio. The extra wires permitted a high-quality picture without compression, but the tradeoff was price. Customers paid line charges of $1,200 per year at a time when median family income was $9,800. Including equipment rental, users in Pittsburgh were paying $160 per month, plus long-distance fees. Even at the lowest rates, $75 per month, Picturephone's monthly charge was the equivalent of $300 at today's prices.[23]

Price was just one limitation to Picturephone. Another may have been privacy. By bringing the parties to a telephone conversation face to face,

22. Good technical descriptions of the system can be found in Irwin Dorros, "The Picturephone System: The Network," *Bell System Technical Journal* 50 (February 1971): 221–33, and A. D. Hall, "Experiments with Picturephone Service," *Bell Laboratories Record* 42 (April 1964): 114–120. By today's standards, the display's long, backward-projecting tube made for a big footprint. Before commercial release, Dreyfuss came up with Mod II, or "P-squared" (P2), as it was popularly known at Bell Labs. This version took on the shape and aspect of the now familiar computer terminal. Mod II included new capabilities, such as a zoom lens, a larger screen, and the ability to handle graphics.

23. Bureau of the Census, *Statistical Abstract, 1999* (Washington, D.C., 1999), 478, table 750. ATT, box 64 10 01 04, Picturephone. "A Policy Status Review," 15 June 1972, ATT, box 64 10 01 22. In addition, the customer equipment was expected to have much higher maintenance costs than a regular telephone.

Picturephone eliminated the invisibility that users found both comforting and practical. How many of us, really, want the person we're talking to to see what we're doing while we talk? If privacy is the right to be left alone, then Picturephone seemed positively criminal, shackling users with eye contact and demanding their undivided attention. According to the technology's most skeptical critic, A. Michael Noll, it was so intrusive that telephone companies would have made more money had they "threaten[ed] the public with the service and charge[d] extra not to have it."[24]

Price and privacy constitute the traditional explanation for Picturephone's demise. Close reliance on market logic and consumer autonomy places this explanation squarely in the social rationality camp. The presumed closure, however, is not as tight as it appears. Taken apart piece by piece, the case reveals suppressed possibilities and alternatives, unanswered questions and a slippage of categories that undermines deterministic notions of success and failure.

Many new technologies, for example, start out with high prices and limited functionality yet become popular.[25] With Picturephone, high rates were expected to be temporary, and the initial target market was business users and corporations; household rates would be lower. Over time, the costs of customer equipment (30 to 40 percent of the total) and of transmission were expected to fall substantially, thanks to digital lines, new solid state components, and mass production.[26] Other evidence suggests that price was not the major problem. In the 1990s, AT&T introduced a second Picturephone, called Videophone. It dispensed with the extra lines by compressing the video signal, making it far cheaper to use. Yet the product still failed to catch on.[27]

The evidence on privacy is also mixed. Consumers rarely discussed pri-

24. Noll, "Videophone: A Flop that Won't Die" (n. 2 above).

25. Cellular telephones originally cost $4,000, with high per minute charges. The IBM PC was introduced in 1981 at almost $2,900, equivalent to approximately $5,600 today. Both products eventually achieved mass-market penetration. For another comparison, in 1890, annual unlimited telephone service in New York City cost $20 per-month, about 40 percent of average family income; this was a much higher percentage of average income than Picturephone. Myron Magnet, "How to Compete with IBM," *Fortune*, 6 August 1984; "Behold, The Bell Tel Cell War," *Fortune*, 22 December 1986.

26. Where analog video transmission "cost" three hundred to four hundred voice channels, coding the video signal for digital carriage would cut this opportunity cost by a factor of ten or more. D. W. Nast and I. Welber, "Transmission Across Town or Across Country," *Bell Laboratories Record* 47 (May/June 1969): 163. A. D. Hall, 115. See "A Policy Status Review" for extensive information on costs. To help users pay for service, AT&T debated pricing schemes to replace monthly rates with a 43¢ per minute usage fee. ATT, box 64 10 02 04, Picturephone.

27. Videophone sold originally for $1,500, and the price dropped within a year to $800. Before it was removed from stores, customers could purchase a pair for $700 each. At ten frames per second, quality suffered. Still, images were full color and calls could be made through ordinary lines at standard voice rates. In 1997, a videophone called the C-Phone sold for $299, with a $9.95 per month service contract and calls charged at 29¢

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vacy as a concern, and it received little notice in articles or surveys done at the time. Though marketing studies revealed that people did not want to be "on display" all of the time, half those surveyed also said that they valued seeing the person they were talking to.[28] "Once the novelty wears off," studies of video communications indicated, users experienced an "enhanced feeling of proximity and intimacy with the other party."[29] In fact, one criticism was that Picturephone was not intimate enough. "It's not really a very personal form of communication," stated an executive at Westinghouse, an early adopter of Picturephones. "There's no color. You're gray. I'm gray."[30] Such reactions suggested that improvements to make telepresence "simulate as closely as possible the naturalness of face-to-face conversation" were the answer. Rather than force users to "sit and stare," Picturephones were equipped with speakers and a swivel base to allow users to move around the room. Video calls would go on much like in-person conversations, with hand, eye, and body movement.[31]

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per minute. At the other extreme, videoconferencing takes advantage of high-capacity systems such as fiber optics and satellites, providing plenty of bandwidth for a high-quality picture. But neither the low-price nor the high-bandwidth versions of video telephony have enjoyed much popularity. Andrew Pollack, "Technology: Video/Phone Conferences," *New York Times*, 26 May 1983, sec. D; "AT&T's Video Meeting Rooms Just Can't Draw a Crowd," *Business Week*, 14 January 1985, 126H; Keri Guten Cohen, "Personal Technology: Era of the Picture Phone Draws Near, Videoconferencing Grows," *Atlanta Constitution*, 19 December 1993, sec. R; Mike Mills, "Lockheed Martin, AT&T Plan Satellite Services: Video Conferencing, Other Applications Seen," *Washington Post*, 5 October 1995. With Picturephone, Chicago rates were half those in Pittsburgh, with a thirty-minute per month calling allowance, but the outcome in Chicago was the same as Pittsburgh. ATT, box 64 10 02 05, Picturephone Chronology; Mainzer (n. 7 above).

28. Noll, "Anatomy of a Failure" (n. 2 above), 307–16. Abstracts of Picturephone Market Studies, 1973, ATT, box 64 10 01 26. AT&T in fact acknowledged some of these intrusive qualities. An in-house cartoon about the device ran with the caption, "Ohhh, you were in the shower"; "Bell Labs Announce 'Picturephone'," *195 Magazine*, September 1956, 16–17. Half of those surveyed also believed it would be "impolite" not to use the video function. Jeffrey Rohlfs notes the mixed reactions to Picturephone and the limited role issues of privacy played; *Bandwagon Effects in High-Technology Industries* (Cambridge, Mass., 2001), 84–85. Surveys placed Picturephone midway between telephone and in-person meeting in terms of effectiveness.

29. Julius P. Molnar, "Picturephone Service—A New Way of Communicating," *Bell Laboratories Record* 47 (May/June 1969): 135. Video plus voice created what AT&T engineers called "telepresence," which added the "inestimable quality of an in-person conversation to an ordinary telephone call"; A. D. Hall (n. 22 above), 114. Studies of videoconferencing suggest that it takes time for users to learn the unique or new characteristics of new media, even when these media seem close to or connected to older media. See Robert Johnsen, Jacques Vallee, and Kent Collins, "Learning the Limits of Teleconferencing: Design of a Teleconference Tutorial," in *Evaluating New Telecommunication Services*, ed. Martin Elton, et al. (New York, 1976). Walter Kiechel III, "The Art of Teleconferencing," *Fortune*, 2 May 1983, 295.

