4 WHO KILLED OPTICAL FIBER? DREAMS OF THE INFORMATION HIGHWAY

Every so often, a story does the rounds on British social media of "how Thatcher killed the UK's superfast broadband before it even existed."[1] Originating from an article on *TechRadar* in 2014, the story is told through an interview with Peter Cochrane, BT's chief technology officer from April 1999 to November 2000. The article begins "in the 70s when Dr Cochrane was working as BT's Chief Technology Officer," although Cochrane was actually a research engineer at the Post Office's research center in Suffolk at this time.[2] The story, as *TechRadar* and Cochrane tell it, is that through the 1980s BT began a massive rollout of optical fiber across the country but, in 1990, the Thatcher government decided that this was "anti-competitive" and so BT had to stop. This, Cochrane argues, is why the UK lags behind South Korea, Japan, and much of Europe in rolling out fiber-optic cables to consumers' homes. In reality, this story is more complex than a single decision made by Margaret Thatcher in 1990. The Post Office and BT had been searching for high-bandwidth transmission technologies that would meet the UK's information needs since the late 1960s, when the telecom business first formulated the plan for a nationwide, integrated digital network that could provide voice, data, and video services to customers. It was the long techno-political history of that search that shaped the rollout of optical fiber in the UK, and not a single political decision made in 1990.

This chapter is about that search. It looks at the transmission media—microwaves, coaxial cables, and optical fiber—that telecom engineers thought could provide the UK with the necessary bandwidth for an information society. This is a history of frustration and anticipation. Engineers and managers kept investing in transmission technologies that they thought would meet the demand for an integrated digital network for video, voice, and data, a demand that never materialized and was never seen as politically important. This chapter thus seeks to understand how and why engineers persisted with this anticipatory development, and uses metaphors to help interpret this history.

Metaphors have a long history of structuring thought about technology and society.[3] Machine metaphors of clockwork and computers influenced liberal democratic and clerical bureaucratic modes of government, while network and platform metaphors for political and economic life have become popular more recently.[4] In the nineteenth century, the nervous system and telegraph networks became metaphors for each other, used by scientists and society to better understand electrical transmission as means of bodily and social discipline.[5] Organic metaphors also became popular descriptions of the early AT&T system, described as a "living conscious being" and an "ever-living organism." This presented AT&T's nationwide telecom infrastructure as both holistic and complex, naturalizing a single national system with a single operator, a "careful steward."[6] In the digital era, metaphors have been particularly prevalent in surfacing values and expectations about the internet, whether it has been described as an "information highway," a "digital library," an "electronic marketplace," or a "digital world."[7] These cases all show how metaphors have acted as "midwives," structuring expectations for emerging technologies, yet were also a normative resource deployed by actors to shape the future of these technologies.[8] This chapter thus examines the various metaphors that the Post Office and BT deployed for transmission media, and particularly their use of the "information highway" metaphor, to better interpret how and why the Post Office and BT were developing particular technologies.

But this history is about more than just these transmission media. It is also about the content carried over those transmission media. The Post Office's vision was for an integrated digital network that would carry both data and video, as well as telephony, and engineers believed that this would protect their monopoly from specialist entrants offering only data services. This integration required a standard for digital transmission that would allow a network to transmit all these services simultaneously and interconnect internationally with other digital networks. This chapter thus also explores the development of a new standard, the integrated services digital network. ISDN

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was favored by the European and Japanese public telecom monopolies and would allow digital networks to simultaneously transmit telephony and data services but, crucially, not television.

Standards—technical rules and conventions that govern how objects and processes are made and used—are vital to technology and infrastructure in modern life.[9] They are important because they embed ideological and political goals in material infrastructure. This means that standards can end up as forms of public policy, and their materiality gives standards an inertia that makes changing them politically and financially costly.[10] Standards have been important for national and international governance since the nineteenth century, helping states manage economies and internationalists create global markets.[11] Since the 1960s and 1970s, a new wave of standardization has emerged in the digital realm. Digital standards have become a contested site for different national and international groups supporting different conventions and politics. During the 1970s and 1980s, a digital standards war emerged between those standards supported by commercial and academic computer scientists and network engineers and those informed by public telecom monopolies.[12] The history of the Post Office and BT's relationship with ISDN standardization thus helps further understand how the vision for an integrated digital network evolved as different technologies emerged and as Britain's telecom infrastructure turned from national monopoly to private operator.

Overall, this chapter thus explores the changing political economy of digital transmission and integration. It investigates the different transmission media and standards that the Post Office and BT hoped would deliver on their vision of a high-bandwidth integrated digital network, and complicates the myth that, if it were not for Thatcher and liberalization, the UK would already have a full fiber-optic network. This history begins in the late 1950s, when the Post Office's focus was on a nationwide network of microwave towers with the Post Office Tower (now BT Tower), London, at its heart. The Post Office Tower served the public not just technologically but also as an instrument of social democracy, and the Post Office's metaphor of the tower as a "lighthouse" combined these functions. The development of this microwave network, which transmitted both telephony and television, reveals the Post Office's disinterest in the early 1960s in integrating these two functions.