30. Boyce Rensberger, "Growth of Picturephones Disappoints Bell System," *New York Times*, 3 July 1971.

31. Dorros (n. 22 above), 222–23. Picturephone's designers were not unresponsive

For a technology that bombed so spectacularly, consumers were surprisingly ambivalent in their views.[32] We should therefore pause to reconsider what we learn by studying the reception of new technology by the public. In the absence of definite consumer expressions from the time, explanations for failure such as a concern over privacy can only be inferred from outcomes. This risks the fallacy of tautology; failure becomes the evidence that privacy was a problem, and privacy the problem that explains failure. At best, privacy remains an unproven assertion. More broadly, privacy, like price, was only an initial problem in a technology undergoing change and development.[33]

Turning from users to producers, some critics have implicated corporate negligence in the death of Picturephone. As a technology-driven monopoly whose primary mission was optimizing a complex system, AT&T was likely to be poor at marketing new products. One wag described the post–World War II Bell system as a conspiracy of engineers to take advantage of the innocence of businessmen.[34] The managerial structure at AT&T remained highly centralized, in contrast to the trend toward more product-oriented, decentralized management in big firms after the Second World War. Centralized organizations force too much strategic decision making to the top, isolating market-savvy line managers, who are needed to coordinate research, manufacturing, and sales.

Ironically, however, Picturephone received greater marketing care than most other products coming out of Bell Labs. "[C]ustomers' needs largely determine the fundamental technical and economic requirements" of Picturephone, explained an early article. It was "essential to know what uses a customer will consider most important."[35] If anything, Bell managers

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to concerns about privacy, either. There was a button to cut off video, and another feature permitted the caller to see him- or herself on screen before placing a call. Commercial users could display a company logo or trademark when calls were answered. The technology was thus adaptable to various attitudes about privacy.

32. On ambivalent attitudes toward privacy, see Dorothy Nelkin, "Forms of Intrusion: Comparing Resistance to Information Technology and Biotechnology in the U.S.A.," in Bauer (n. 18 above), 383.

33. Part of the problem of explaining away Picturephone by reference to privacy is that some users might well want a technology precisely because others regard it as intrusive—superiors using videophones to control and discipline subordinates, for example. It does no good to counter these possibilities by reference to Picturephone's demise, for doing so still constructs a tautology by which the outcome is always the sufficient answer to the possible alternative. It is akin to the problem of experimental regress in science, addressed in Harry Collins and Trevor Pinch, *The Golem at Large: What You Should Know about Technology* (New York, 1998), 40.

34. Alvin von Auw, *Heritage and Destiny: Reflections on the Bell System in Transition* (New York, 1983), 182. On the problems with consumer-oriented innovation at Bell Labs, see Sally Clarke, "Negotiating Between the Firm and the Consumer: Bell Labs and the Development of the Modern Telephone," in *The Modern Worlds of Business and Industry*, ed. Karen Merrill (Turnhout, Belg., 1998).

35. A. D. Hall (n. 22 above), 114.

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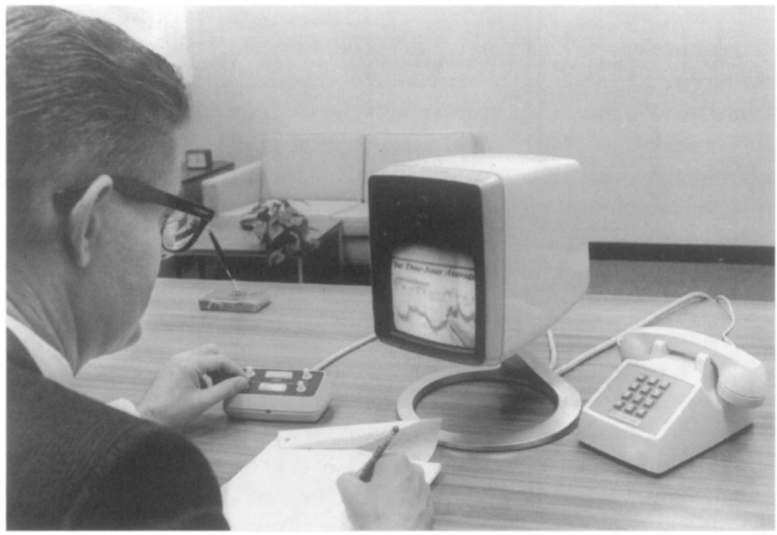

FIG. 2 The Mod II Picturephone as information terminal. (Courtesy of the AT&T Archives, Warren, N.J.)

believed they were moving with notable caution in bringing the product to market. "A lot of people are requesting it and want it," one member of the organization stated, but "[w]e need to see who is willing to pay the price."[36] To this end, a marketing laboratory was set up in Chicago for the purpose of adding the customer to the engineering equation.[37] There Bell Labs personnel discovered that much important information was conveyed by body language and gained other insights into the potential uses of their technology.

More importantly, Picturephone was not as one-dimensional as it might seem from its brief history. As preferences were revealed by customer feedback, AT&T added new features. Marketing trials, for example, uncovered strong business demand for graphic information and data. Customers could connect Picturephones to mainframe computers to retrieve information (fig. 2).[38] Add-on options allowed the display of 35-millimeter slides and electrocardiograms. A flip-out mirror captured images of documents placed on a desk. Toward the end of the Picturephone episode, moreover, AT&T

36. John Noble Wilford, "Television Use is Nearing Reality," *New York Times*, 19 March 1967, sec. 3.

37. "What Would Happen if We Abandoned Picturephone Service?" (n. 6 above). On customers as just another variable in the engineering equation, see Clarke.

38. Julius P. Molnar, "The Telephone Plant of the 1970s," *Bell Laboratories Record* 49 (January 1971): 4–12. Memorandum, 10 December 1971, ATT, box 64 10 01 20. Noll, "Anatomy of a Failure" (n. 2 above), 309. William K. Stevens, "Picturephone Screen Shows Data, Not Faces," *New York Times*, 23 June 1968, sec. 3.

changed. The company shifted to the product-oriented organization suited to a more competitive environment.[39] By the time Videophone appeared, in the 1990s, AT&T was a competitive firm with a much different structure. None of this, however, made any difference to video telephony's fate.

Standard treatments of Picturephone grounded in market logic and user consensus cannot bring closure to this story because they project a rather static and unambiguous image of technology. The search for a fatal flaw, such as price or privacy, ignores important temporal and distributional issues. Different actors can have quite different views of a technology, and their views can change with time and circumstance, as technologies change. As I shall argue, we must take a longer and more problematic view of the innovation process. We must also treat consumer acceptance of new technology as indeterminate and highly contingent. When we do, the seeming stability of a technology vanishes, and the interpretive flexibility surrounding it increases enormously.

Why Picturephone?