This changed with the waveguide, a method for burying extremely high-frequency microwaves underground, which the Post Office pinned its hopes on during the 1970s as a high-bandwidth "information highway" for integrating voice, television, and data transmission along Britain's long-distance trunk lines. The chapter then explores how the Post Office's integrated vision began to falter as the development of the ISDN standard for these integrated digital networks began. The market for data services had developed faster than expected, while television remained resistant to integration, and so the Post Office began to depart from its integrated vision. It remained committed to entering the television market, however, and so the chapter turns to new transmission media—coaxial cables and optical fiber—that the Post Office and BT hoped could still provide "information highways" for the UK. These plans were frustrated both by government regulation of telecom and media and the development of the ISDN standard. The chapter thus concludes by reflecting on how and why digitalization, privatization, and liberalization meant that, for BT and for the UK, integrating digital services into a high-bandwidth national network succeeded in some ways and failed in others.

MICROWAVES: LONDON'S LIGHTHOUSE

Microwave transmission started with the exploration of centimeter-wavelength radio waves, ranging from 300 MHz to 100 GHz frequencies, as a potential medium in the 1930s. These short waves, first called "micro waves," were also known as quasi-optical waves because of their similarity to light. Both traveled in straight lines, lost intensity over distance traveled, and required direct line of sight. In 1931, ITT's Paris laboratory began experimenting with microwave terminals transmitting telephone and telegraph messages across the English Channel. By 1934, the first Anglo-French microwave service opened, and in the UK, the Post Office opened a second commercial link in 1937 between Stranraer, Scotland, and Belfast, Northern Ireland.[13] World War II, however, interrupted, and not until the 1950s did Britain's microwave network develop further. The first microwave links to open after World War II in the UK were for television. In 1949, a London–Birmingham link opened, followed by a link between Manchester and Kirk O'Shotts, Scotland, in 1952. In August 1950, British and French engineers conducted the Calais Experiment, the first live transnational television transmission, using microwave links to broadcast a variety program, *Calais en Fête*, presented by Richard Dimbleby and filmed in Calais, to BBC viewers.[14] Full-scale microwave telephony development started only in 1956, as it was harder to transmit large numbers of telephone calls than a single television signal.[15] By 1964, the Post Office had opened microwave telephone links between Manchester and Newcastle, Elgin and Kirkwall in Scotland, and from Carlisle to Belfast (figure 4.1). Birmingham and London, however, remained isolated because their built environments and natural geography meant that it was challenging to provide line-of-sight links to the city centers.[16]

For this reason, the Post Office had planned two communication towers for London and Birmingham. Work on the Post Office Tower in London began in 1961, but it was not a smooth road from planning to building. Dame Evelyn Sharp, permanent secretary for the Ministry for Housing and Local Government from 1955 to 1966, wrote to Postmaster General Ernest Marples in 1959 to express her and her ministry's "horror" at the plans for such a "particularly conspicuous" tower.[17] Marples defended the tower as a "bold and imaginative solution" to London's line-of-sight problems, endorsed by the Royal Fine Arts Commission, and that it would also offer public amenities in the form of a revolving restaurant and observation gallery.[18] Construction went ahead, finishing in 1964, and the tower opened to the public in 1966.

The Post Office used the tower's amenities and visibility to present itself as a scientific and technological public service. A visitors' information booklet explained how the tower was "a symbol of the modern Post Office, a science based industry using the most refined techniques in the telephone, teleprinter, television and computer communications so necessary for modern society."[19] The presentation of the tower as a high-tech symbol also occurred outside the Post Office. In 1964, the tower appeared in *Eagle and Swift* boys' comic, which played a prominent role in science and technology popularization in 1960s Britain.[20] The Post Office Tower appeared in two recurring features: the adventures of Dan Dare, "Pilot of the Future," and *Eagle and Swift*'s cutaway illustrations of technological wonders, which had previously included examples such as the LNER *Mallard* high-speed steam locomotive and the Avro Vulcan bomber. In *Eagle and Swift*'s May 31, 1964, issue, the front page showed Dan Dare locked in battle with Xel, a dangerous alien, atop the Post Office Tower, while the cutaway illustration inside showed off the tower's interior and exterior workings.[21]

The Post Office Tower also played a key part in the Post Office's role in British social democracy. The Post Office Tower's public revolving restaurant and observation galleries situate the tower alongside other social democratic

FIGURE 4.1
The British microwave radio-relay network in 1964, showing links already constructed and those in development. Source: D. G. Jones and P. J. Edwards. "The Post Office Network of Radio-Relay Stations. Part 1—Radio-Relay Links and Network Planning." *Post Office Electrical Engineers' Journal* 57, no. 3 (1964): 147–155. Reproduced with permission from the Institute of Telecommunications Professionals.

projects such as London's Royal Festival Hall, built in 1951, where publicly accessible spaces could generate new patterns of social relations for a democratic, modern Britain, allowing people from different backgrounds to mingle. In the case of the Post Office Tower, the observation gallery was a place not just to mingle but also to survey the landscape of the nation's capital. In practice, however, the public spaces of the Post Office Tower may have served to reinforce, rather than break down, class differences, as the reservation-only revolving restaurant admitted only citizens wealthy enough to pay its high prices, while the cheaper observation gallery was open to the masses.[22]

The Post Office developed a metaphor of the tower as a "lighthouse" that combined its technological and democratic modernity, interlinking technological progress with public service. The brochure for the tower's opening ceremony described the tower as a "lighthouse-looking structure," while an information booklet for visitors described the tower as a "giant lighthouse."[23] A 1962 press release also described the tower as a "modern, slender lighthouse." In this press release, the metaphor first drew parallels between the revolutions of the restaurant and a lighthouse's signal and, second, linked the tower to an early Victorian telephone exchange, which, built on the roof of a courthouse, was also described as a "lighthouse."[24] So, *pace* Ronald Coase, as lighthouses provide a public service to shipping, the "lighthouse" metaphor here, presenting the tower as both a public amenity and a technological successor to Victorian exchanges, highlighted the Post Office's role in social and technological progress.[25] The "lighthouse" metaphor was also apt because it evoked the quasi-optical nature of microwaves, and, when combined with the connotations of the lighthouse as a navigational instrument of public service progress, suggests the deep entanglement of the tower's threefold function: a node in the microwave relay network, a symbol of technological progress, and a site of democratic modernity.

The Post Office's focus on London's "lighthouse" shows, however, that as much as metaphors emphasize some aspects of technology, they can conceal others. In this case, the lighthouse obscured, rather than illuminated, Britain's nationwide microwave network, as well as the Post Office's other plans for microwaves. The tower was more than just a microwave transmitter and receiver, also housing three telephone exchanges and the London Television Switching Centre.[26] These exchanges, obscured by the tower rising above them, were as crucial to the microwave network as the aerials at the top of the tower yet were much less visible. The tower's television center

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did not feature heavily, relatively speaking, in publicity. At this point, telephony and television were transmitted via separate, analogue networks, and so the Post Office likely did not yet see television transmission as something that could be integrated into their telecommunications network. This interest would change significantly through the 1970s.

The Birmingham Radio Tower, built at the same time as the Post Office Tower in London, also received less publicity but did further reinforce the "lighthouse" metaphor and the Post Office's commitment to technological modernity. The radio tower featured in the Post Office's "Progress" series of publicity posters (figure 4.2) and, like the Post Office Tower, was compared to "a giant lighthouse but instead of sending out a beam of light it transmits microwave radio signals," further connecting the lighthouse metaphor to microwaves' quasi-optical properties.[27] Even less visible was the nationwide infrastructure of smaller microwave relay towers that linked cities together. By 1966, there were 120 relay towers, situated at intervals of about 30 miles, with an aggregate route length of 2,000 miles.[28] By 1969, the Post Office planned to miniaturize these relay towers even further and introduce them into the local networks. A promotional film, *Telecommunications Services for the 1990s*, made by staff at Dollis Hill, the Post Office research station, described how microwave poles on every street corner would beam voice, data, and video signals into residential homes.[29] By the end of the 1960s, microwaves were thus beginning to feature in the Post Office engineers' visions for an integrated digital network that would combine telecommunications and television.

While the Post Office's plans for microwaves would continue, the Post Office Tower's fate was less hopeful, instead illustrating the passing of the Post Office's moment of democratic modernity. On October 31, 1971, a bomb exploded in the tower's restaurant toilets. At first attributed to the Provisional IRA, the bomb has since been linked to the Angry Brigade, a British anarchist collective active from 1970 to 1972. The tower subsequently closed to the public and, after the restaurant's lease expired in 1980, the restaurant remained closed.[30] With privatization, the tower became BT Tower, and in the 1990s BT turned it into a space for corporate functions. This turn from public to private did not go unnoticed. In 1994, the *Independent* newspaper criticized "the ephemeral fizz of public relations receptions" that excluded the public, and a 1995 article in the *Scotsman*, "Tower to the People," also laid in, asking, "How come, 30 years on, nobody except corporate fat-cats can

FIGURE 4.2
Birmingham Radio Tower also featured in the "Progress" poster series (as in chapter 2, for the Post Office's Computer Centre). Source: TCB 420/IRP (PR) 6, BT Archives. Courtesy of BT Group Archives.

get inside it?"[31] The tower continued to transmit into the 2000s, giving it a healthy forty-year lifespan, but by the 1990s, it was clear that the Post Office Tower's era of democratic modernity was over.