To get at these issues, we have to start with a new question. We should ask not "Why did it fail?" but rather, "Why was it invented?" Picturephone's invention can be traced to internal developments within AT&T and to the larger culture of information technology in the 1950s and 1960s. Within AT&T, Picturephone was an unusual but timely project. The company had made its reputation through slow, incremental system improvements overseen by self-confident scientists and engineers. Their confidence had only risen with the prestige of big science after World War II. But it also rode atop a nagging sense of doubt. Voice telephony was approaching universal penetration. What could replace it as the company mission? Only something equally daring—a second communications revolution—would do. Indeed, within the company Picturephone was referred to as the new mission. It would have, company supporters hoped, an impact as great as voice telephony itself.[40]

Broader developments from outside reinforced internal company culture. The 1950s and 1960s were rife with speculation over a coming information revolution. Sound and voice were to be merely the first steps toward a twentieth-century media extravaganza. Whatever the public's later doubts, Picturephone's initial reception encouraged such feelings. A hit at the 1964 World's Fair, the technology dazzled science popularizer Hugo Gernsback, who was sure that it would make shopping a breeze and per-

39. ATT, box 64 10 01 21, Picturephone. See also Mainzer (n. 7 above) for a thorough critique of company structure.

40. Donald Janson, "Picture-Telephone Service Is Started in Pittsburgh," *New York Times*, 1 July 1970.

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form many other everyday functions. "No more inadequate streets, overcrowded stores, impossible traffic," he predicted.[41] An early article in the *New York Times* discussed such uses as "eyeball-to-eyeball confrontations" between managers and their bosses, interviews with faraway job applicants, and magazine layouts completed over the phone, all portending a major impact on "the nation's telephoning habits and way of doing business." An airline vice president suggested that the technology would help to solve some of the nation's transportation problems. General Telephone and Electronics (GTE) and Stromberg-Carlson, both AT&T competitors, worked on their own videophones, and similar projects were underway in England, France, and Sweden.[42]

Faith that image inevitably followed voice had a long history. The nineteenth-century American utopian Edward Bellamy, for example, had imagined homes of the future filled with piped-in images and sound, a prediction echoed half a century later by the French poet Paul Valery. "Just as water, gas and electricity are brought into our houses from far off," Valery wrote, "so we shall be supplied with visual or auditory images, which will appear and disappear at the simple movement of the hand."[43] Radio and television seemed to be fulfilling these promises, but there was room for "point-to-point" communications to join in. The 1939 New York World's Fair featured a "pharmacy of the future" with a television phone booth, a fanciful early attempt to merge these two technologies. But connecting voice and image was no mere inventor's fancy. In the 1930s, Germany used telephones and television to construct a video communications network that stretched from Berlin to Leipzig to Munich.[44]

Futurologists after World War II reinforced this sense that image was growing more important than sound or text alone. A RAND study cited by Picturephone advocates at Bell Labs called for an integrated approach over a single network for multiple media—data, voice, text, graphics, and

41. Hugo Gernsback, "Picturephone in the Future," *1965 Forecast*, December 1964. Gernsback reminded his readers of television pioneer V. K. Zworykin's motto: "Whenever it is too difficult, too dangerous, too expensive, too inconvenient, too inaccurate, too far, too hot, too cold, too high, too low, too dark, too small to observe directly—use television." This was one in a series of annual forecasts that Gernsback, "the father of science fiction," published in booklet form, beginning in December 1951, and distributed to friends and associates. Back issues are on-line at www.third-wave.com/ird/forecast.

42. Wilford (n. 36 above); E. M. Dickson and R. Bowers, *The Video Telephone* (New York, 1973).

43. Valery, quoted in David Harvey, *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* (New York, 1989), 346. Further examples from literature can be found in R. W. Burns, "Prophecy into Practice: The Early Rise of Videotelephony," *Engineering Science and Education Journal* 4 (December 1995): S39.

44. On the German system, see Burns.

video—in both digital and analog form.[45] It was almost an engineering road map to the media future. By the time Picturephone debuted at the 1964 World's Fair, information and communications had become one of the most important sites for imagining technology's future. "It's a Small World," the fair's cloying refrain, expressed this sense that technology was shrinking the globe.[46] Just as Picturephone entered the commercial market, an influential Carnegie Commission report on technology in education began with these words: "By the year 2000 . . . a significant proportion of instruction in higher education may be carried on through information technology." Visual and telecommunications media were expected to open access through what today would be called "distance learning."[47]

Consciously or not, promoters of Picturephone were implicated in a historical narrative, based in fact but constructed with a powerful teleology that made Picturephone seem all but inevitable. Projections of technology, even uninvented technology, sometimes take on a life of their own, creating a "cultural imperative" that influences inventors, engineers, and business people. Usually these projections are based on the extension of an existing and well-understood pattern. The addition of sight to sound with telephones seems to have followed this course.[48]

All predictions, of course, must be taken with a grain of salt. Yet the same language of prediction resonated within the halls of Bell Laboratories. In justifying Picturephone, company promoters noted that history showed "the dominance of television over radio," indicating "how important vision plus sound is to human beings."[49] AT&T had developed the first working television in the 1920s and built a videophone prototype, called Iconaphone, in 1930.[50] By 1953, just before work on Picturephone began, the company committed itself to determining "the requirements of a complete system" of

45. "What Would Happen if We Abandoned Picturephone Service?" (n. 6 above).

46. Sheldon J. Reaven, "New Frontiers: Science and Technology at the Fair," in *Remembering the Future: The New York World's Fair from 1939–1964* (New York, 1989), 84–85. The Disney attraction *It's a Small World* was first set up at the 1964 fair. Communications was the second most important technology on exhibit, next to the space program. With its elliptical shape, Picturephone's display unit emulated the fair's central artifact, the Unisphere depicting earth orbited by space capsules.

47. Carnegie Commission on Higher Education, *The Fourth Revolution: Instructional Technology in Higher Education* (New York, 1972).

48. The term is Michael Brian Schiffer's. See his "Cultural Imperatives and Product Development: The Case of the Shirt-Pocket Radio" *Technology and Culture* 34 (1993): 98–113. Schiffer notes the role that Hugo Gernsback played in the miniature radio as well.

49. Mathews Memo, 20 March 1972, ATT, box 64 10 01 20.

50. Mainzer (n. 7 above). Fascination with image in fact had a long history at the company. In 1889, AT&T vice president E. J. Hall predicted: "Some day we may see as well as hear our distant friends when we communicate with them by telephone"; Burns (n. 43 above), S35.

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information conveyance, in place of piecemeal additions to existing facilities.[51] That same year Mervin Kelly, the head of Bell Labs, stated that soon "very cheap broadband channels in the local plant" would offer possibilities for television or movies directly to the home over the telephone network.[52] These channels would also handle a growing demand for data, which was expected to surpass voice traffic soon.[53] Reckoning that the telephone network should be capable of delivering this information cornucopia, AT&T launched into Picturephone as a key part of its information strategy.

The politics of communications reinforced the company's commitment to Picturephone as the proper object for that strategy. In the 1950s, broadcasters successfully pressed the Federal Communications Commission (FCC) to open Bell's monopoly on microwave channels. By the late 1960s the commission was licensing "special" common carriers to compete on a limited basis with AT&T. Business users with heavy data needs were contemplating building their own faster, cheaper links to bypass the telephone network. Futurologists of the 1960s waxed eloquent with predictions of vast banks of information carried into the home, but none of this necessarily required AT&T.[54]

Picturephone had distinct advantages in this political environment. In 1956 AT&T had settled a major antitrust case by agreeing not to enter new lines of business or exploit "discreet inventions or subsystems" beyond the scope of the telephone network.[55] This line of business restriction would create problems later, as computer and communications applications began to merge in the 1960s. The first FCC "computer inquiry" in fact occurred in

51. R. V. Hartley, Report of the Committee to Consider New Research and Development Possibilities, 31 August 1953, ATT, box 86 02 02 02, Transmission Research. The power of these predictions is also attested to by the fact that they have never really stopped. In the 1990s, boosters continued to produce sober market studies and reports for use in the industry that predicted "the next step in the video revolution is likely to be two-way video communication" and "In the next millennium we are certain to be increasingly 'telepresent' both at work and play," predictions designed to prove that interactive telephony was a sure bet. Lawrence Vanson et al., *Video Communications: Forecasts of Markets and Technologies* (Austin, Tex., 1992), ix, and G. R. Walker and P. J. Sheppard, eds., *Telepresence* (Dordrecht, 1999), 1.