WAVEGUIDES: SUPER COMMUNICATIONS HIGHWAY

Even as microwaves crossed Britain's skies in the 1960s, the Post Office's attention had already turned to a new earthly transmission medium, millimetric waveguides, which are metal tubes that direct millimetric microwaves. Millimetric microwaves have shorter wavelengths than the centimetric microwaves used for aerial microwave transmission. The shorter wavelength accentuated microwaves' quasi-optical nature so that, while centimetric microwaves could propagate through air, millimetric microwaves degraded too much during rainstorms and other adverse conditions. The trade-off, however, was that as wavelength decreased, frequency increased, which meant higher bandwidth and greater transmission capacity. The Post Office thus turned to waveguides as a housing and guidance system for millimetric microwaves. In the UK, the Institute of Electrical Engineers held the first conference on millimetric waveguides in 1959, and a conference report in the *Post Office Electrical Engineers' Journal* suggested that further research and development work was needed.[32]

The Post Office was not the only organization to explore waveguide development. Bell Labs also undertook a lengthy research and development program on waveguides, which was abandoned by 1973, and Standard Telecommunications Laboratories also conducted some early research into waveguides.[33] Alec Reeves, the creator of digital pulse-code modulation, was the chief figure at STL assessing waveguides and was unconvinced, particularly regarding limitations in waveguide geometry. To avoid signal degradation, waveguides needed to avoid kinks and tight turns. The significant distances between urban centers in the US meant that waveguides, requiring gentle, sweeping curves, potentially suited AT&T's needs. Reeves, however, was skeptical that waveguides suited Britain's densely built-up landscape, so, in 1963, STL abandoned their waveguide project to pursue optical fiber transmission instead.[34] The Post Office continued with waveguide research, expecting that its integrated digital network would come to fruition soon enough that it needed to find a high-bandwidth backbone for Britain's digital infrastructure straightaway.

By 1967, engineers began field trials at Martlesham Heath, the location for the Post Office's new research center. Engineers began with a one-mile circular waveguide test, working with Professor Harold Barlow, professor of electrical engineering at University College London.[35] By 1975, the Post Office had begun a 14 kilometer trial between Martlesham Heath and Wickham Market, a nearby town. The trial revealed the need for significant auxiliary infrastructure, including a special bridge to navigate a river, a purpose-made tunnel for a stream and marsh, and "mirror corners," using reflective surfaces to bounce the beams at tight angles, in segments with unavoidable sharp bends. Engineers also had to install mechanical tensioning equipment at both ends to hold the waveguide taut, mitigating soil subsidence and overcoming expansion and contraction during temperature changes.[36] Combined with STL and AT&T's abandonment of waveguide research, these issues invite the question of why the Post Office continued with the waveguide. There were several reasons. Both the Post Office's vision for an integrated high-speed digital network and its expectations of an impending information revolution meant it predicted great demand for high bandwidth in the near future. Furthermore, the Post Office also expected that optical fiber, a high-bandwidth alternative, would take much longer to develop than waveguides.

Showing again the power of long-range planning in the Post Office, the UK Trunk Task Force's study on the integrated digital network, run by the Long Range Studies Division, strongly influenced the Post Office's commitment to the waveguide. The UKTTF's modeling studies, which affirmed the digitalization of the entire network, also affirmed the waveguide as the natural next step for transmission. The UKTTF highlighted the waveguide as a technology suited to both the increasing traffic that the Post Office expected and the multimedia nature of that traffic, including voice, data, and video. These expectations and forecasts may have been reinforced by the fact that, when Harris first started establishing the requirements for the general-purpose digital network in "Telecommunications Systems of the 1980s" (discussed in chapter 2), the press frequently criticized the Post Office for not keeping up with public demand for telephones, and in the early 1970s, when the UKTTF made these forecasts, this demand sharply increased (figure 4.3).[37] The UKTTF report showed that digitalization was economical regardless of transmission medium, but the waveguide was the most cost-effective and high-bandwidth transmission medium available. The task force's final report included a recommended waveguide layout for 1986, stretching from

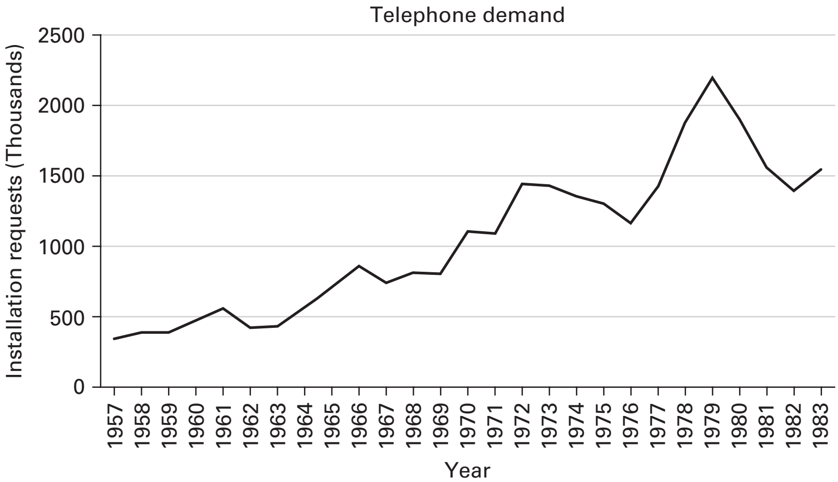

FIGURE 4.3
Public demand for telephone installations from 1957 to 1983. As well as increasing from 1967 to 1972 and from 1976 to 1979, demand also slumped following the 1962–1963 capital restrictions, Harold Wilson's 1966 July measures, and during the 1973–1975 and 1980–1981 recessions. Sources: Post Office and BT Annual Reports and Accounts, 1959–1984, TCB 10, TCC 11, TCD 12, TCE 13, BT Archives.

London to Bristol, and Carlisle via Manchester and Leeds, with onward connections to Cardiff and Glasgow if there was enough demand for Viewphone, which again appeared as an avatar of Britain's integrated digital network.[38] The UKTTF report also, however, marginalized optical fiber as a potential high-bandwidth digital transmission medium. The task force viewed optical fiber as an experimental technology and did not include it in any forecasts.[39]

The relationship between optical fiber and waveguides continued to influence appraisals of both media through the 1970s. In 1972, a report of the meeting of the Managing Director's Committee for Telecommunications, including James Merriman and the managing director Edward Fennessy, noted that optical fiber research showed greater potential than expected but predicted that the trunk network would still use waveguides, while optical fiber was better suited to the local network.[40] In the mid-1970s, Post Office publicity and information brochures described waveguides as the "big brother" of optical fiber, carrying heavy communications traffic, whereas optical fiber would serve local networks.[41] This complementary attitude was prominent at a 1976 IEE conference on the millimetric waveguide. In his opening address, Merriman argued that waveguides "will have to be judged—against their timeliness and relevance or irrelevance—to the spectrum of competing or complementary technologies."[42] Merriman reviewed potential alternatives to the waveguide: coaxial cable, low-bandwidth but already in extensive use; microwaves, already exhausting the available frequency spectrum and vulnerable to degradation during heavy weather; satellites, economically viable only for international transmission; and optical fiber, "not yet in a position to compete" in the trunk network, but a promising option for local networks. Merriman concluded that waveguides were the clear victor, referencing "their extraordinary capability for information/bandwidth."[43]

The waveguide's primacy peaked in 1977 when the Post Office board approved Britain's first trunk transmission system designed specifically for digital use, a link between Reading and Bristol, connecting South Wales and the West with London. Bristol was also an important node for routing international traffic to London from submarine cable stations in Cornwall and the Post Office's two satellite earth stations, Goonhilly in Cornwall and Madley in Herefordshire. The telecom business proposed two versions of the link to the Post Office board. The first version, a waveguide system, would be ready by the end of the decade, while the second, an optical fiber link, would not be available until 1983. The Managing Director's Committee for Telecommunications recommended the waveguide system because optical fiber had not yet entered development, and also because the committee believed that the Post Office, as one of the few remaining waveguide pioneers, had the opportunity to showcase its world-leading position and create an export market for the UK. The telecom business's proposal also further showed its high expectations for a future integrated digital network. The proposal explained that while the Bristol–Reading link would use only 20 percent of the waveguide's capacity over twenty years, this meant that there was excess capacity for other content, including videoconferencing.[44] The Post Office's management board approved the waveguide in February 1977, not least because its members also saw the Bristol–Reading waveguide as "insurance" against delays in optical fiber development.[45]

The Bristol–Reading waveguide project failed, which signaled the end for the waveguide. The Post Office board, as part of the project's "insurance policy" status, had decided in advance that Bristol–Reading would be the only waveguide link, expecting that optical fiber would be developed before other trunk routes needed waveguides. When Marconi, the Post Office's manufacturing partner on the project, heard the news, it decided to recoup all its waveguide R&D expenditure from the Bristol–Reading link by raising costs. Britain's economic downturn in the late 1970s also affected the project, as telephone growth slowed relative to the UKTTF's earlier forecasts. Long-range planners' optimistic projections of a high-capacity integrated digital network serving telephony, data, and video over waveguides had become excessive after economic slumps slowed telephone use.[46] The combination of slow telephone growth, faster-than-anticipated optical fiber development, and higher manufacturing costs meant that the Post Office canceled the Bristol–Reading waveguide project in 1978, only a year after its approval.