52. Hartley, Report of the Committee to Consider New Research.

53. "Data Communications in the Bell System: An Interview with V. M. Wolontis," *Bell Laboratories Record* 48 (August 1970): 195–202.

54. Nicholson to Davis, 14 November 1972, ATT, box 64 10 02 05. The danger of competition from cable and television networks was perceived early. See R. V. Hartley, Transmission Research, ATT, box 86 02 02 02. Also Robert Britt Horwitz, *The Irony of Regulatory Reform: The Deregulation of American Telecommunications* (New York, 1989), 146–48. Dan Schiller, *Telematics and Government* (Norwood, N.J., 1982). Microwave Communications Incorporated (MCI) would take advantage of this opening and help end the Bell monopoly in 1984. Edward M. Dickson, *The Video Telephone: Impact of a New Era of Telecommunications, A Preliminary Technology Assessment* (New York, 1974).

55. Horwitz, 222–28. "What Would Happen if We Abandoned Picturephone Service?" (n. 6 above).

1966, just as Picturephone was being readied for market. Picturephone, however, would take "maximum advantage of existing telephone equipment" and "complement the telephone network," avoiding antitrust pitfalls.[56] .

Technically as well, Picturephone seemed the tool AT&T needed to stay ahead in the information race. New media services required a vastly expanded and updated network infrastructure. The best way to increase network capacity was by moving to higher transmission frequencies. The greatest untapped potential for higher frequency transmission was "pulse-code modulation," or digital methods.[57] A move to digital technology was thus vital to AT&T's future. It would keep the firm out front on transmission, and it would afford opportunities to deliver enhanced services through the network within the boundaries of regulation.

Though conceived as an analog device, Picturephone was expected to benefit immensely from digital technology. Digital T-1 lines, for example, were just being deployed in interoffice trunks, the circuits that connected switching points. These lines would soon be connecting high-end customers directly to the telephone network. Data as well as voice traffic could be "efficiently intermixed along the same transmission facility" with Picturephone signals, once everything was coded in digital form.[58] As Picturephone went public, the executive director of data systems at Bell Laboratories wrote: "We see an evolution toward an ultimately all-digital switched network." Digital technology would "provide a wide spectrum of customer services, including Picturephone." Just as important, this new technology could meet customers' demands for high-speed data transmission. Combined with improved switches, the digital network would allow users with Touch-Tone phones to input and respond to machines—a service that exploded in the 1980s. Picturephones would permit a higher-level interface with machines, a "bonus" for the subscriber using it for communications anyway.[59]

56. Horwitz, *Irony of Regulatory Reform*, 141–45. On this as related to Picturephone, see "A Policy Status Review" (n. 23 above). Peter Temin and Louis Galambos, *The Fall of the Bell System* (New York, 1987), 41–47. Dorros (n. 22 above), 222. Regulation had another implication that favored Picturephone as well. With the FCC's 1968 "Carterphone" decision Bell lost control over terminal devices, and new competitors quickly undercut Western Electric prices. A proprietary system such as Picturephone, on the other hand, did not face such price competition. In 1968, AT&T chief executive H. I. Romnes touted Picturephone as a network interface between people and computers, responding to pressures from other manufacturers to permit attachments of data devices to Bell's network. Gene Smith, "Face-to-Face Telephones on the Way," *New York Times*, 5 January 1968.

57. M. E. Hines, "A Discussion of Some Long Range Problems in Transmission Research and Development," 9 December 1958, ATT, box 86 02 02 02, Transmission Research.

58. Nast and Welber (n. 26 above), 163. Molnar, "The Telephone Plant of the 1970s" (n. 38 above). E. F. O'Neill, ed., *A History of Engineering and Science in the Bell System: Transmission Technology, 1925–75* (Short Hills, N.J., 1985), 581–88.

59. "Data Communications in the Bell System" (n. 53 above), 197–98.

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Picturephone's potential as not just a video device but a communications interface was crucial here. "Adding Picturephone to the network," Bell engineers noted, "makes it more versatile and potentially useful for a variety of wideband communications services," such as data transmission and computer networking.[60] "For each face to face use," a marketing study concluded, "scores involving viewing of written material or objects can be found."[61] "It now seems that growth of Picturephone service," wrote its chief advocate, Julius P. Molnar, "will be the main impetus to increase long-haul digital transmission facilities." "Telephone and data services" would "rid[e] the coat tails of the larger and broader band network that is needed for Picturephone."[62] In the ideal world, Picturephone and the digital network would evolve in tandem, with Picturephone providing "the main impetus" for rapid upgrade to a digital network.[63] So long as the telephone network was used primarily for voice calls, customers had little reason to pay for broadband lines to the home; copper would do just fine. But should Picturephone take off, they would be able to justify the costs of upgrading their local lines. Once they did, all sorts of new services could be delivered through the widened channel.[64]

Seen in this expanded context and time frame, Picturephone the failure no longer lines up cleanly in our sights, ready to be dispatched with a single causal bullet. Picturephone the desktop box was only the user interface to a vast new architecture of information conveyance. It fit a long tradition of adapting the telephone network to new communications needs. Using multiplexing (carrying multiple channels on a single circuit) techniques in evolution since the 1920s, Bell had expanded its network by the 1950s to carry network television programming. Possibilities for the future were "embarrassingly rich"—hundreds, indeed thousands, of channels on a single circuit. Picturephone would be one of several "new and more complex services" carried by this low-cost addition to network capacity "without disrupting existing communications services."[65]

Picturephone also went well beyond face-to-face video telephony. It led a corporate strategy to build the infrastructure for a predicted new media age. Data communications and other informational uses, as much or more

60. Nast and Welber, 162. Evidence for the connections between Picturephone and other data and digital needs abounds. A good summary of the connections is found in ATT, box 64 10 01 06, Picturephone.

61. Memorandum, 10 December 1971 (n. 38 above).

62. Molnar, "The Telephone Plant of the 1970s," 4–6.

63. Ibid., 5.

64. On local loops, see ATT, box 86 01 01 02, Transmission Developments, and R. V. Hartley, Transmission Research (n. 54 above). On the relationship between Picturephone and digital switching, see O'Neill (n. 58 above).