The waveguide was, however, a metaphorical success as the subject for the Post Office's first uses of the "highway" metaphor. According to *Wired Style: Principles of English Usage in the Digital Age*, a 1997 dictionary published by the digital utopian magazine *Wired*, Al Gore Jr., the US senator and later vice president, coined the metaphor "information superhighway" in 1978 to refer to a range of high-bandwidth digital communication technologies. Gore later popularized the term during the 1990s to promote a national information infrastructure when he was vice president to President Bill Clinton.[47] The "highway" metaphor, however, has a much longer history with communication networks. In the 1920s, AT&T used the metaphor "a highway of communication" to compare its telephone network, a government-sanctioned private monopoly, to the US public highway system, attempting to persuade its customers of "the logic and beneficence of a unified system."[48] In the 1970s, the Post Office used the "highway" metaphor to communicate the waveguide's high bandwidth and the telecom business's plans for a general-purpose digital information network. The highway metaphor first appeared in the *Post Office Telecommunications Journal* in 1970, which described waveguides as "highways of communication" and "super-highways for telecommunications traffic."[49] This usage continued throughout the 1970s in publicity about the Post Office's various waveguide projects. A press release for the 1975 Martlesham–Wickham Market trial described waveguides as a "super-highway" solution that the Post Office had prepared for "major telecommunication highways," while press notices for the Bristol–Reading link called the waveguide a "super communications highway" that would carry data, television, videophone, and videoconferencing services as part of an integrated digital network.[50]

The interesting feature of the Post Office's "highway" metaphor is how it employs one infrastructure as a metaphor for another. There is a long history of using metaphors for infrastructure, such as the nervous system for the telegraph, but the highway metaphor is different because it used one national infrastructure as a metaphor for another, rather than applying social or biological metaphors to technology or vice versa. There is a longer history here, too. Telegraphy was used as a metaphor to understand the emergence of radio, which became "wireless telegraphy," focusing early attention on radio's point-to-point communications applications rather than its potential for broadcasting.[51] This suggests that, for engineers, some infrastructures become "paradigmatic" in terms of setting their expectations and defining their assumptions how about their own infrastructures will develop.[52] For the Post Office, the highway metaphor in the 1970s served different purposes from AT&T's use in the 1920s. Where AT&T had used it to defend its private monopoly, the Post Office used it to conjure an image of the future, one in which communications routes would have the high capacity of highways, distinct from local roads, and would carry the mixed "traffic" of data, telephony, and television. While the waveguide failed as a technology, like Viewphone, it successfully reinforced the "highway" metaphor's implication that Britain's future digital network would integrate telecommunications, both voice and data, with television and video services. But Post Office engineers and managers soon began to develop new digital ambitions that pushed the integrated vision beyond its breaking point. They simultaneously tried to expand into television transmission, contributed to integrated digital standards development, and started building their own specialized data networks, previously anathema to their vision of integration.

STANDARDS AND SPECIALIZATION IN DATA NETWORKS

Chapter 1 explored how one of the key parts of Post Office engineers' vision for Britain's digital future was an integrated digital network that combined voice, data, and video services, and that one of the motivations behind that vision was to defend the Post Office's monopoly from specialized, commercial data networks. This vision developed from national experiments with integrated digital networks during the 1960s, such as the Post Office's 1967 trial integrated digital network in Washington New Town, then expanded to further experiments in 1968, and also drew on the successful digitalization of switching networks in Japan, and France.[53] By the start of the 1970s, it was clear not just in the UK but around the world that integrated digital networks were one direction that digitalization could take. The other direction was building separate digital networks for telephony, data, and perhaps even television and other video services such as videoconferencing. But which direction was preferable, and how that vision might take shape, was a question for more than just Post Office engineers. It was a question that, from the start, was transnational, framed and answered by the International Telecommunication Union's standard-setting organization, the Consultative Committee for International Telegraphy and Telephony (CCITT). In June 1971, the CCITT established a sub-working party to discuss the terms "integrated digital network" and "integrated services network," which led to the term "integrated services digital network." The following year, the CCITT distributed a circular letter to national representatives, including the Post Office and other public telecom monopolies in Europe, asking for their opinions on how integrated digital networks should be studied during CCITT's 1973–1976 study period.[54]

The CCITT circular letter offered three options: a "service integrated digital network," as the Post Office had envisioned; "specialised digital networks"; and two specialized networks, one for data and one for voice, with "limited interconnection." The different responses to this question reveal the different ambitions and pressures shaping national telecom operators at the time. Japan lamented that the CCITT question already excluded video services from the ISDN and argued that video would be "indispensable" to the "ideal communication network for the future." Many European PTTs, especially in the Netherlands, Spain, Italy, and France, argued that maximum integration was the best solution, as the most economic and flexible option, and that the national PTT administrations were best-placed to coordinate these integrated digital networks. The US, on the other hand, argued against integration and in favor of separate digital networks for telephony and data, asserting that they were sufficiently different services that they required separate networks, and that an ISDN could delay establishing specialized data networks in countries around the world.

US opposition to ISDN was a familiar sight from digital standards conflicts that took place during the 1970s, which exposed the vested interests of European PTTs, US computer and data services corporations, and academic computer scientists and network engineers. During the 1970s, the CCITT and

ISO, the International Organization for Standardization, became involved in two particularly fraught battles over the standards for packet switching and the architecture of these data networks. For packet switching, the choice was between datagrams and "virtual circuits." Datagrams built on packet switching's potential to have data messages disassembled by the sending computer, sent by different routes over the network, and then reassembled by the receiving computer. Virtual circuits, which took shape in the X.25 standard, meant that the network would open a virtual circuit between sending and receiving computers, akin to the physical circuit opened between telephone callers, allowing a continuous stream of data packets via a single route. Advocates of liberalized, open, decentralized networks supported datagrams, which shifted control to users' computers, while the European telecom monopolies, including the Post Office, supported X.25, which was modeled on their circuit-switched telephone networks and preserved control within the network.[55] By 1976, the CCITT, dominated by European PTTs, approved the X.25 standard.

For network architecture, the conflict was between IBM's proprietary standard, the Systems Network Architecture, the ISO's Open Systems Interconnection (OSI) model, and the internet's framework, TCP/IP.[56] Standardizers at the ISO conceived of OSI as a critique of both IBM's dominance over the computer industry and of the European PTTs' monopolies over their networks, and therefore called for open standards that would promote opportunities for competitors. ISO's openness meant, however, that IBM and the European PTTs joined the negotiation table, slowing down the standardization process to the point that OSI failed and the internet's TCP/IP framework became the dominant framework for connecting digital data networks around the world. This history shows that US interests were often opposed to European interests in setting standards for digital networks. Standards that preserved European PTTs' control over communications networks reduced opportunities for American computer services and data networking firms to set up specialized data networks in Europe. For the European PTTs, integration and ISDN offered a way to protect their monopolies against competition from these data networking companies.

Most European PTTs thus answered the CCITT in favor of the ISDN, but the Post Office, surprisingly, reversed its position and argued against the integrated digital network. The Post Office instead argued that there was an "immediate and pressing need" for new data communications and telex services, while there was less certainty that digital telephone networks would be rolled out within the decade.[57] The Post Office also believed that an integrated digital services network would be optimized for digital telephony in ways that were not optimal for data services. Submitting a flow chart explaining its argument (figure 4.4), the Post Office concluded that the most logical choice was the second option, developing separate, but interconnectable, digital networks for data and telephony. This seems completely at odds with the Post Office's goal, first outlined in 1967 by Merriman and Harris, of an integrated digital network. These goals had since been repeated and reinforced. In 1971, Merriman had warned the Post Office board that closed packet-switched data networks threatened the Post Office's monopolistic goal of "universal integrated networks," and in July 1973, the Post Office management board, following the recommendations of the long-range planners' UK Trunk Task Force and Roy Harris's Advisory Group on Systems Definition, approved the telecom business's plans for an "all-purpose digital transmission environment."[58]

Two factors might have caused the Post Office's change of heart and its opposition to transnational ISDN standardization. The first, more speculative, reason is that ISDN standardization, as Japan had lamented, omitted video services. From the start, both Merriman and Harris had emphasized that the future digital network would carry not just voice and data, but also video. This view is underscored by the lengths the Post Office went to keep developing the Viewphone and by the Post Office's commitment to the waveguide as a microwave backbone that could carry, like the airborne microwaves that preceded it, both telecommunications and television signals. The Post Office was thus perhaps less interested in a standardization effort that, from the start, excluded video services, and this is reinforced by the fact that, as the next sections show, the Post Office kept investing in technologies and lobbying the government in order to expand into television.