65. Molnar, "The Telephone Plant of the 1970s" (n. 38 above), 4. Nast and Welber (n. 26 above), 162. In the 1930s, AT&T had used coaxial cable to carry national radio programming as well.

than video telephony, were part of Picturephone's justification from the start. Bell engineers saw themselves at work on "a technological marriage between the computer and the Picturephone" that would permit households to receive local weather reports, watch the stock market, and make airline reservations. Responding to "a strong trend in business to get information from a computer rather than by shuffling papers," Picturephone would serve as an input/output device for accessing files and recalling information encoded in digital form. Video capacity would provide a way of displaying data, sending text and graphical images, selling products, and conducting classes. All of this would be supported by a high-speed digital network.[66]

Once we understand these multiple motivations, it becomes clear that Picturephone was situated in a discourse about technological change that stretched deep into the past and was projected far into the future. Picturephone was a product in evolution and a component of a system undergoing change. Its status becomes much more problematic. Should it be seen as a necessary step in the development of new information technology and services, in the manner suggested by evolutionary views? Can it be treated as part of the learning process, whereby users communicate their wishes back to producers who, by trial and error, find the best design match? Or can it, as I will argue, be placed in a narrative of technological change that shaped the world of information technology?

Consider the following thought experiment. Imagine that AT&T had not abandoned Picturephone, but instead continued to refine it by offering another service, such as text messaging or electronic mail. Once enrolled through electronic mail, users would have had reason to take Picturephone service. As the network of subscribers grew, there would have been opportunities for additional features, such as data, audio, and video communications.[67] Notice that this counterfactual scenario is quite similar to what actually happened with personal computers and the Internet, which now perform many of the functions envisaged for Picturephone. Sold originally for reasons other than communications, personal computers grew popular and became well-established, and hence were available to be connected to the Internet. The Internet itself began as a government-sponsored project

66. Wilford (n. 36 above); Stevens (n. 38 above). If this seems speculative, my point is merely that there was no way at the time to know whether or not such uses would work. For example, on the same day Picturephone was being discussed in the *New York Times* there was an adjacent article on large-scale integration of microcircuits, a project that some thought years away and others believed would make computers "small, simple and inexpensive enough to become household appliances." William D. Smith, "Circuit Technology Yielding Compactness and Versatility," *New York Times*, 19 March 1967, sec. 3.

67. There is no guarantee this scenario would have worked out, of course. The French Minitel, a great leap forward in videotext technology for its time, was supplanted by the Internet. Nearly everyone missed the significant role that electronic mail would play in information services.

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with a military and scientific agenda. No one witnessing the birth of the computer or the beginnings of the Internet could have realistically predicted that they would lead to today's World Wide Web.[68] Indeed, with its head start Picturephone might well have been the more likely candidate. From a terminal accessing mainframes (very much like the early Internet) it could have evolved toward desktop computing, data transmission, and information retrieval. Notice that by assuming that Picturephone brings us to the present, we eliminate all concerns about privacy, use, and value. We know, at the very least, that this was *one* possible way history could have gone.[69]

History would have offered this shadow Picturephone plenty of opportunities to fail, too, as it does any new technology. But an experiment in the counterfactual helps us remember that the architects of Picturephone had a strong grasp on trends in information technology. They grappled with the same information-laden vision of the future as did promoters of computers and the Internet. Behind Picturephone lay the same world of digital switches and broadband lines. Part of Picturephone's original conception were what seemed at the time fantastic notions of individuals manipulating vast banks of data, buying and selling products (fig. 3), and conducting classes "on line."[70]

The question we must now turn to is why Picturephone's life ended and other equally immature and cumbersome systems enacted the very future that Picturephone's designers had hoped for for their invention. To answer it, we must examine the interaction between producers of technology and

68. To sharpen this point, note how we can we look back at ENIAC, that 80-foot-long, 30-ton behemoth that delivered less computing power than the average personal computer of today, as the first successful step on the road to the computer revolution. Yet no one who saw ENIAC could have realistically deduced today's computers from it. They could have imagined them, as Bell imagined the new world of digital information, but they could not have foreseen the exact steps in getting to them. It is important to remember that how a technology gets started and becomes accepted and how it later evolves may well be two separate things, though the second requires the first. Thus, Alexander Graham Bell originally thought of the telephone more as a broadcast device, a "radio," not a point-to-point medium. The radio began as point-to-point, but later broadcasting was "invented." The Internet was largely point-to-point electronic mail, and the World Wide Web only came later.

69. I am not arguing that today's technology was the only possible outcome. I am only taking today for the sake of argument, since it is at least *one* possible world that we can be sure could exist. Nor do I mean that video telephony would have succeeded had AT&T done things differently. Indeed, I believe that this service's most likely fate was to be a minor player, akin to a successor system, PictureTel, today. But to limit Picturephone to video telephony is to take an extremely narrow view of the technology. The real question here is not about the failure of stable, well-defined products, but about the path by which new information services of many kinds emerged out of humble beginnings, out of technologies that looked and performed far differently at the outset.

70. In fact, it came closer than we might imagine. At one point, the government offered AT&T the opportunity to take over the Internet, an opportunity it declined for reasons I have as yet not explored.

FIG. 3 What might have been: P-commerce. S. T. Slater, of the Benay-Albee Novelty Co., New York, displays a hat to a potential buyer in Chicago. (Courtesy of the AT&T Archives, Warren, N.J.)

consumers. As with hardware, though, we must not treat demand in a static fashion. Instead, we must look at the second part of the innovation process, the construction of the market for information and of a group of information subjects.

Constructing the Information Subject

Many studies of consumer behavior begin with a democratic and individualistic notion of the marketplace. Individuals make choices, which add up to a social choice. This approach assumes that actors have fixed, stable preferences and clear strategies for achieving what they want. Can preferences be taken as essentially given and individual? Or do they change as technology changes? Are consumers isolated actors, or are they best understood as part of a collective?

These questions have divided students of consumer society for decades, and no doubt will continue to generate controversy. But when dealing with complex systems of technology, particularly interactive communications technology, the literature has identified a number of ways in which consumption is collective and contingent. Consumers of system products often act on the basis of what else is available and what others do. Individual choices hinge on group behavior when the value of an interactive system depends on the universe of all other users. Fax machines, for example,

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"failed" when first introduced to consumers in the 1970s because there were too few people to send faxes to. It took a decade before the market grew large enough to be self-sustaining. The telephone itself initially had to overcome this chicken-and-egg problem, or network externality.[71]

As a network technology, Picturephone faced the same hurdles. Studies of Picturephone have noted how the limited base of early users undercut its appeal.[72] But Bell engineers understood the problem at the time. Consumer surveys indicated that people were willing to pay as much as $125 per month if they could be guaranteed that there would be a face on the other end.[73] Business users stated that they would find Picturephone much more appealing when long-distance service was available, greatly increasing the number of parties they could call.[74] If growth is self-reinforcing, as this evidence suggests, how do markets for interactive technologies get started? What convinces the potential user that a new product will indeed become popular? What, in short, makes markets "tip" in the direction of self-sustaining growth? This classic network issue continues to shape information technology today.

Producers can take a variety of strategic actions to tip a market in favor of growth. For example, companies can sponsor networks to encourage a single technological standard.[75] Standardization eliminates incompatibility

71. There is a vast literature on networks, externalities, and strategy. See, for example, Brian Arthur, *Increasing Returns and Path Dependence in the Economy* (Ann Arbor, Mich., 1994); Stanley Besen and Joseph Farrell, "Choosing How to Compete: Strategies and Tactics in Standardization," *Journal of Economic Perspectives* 8 (1994): 117–31; Paul David and Edward Steinmueller, "The Economics of Compatibility Standards and Competition in Telecommunications," *Information Economics and Policy* 26 (1994): 21–41; Joseph Farrell and Garth Saloner, "Standardization, Compatibility, and Innovation," *Rand Journal of Economics* 16 (1985): 70–83; Landis Gabel, ed., *Product Standardization as a Tool of Competitive Strategy* (Amsterdam, 1987); Peter Grindley, *Standards, Strategy and Policy* (Oxford, 1995); Michael Katz and Carl Shapiro, "Systems Competition and Network Effects," *Journal of Economic Perspectives* 8 (1994): 93–115. Diffusion also depends on the existence of complementary goods and services. Color televisions, for example, were first sold in 1954, but few people bought them until the mid-1960s, when color programming became available. See Michael Cusumano, Yiorgos Mylonadis, and Richard Rosenbloom, "Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta," *Business History Review* 66 (1992): 51–94; Andrew Pollack, "The Perils of Consumer Electronics," *New York Times*, 22 March 1981, sec. 3.

72. Rohlfs (n. 28 above), 83–90. However, he only considers the video aspect of Picturephone, and not its other possible uses.

73. Fitzwilliam to McKeage, 30 December 1971, ATT, box 64 10 01 20. The letter refers to a survey by Yankelovich, a public opinion survey company.

74. Initial commercial release of Picturephone in Pittsburgh was confined to the downtown business loop only, in part because of technical problems with connecting users who resided more than a mile from a switching point and in part because AT&T awaited approval of intercity tariffs from the Federal Communications Commission. Janson (n. 40 above); Rensberger (n. 30 above).

75. In technologies with network issues, a single sponsor can frequently overcome

between components and puts to rest fears that an orphan technology will leave customers stranded. Firms can move early with the first product to market, building a user base that others are encourage to join. User groups and communities provide another method of building demand, serving as fonts of learning and experimentation that encourage trials of new technology. Firms can also deploy rhetoric and persuasion to bring aboard the skeptical by connecting the old with the new or touting new products as improvements or extensions of familiar ones.[76] Timing product introduction, building support among early users, gaining market share, setting standards, representing oneself as the agent of the future: these are all ways of tipping the market in favor of a new product.[77]

Seen in this way, innovation is a process of social change that involves the gradual enrollment of new users and the creation of a platform or standard from which further product innovation can take place. This is a subtle but important difference from traditional views of consumption as a purely individualistic, rational process. Definitions of functionality, value, and performance are not obvious at the beginning. When products or systems are still in development, users are attracted by the promises they convey, the image of the future they represent, and by what other users may do.[78] Demand is defined through use and by user groups, who organize around new technology. Users are no more fully formed than are machines at the start, since part of what it means to be a user is to have a machine to use.[79] Thus, it is problematic to say that users simply accept new technology.

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the roadblocks to diffusion. Michael Katz and Carl Shapiro, "Technology Adoption in the Presence of Network Externalities," *Journal of Political Economy* 94 (1986): 822–41. On the disadvantages of being first, see Joseph Farrell and Garth Saloner, "Competition, Compatibility and Standards: The Economics of Horses, Penguins and Lemmings," in Gabel, 1–21.

76. AT&T seems to have used all these methods to try to establish Picturephone. It built a complete system that had no competing standards; it launched Picturephone as the first product to harness the new capacity of the telecommunications network and provide new services. It began with video telephony, the vertical extension of voice telephony, a better "face-to-face" way of communicating, but redesigned its product to incorporate features of text and data communications. See Mainzer (n. 7 above), 13–14; Molnar, "The Telephone Plant of the 1970s" (n. 38 above); Memorandum, 10 December 1971 (n. 38 above).

77. One does not have to believe that producers hold all the cards or have total power over consumers to see how networks can be tipped in one direction or another by strategic action. Indeed, given the delicate balance tipping implies, a very small volume of power can have large consequences. A small move in favor of a product or service at an opportune moment may start a stampede.

78. As Wiebe Bijker puts it, things "work" for the relevant social group, but the group is partly constituted by the thing; "Do Not Despair" (n. 16 above), 119.

79. With technology, as Bruno Latour puts it, "existence precedes essence." Having something that can attract key supporters (existence) matters more than perfect functionality (essence). Bruno Latour, *Aramis, or The Love of Technology* (Cambridge, Mass.,

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Still, connecting users to new technology is not easy. An important part of the process of enrollment is attracting an initial group of enthusiasts to the machine. They nourish a fledgling device and provide the resources it needs to grow, change, improve, and attract still more supporters. Most consumers are conservative, waiting to see how a new product fares and what others do before making their choices. Some users, however, are different—the initial adopters. For various reasons, they want to be the first to have a new product or service. They tend to be technically sophisticated and have a much different set of preferences than do latecomers. These initial users can often refine early products, serving as test agents for products that have yet to make their way into the larger society. The Internet and personal computers benefited from small cadres of sophisticated early adopters who put up with inconveniences and contributed to product refinement.[80]

Large firms have problems here with what Clayton Christensen has identified as the "innovator's dilemma." They tend to overshoot the mark with products too expensive or too sophisticated for early adopters and experimenters.[81] Or, focused on current customers and the bottom line, they ignore crucial niche markets, where low-cost, low-risk learning and experimentation can take place. Innovation is difficult for established firms not because they place technical competence ahead of economic or commercial reality, but because they are too caught up with everyday commercial reality and current customer needs to break away from those constraints and set in motion the forces that would create a new "relevant social group" for a new technology.

This is the problem AT&T confronted with Picturephone. Integrated into the telecommunications network, Picturephone was treated as an enhancement of existing service rather than as a new consumer product in an uncertain market for information. It was launched precisely at the moment when AT&T was facing competition in its main markets as well as political pressure that limited its options in new markets. These conditions reinforced a desire to aim at a mass market initially, rather than focus on niche markets.[82] In seeking a mass market, AT&T was unable to exploit the

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1996), 48. Steven Woolgar, "Configuring the User," in *A Sociology of Monsters: Essays on Power, Technology and Domination*, ed. John Law (New York, 1991), 57–72.

80. On early adopters, see Eric von Hippel, *The Sources of Innovation* (New York, 1988). This is a simplified version of the building of the Internet, of course. For more detail, see Janet Abbate, *Inventing the Internet* (Cambridge, Mass., 1999), and Tim Berners-Lee, *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by Its Inventor* (San Francisco, 1999).

81. Clayton Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston, 1997).

82. In a public statement responding to pressure to permit equipment made by non-Bell manufacturers to attach to the network, just months before the Carterphone deci-

potential for learning among early adopters, which might have helped in developing new information services.

Late in the game, in fact, a group of younger Bell engineers experimented with niche marketing ideas, such as giving Picturephones away to an entire town to see how users would respond, or trying to connect distinct subgroups within the larger population.[83] Such plans were regarded as either too expensive or as potential violations of regulatory laws requiring that services be priced at cost, and so never came to fruition. As a monopoly, AT&T was particularly sensitive to the charge that it was blocking competition through predatory pricing. Likewise, the corporation was unable to "cross subsidize" Picturephone by introducing it at low rates to build demand, a move that invited charges of monopoly abuse.[84] As the dominant firm in the industry, AT&T was hamstrung in carrying out the sort of demand-side innovations its product needed.

The issues here can be grouped under the category of path dependency or, perhaps better, historical contingency.[85] Picturephone's failure can be

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sion ended Bell's monopoly on equipment, Chairman H. I. Romnes explicitly mentioned Picturephone as the interface between users and the network, which would handle not only communications but data and other services. Gene Smith (n. 56 above).

83. Peter Vargo, memorandum, 22 February 1972, ATT, box 64 10 01 21, Picturephone. On Picturephone user groups, see Mathews Memo, 20 March 1972, ATT, box 64 10 01 20. Alternate plans for marketing Picturephone are discussed in "What Would Happen if We Abandoned Picturephone Service?" (n. 6 above); ATT, box 64 10 01 04, Picturephone; "A Strategy for Launching Picturephone Throughout the United States," 1 December 1971, ATT, box 64 10 01 15, Picturephone. On the need for nonvideo content, see "Comments on E. Goldstein," memorandum, 23 February 1973, ATT, box 64 10 01 24, Picturephone. Memorandum, 10 December 1971 (n. 38 above). On the advantage of niche markets for new broadband services, see Björn Fjaestad and P. G. Homlöv, "The Swedish Market for a Public Switched Multi-Purpose Broadband Network," in *Evaluating New Telecommunications Services*, ed. M. C. J. Elton, William Lucas, and David Conrath (New York, 1978), 489–507.

84. For example, in 1971 an application to begin Picturephone service in New York was denied because rapid growth and change in the conventional telephone network had resulted in breakdowns and service delays. Bell was told to fix its existing services first, a need that was recognized in-house as competing with the demands of Picturephone. The Federal Communications Commission likewise objected to the introduction of a high-cost service that had so little apparent demand. "P.S.C. Bars Picturephone Test," *New York Times*, 27 April 1971. Other agencies also refused to allow the firm to recoup its start-up costs in this new technology or to set prices low to encourage early users. See Rohlfs (n. 28 above), 86.

85. The literature on path dependency is vast. See, for example, Paul David, "Clio and the Economics of QWERTY," *American Economic Review* 80 (1985): 332–37; W. Brian Arthur, "Competing Technologies: An Overview," in *Technical Change and Economic Theory*, ed. Giovanni Dosi et al. (New York, 1988), 590–607; Paul Pierson, "Increasing Returns, Path Dependence, and the Study of Politics," *American Political Science Review* 94 (June 2000): 251–67; Carl Shapiro and Hal Varian, *Information Rules: A Strategic Guide to the Network Economy* (Boston, 1999).

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traced to this complex social process, a series of small steps and choices, none of them fully determined by structural factors. Failure thus stemmed not from some functional flaw in the product or from a traditional notion of consumer demand, but rather from a contingent sequence of actions that reflected the influence of expectations, assumptions, uncertainty, politics, and self-reinforcing decisions. This is the best answer to the highly interpretative question, "Why did Picturephone fail?" Alter any number of circumstances and failure might have been success. Had there been less political pressure, or had the market been more competitive, with more firms experimenting with video technology, or had AT&T been able to overcome the blinders imposed by its own position, things might have turned out differently. Yet this sort of socially enriched, contingent, and contextual explanation also opens up new problems. It calls into question the very notions of success and failure, and in doing so undermines one of the major premises behind the social construction of technology.

Contingency and the Narrative of Technological Change

We cannot know what might have been with Picturephone. But the point of stressing contingency and path dependence is not to resurrect a dead technology. Rather, it is to focus our attention on the problem of closure in designating a technology a failure. When we widen the field of vision and see technology as a system undergoing dynamic change, in which machines have ramifications for other machines, for the plans of contending actors, and for politics and culture, all technological change becomes problematic. This indeterminacy flows from the fact that technology is not a stable artifact but a system in evolution, one whose features and functions are up for grabs. Markets are not impersonal arbiters of outcomes but shifting groups of users whose very identities are being shaped along with the technology they use.

Theories of social construction avoid technological determinism, but when they seek to "explain" failure they fall back on market or social determinism. Users' voices or some sort of social consensus provide the closure that stabilizes a technology. Structural forces, such as the market, class, or interest group dynamics, are seen as driving technology in predictable ways. But path dependency, uncertainty, and contingency undercut both technical and social determinism. Unless we posit fully rational producers receiving unambiguous information from fully autonomous consumers, the reception of technology involves open-ended choices that could go either way.[86]

86. On the challenges introduced by uncertainty and path dependence to traditional explanations of choice and selection of technology, see Richard Nelson, "Recent Evolutionary Theorizing about Economic Change," *Journal of Economic Literature* 33

Contingent outcomes cannot be explained or predicted by structural conditions alone. This does not mean, though, that outcomes are wholly inexplicable. Contingency also means that things *connect.* But what is the glue that joins actions in ways that add up to a new product or system? What shapes the contours of our technological world as an "ensemble" of contingent technological relationships?[87]

Here I would argue for the importance of studying narratives of technological change. A powerful cultural imperative drove decisions about Picturephone. That narrative explained to telecommunications engineers why, in the early 1950s, they should conceive of their work as promoting new modes of information conveyance. It motivated them to rebuild networks to carry more information, to encode that information in digital form, to place in homes and offices terminals that could access that network. They carried out all this work in the name of a specific representation of future technology. They carried it out in the name of a failure. This failure was a rather successful piece of the technological imagination that guided innovators by helping to establish a basic paradigm for information services and technology.[88] It was, in all the senses used in this article, contingent—not inevitable, but rather the coming together of many circumstances. Picturephone worked to hold those circumstances together, helping to form a new technological world.

Picturephone must be acknowledged for this narrative work. The flawed telephone of the future was able to enlist the resources of the nation's largest corporation in the cause of creating a new world of information. It helped write a new chapter of the technological narrative that shaped other machines and systems that followed. By promoting Picturephone, Bell engineers helped to make predictions about the future legiti-

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(March 1995): 48–90. The emphasis here is on market rationality, but the same critique applies to other social structures, such as group identity and interest. Explaining technological outcomes with reference to categories such as race, class, or gender relies on those groups having clear identities and interests exogenous to technology.

87. Contingent, from the Latin *contingere*, to touch together, to connect. The sense of happenstance or incidental occurrence is secondary and would be the appropriate meaning only if technologies were treated in isolation and if connections between machines and society were random, not systematic. Accepting contingency in the first sense means accepting some notion that technologies or systems of technologies "shape." Contingent, in both senses, is also to be distinguished from "necessary," as in determined.

88. One might argue that Picturephone was quite different from information technologies that followed: it was standardized and hardwired rather than modular and flexible, and it was developed by a large corporate bureaucracy rather than small, entrepreneurial firms. The differences here need to be explored further, but I am not convinced that hardware was the key difference. Moreover, the underlying hardware of the Internet and Picturephone, while different in some respects, are not fundamentally incompatible. The basic idea of using a network to access and transmit information is consistent with both Picturephone and later information technology.

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mate and concrete. Like the futurist scenarios found in fanciful literature and science fiction, Picturephone was one more story that drove innovators and designers to the present.[89]

To call Picturephone a fiction or narrative does not mean that its significance lies only in the realm of ideas and imagination. Technologies have material form as well as discursive implications. Even as a failure, Picturephone was a "real" machine that suggested the underlying vision might find its way to reality. It transformed technological rhetoric into design and technological enthusiasm into practice. It led Bell engineers to construct a new system of information conveyance and to deploy digital hardware that would bring new media services to the user. It motivated construction of a new communications architecture and promoted a new vision of information as the manipulation of voice, image, text, data, and, yes, even video through a single network. Far from a dead end, Picturephone contributed to the knowledge necessary to build, develop, and manage that system and make it available for others. The work of adapting the telephone network to new uses and the effort to provide new services to the home and office continued, as it does down to the present.[90]

Even when technologies disappear from the visible scene, they help to dig the channels of our technological world deeper. Even when they are the products of contingent social experience, failed technologies end up narrowing our options and constricting our choices. The fact that failures can do so also offers clear evidence that technological determinism is not primarily technological but rather an artifact of how the technological narrative inserts itself into consciousness, even against our best efforts to keep it out. Despite being wholly shaped by society, technology ends up working its will on us.

One piece of evidence for the enduring impression technology leaves on consciousness is the continued persistence of the Picturephone concept itself. Since the 1970s there have been predictions that technical advances such as coaxial cable, satellites, fiber optics, and, most recently, packet switching would solve the problems that had put the original Picturephone on the shelf.[91] Amid warnings that it was pursuing "a utopian vision that

89. This approach should be distinguished from the evolutionary model of technology discussed above. Evolutionary approaches often remain wedded to functionalism, whereby through trial and error optimal—or at least better—designs emerge. Path dependency can complicate this story, as I have noted. But I am suggesting here that the story is even richer, for the possible paths that can be followed are themselves "preselected" by the cultural work that technologies, failed or otherwise, do.

90. Although Bell was pressured by users, especially large corporate users, to provide these new information services, it also bought into the predictions of the future.

91. A search of journals, newspapers, and magazines on the keyword "Picturephone" brought up several dozen examples between the mid-1970s and today. Picturephone appears sometimes as a failure, often as a prelude to the dawn of interactive video com-

ignores history," AT&T itself came out with a second version in 1992—Videophone.[92] Today, a California firm sells the View Desk, a set-top device that plugs into an analog phone line and displays pictures on home televisions. Another company markets headsets with a tiny camera and eye-level miniature screen, allowing users to see each other as they talk. Cellular versions can simulate an office backdrop for use while on vacation or at the beach.[93] When world events or energy prices raise the cost of travel, new articles appear prophesizing that this time video telephony will make it.

Of course the conditions that blocked the first Picturephones could change. The seemingly final commercial failure could turn out to have been, from a longer and wider perspective, merely a temporary setback. Yet these hopes for a rebirth of videophone also show us how technologies exert influence from beyond the grave. Picturephone the failure gives way to other efforts to enact the same rhetoric of information technology. Indeed, the same utopian language of information that first attached itself to Picturephone has accompanied the personal computer and the Internet, which are supposed to harness communications capacity to change the ways we live, work, and play.[94] Like Picturephone, they too promote the idea that technology can be liberating by allowing us to transcend space and simulate personal contacts and connections with virtual ones. They too promise that a high-capacity pipeline is all that is necessary to flood the home or office with information that any individual can deploy and manipulate at will. They too spin the fantasy that the power to access infor-

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munications. See, for example, Don Clark, "The Next Generation in Communication," *San Francisco Chronicle*, 25 August 1993; Jerri Stroud, "Phones Link Up to Future," *St. Louis Post Dispatch*, 19 November 1992. Other predictions focused on the falling price, improving performance, and decreasing size of cameras and displays. See Vanson et al. (n. 51 above), ix, xiv.

92. A. Michael Noll, "Baby Bells Should Stick with Strengths," *Los Angeles Times*, 22 October 1993, sec. B. After assuring the public that Videophones would become as common as automatic tellers and more important than the fax machine, the company pulled this "profound change in communications" from stores a few years later: Bart Ziegler, "AT&T Unveils VideoPhone, But Some Wonder if Market Is Ready," *New York Times*, 6 January 1992; John Schneidawind, "AT&T Unveils VideoPhone," *USA Today*, 7 January 1992. Nor was this AT&T's only effort to erase its past mistake. In the 1980s the company pushed videoconferencing, originally using Picturephones, later with more sophisticated technology, as a way to market face-to-face telecommunications. Though videoconferencing lives on, AT&T eventually closed its own public facilities. Cohen (n. 27 above).

93. Connie Koenenn, "An Idea That's Been Difficult to Picture," *Southern California Living*, 7 February 1999; Peter Howe, "Brainstorms," *Boston Globe*, 26 April 1999.

94. Levels of sophistication in treating technology vary, but many books on media and information seem to suffer a bias toward determinism. See Mark Poster, *The Mode of Information: Post Structuralism and Social Context* (Chicago, 1990); William Mitchell, *E-topia* (Cambridge, Mass., 1999); Esther Dyson, *Release 2.1* (New York, 1998); Michael Dertouzos, *What Will Be: How the New World of Information Will Change Our Lives* (New York, 1997); and Bill Gates, *The Road Ahead* (New York, 1996).

mation can radically transform society. These very notions were embedded in Picturephone.

The Language of Success and Failure

Even the most scientific and rational work on technology requires imagined products that embody visions of the future, directing engineers and inventors along the path of broad, usually unquestioned paradigms of change. These paradigms are very hard to dislodge, and failures do not necessarily call them into question. Even when a bold project such as Picturephone fails, others continue along the same road. It is not clear how many failures it would take to call into question the underlying vision. Indeed, the entire vocabulary of failure is confined to discreet machines, products, or projects. It does not speak to the ensembles, the systems, and the values embedded in machines. Instead, failure of a part or component usually provokes a different response, about the inevitability of mistakes and dead ends, about the value of learning from past failures. Failure modifies the process but not the driving vision behind the creation of new technology. In this way, learning through failure is circumscribed, unable to open questions on the underlying direction of change. Indeed, failure may only reinforce that direction by extending the narrative of technology.

The case of Picturephone also undercuts optimistic assumptions about consumer agency. When consumers reject a product, even as thoroughly as they rejected Picturephone, they take no definite political stand on technology. They do not win the right to question the prevailing definition of progress. Instead, they express ambivalence. They show themselves to be both frightened and intrigued by the promises made for a brighter tomorrow. No one in a capitalist society, however, makes money by refraining from producing something because it might be disturbing or frightening. They make money by learning how to assuage those anxieties and erase those doubts, by finding a way to match what they have to sell with what people desire, no matter how ambiguously they desire it.[95]

The language of success and failure makes it more difficult, not easier, to see such patterns by limiting our investigations to individual products and restricting our time frame to the period of invention or initial diffusion. A broader perspective should caution us against having too much

95. For these reasons, I reject celebration of markets and competitive innovation as a democratic alternative to top-down corporate innovation. Entrepreneurs do not face problems such as the innovator's dilemma or raise political suspicions the way large corporations do. But entrepreneurial behavior does not eliminate failure. Rather, it normalizes failure. Entrepreneurial failures produce different reactions than do grand projects that never meet their original promise. While those responsible for the latter are favored with exposés, investigations, and public cynicism, those behind the former are treated to lunch by venture capitalists.

faith that we can control technology by our consumption decisions alone. Now, as in the Picturephone era, information technology is a giant system run by a small vanguard of experts and designers. Users of computers still rely on a capital-intensive semiconductor industry. Software is answerable not directly to the public but to a group of highly paid, highly skilled professionals, whose judgment few of us can directly question. Despite the public's distaste for surveillance by technology, the Internet is a vast, intrusive system that is growing in size and in the multiple ways by which it insinuates itself into our daily lives. In contrast to the centralized Bell system, power is more diffuse, elusive and fragmented. It is harder to see, harder to identify than in the days when AT&T was the largest corporation on earth. It is not so legible when it flows through millions of web sites and millions of users with multiple identities, not so visible as when it embraced the clearly articulated goal of a universal medium of communications. Forms and process may change, though perhaps in the end we shall have videophones after all. But failure did not deflect technology from what Julius Molnar and his Bell Labs engineers confidently predicted was the road to the future.