The second, firmer, reason was that the growing domestic pressure for data networks undermined integration. By the early 1970s, it was increasingly clear that the growing demand for data services from British business users meant that the Post Office would have to develop a specialized packet-switched data network. The Post Office thus began developing, in partnership with Ferranti and the British academic community, a domestic data network, which debuted in London and Manchester in 1975.[59] This network, the Experimental Packet Switched Service, aka EPSS, was hugely oversubscribed, and the Managing Director's Committee for Telecommunications

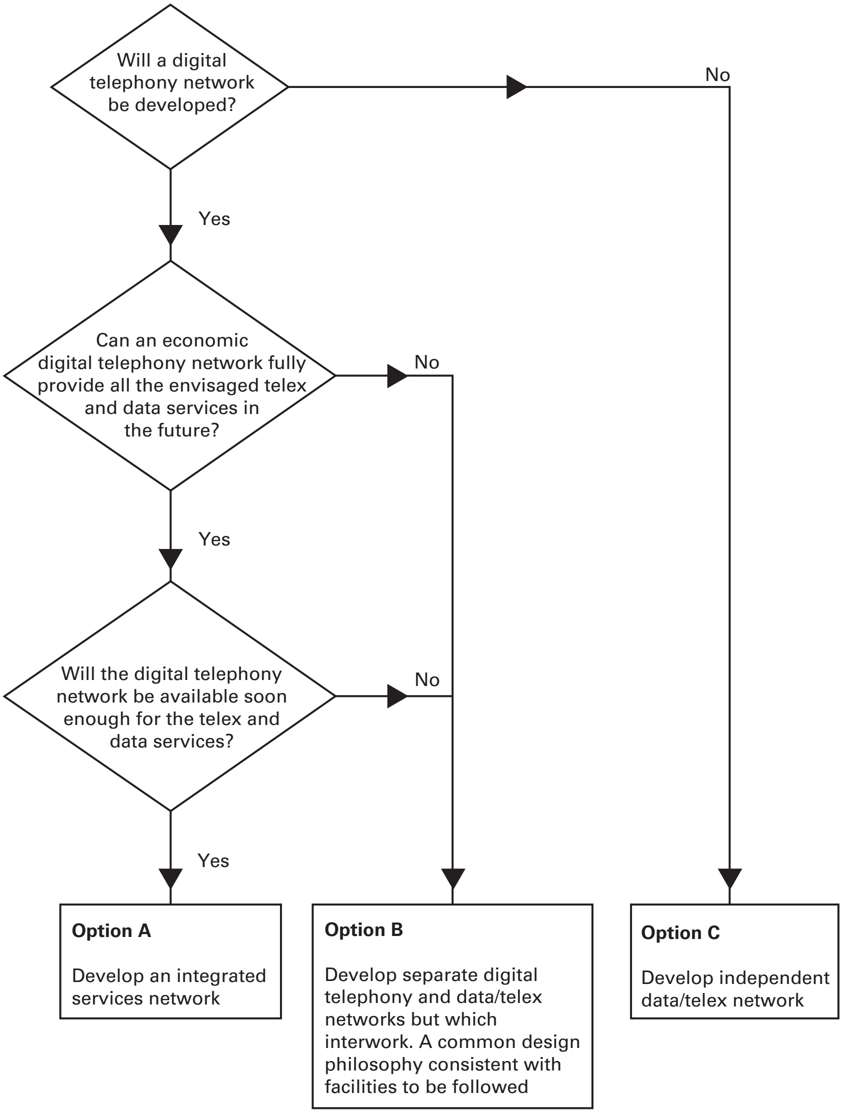

FIGURE 4.4
The Post Office's reasoning against integration for CCITT. Source: The International Telegraph and Telephone Consultative Committee: Fifth Plenary Assembly: Green Book, Volume III-3: Line Transmission. Geneva: International Telecommunication Union, 1973. Reproduced with permission from the ITU.

was particularly concerned that the business sector might lobby the government to liberalize the Post Office's telecom monopoly if it did not roll out further packet-switched data services.[60] As it happened, the financial sector lobbied along exactly these lines, so this concern was not baseless (see chapter 7). The Post Office thus continued to develop a packet-switched data network and so, as senior management began to worry that liberalization would happen regardless, the monopolistic promise of integrated digital services networks began to lose its allure. The Post Office's retreat from ISDN standardization can thus be explained by the growing domestic business pressure for specialized data networks and the ISDN's neglect of video services.

ISDN studies nevertheless continued under the auspices of the CCITT through the 1970s, and formal development of the ISDN began in the 1981–1984 study period, which set the basic framework of ISDN concepts and network architecture. Nippon Telegraph and Telephone (NTT), the Japanese public telecom monopoly, pioneered this effort, developing an ISDN technical concept in 1982 and implementing it in Tokyo in 1984. During this period, European PTTs also focused more effort on standardizing and launching the ISDN, influenced by the liberalization of BT's monopoly in the UK. PTTs on mainland Europe saw ISDN standardization as a method to preserve control over their monopolies against the threat of liberalization.[61] This took shape in two ways: First, PTTs' multinational business clients usually leased telecom lines for their communications needs. One of the earliest targets for telecom liberalization was the market in leased lines, so that new telecom companies could provide leased lines to corporate customers, competing with the PTT's own leased lines services. The ISDN, however, would make leasing lines unnecessary, as all digital services could be transmitted over the same network—the PTT's network.[62] The second way that ISDN benefited European PTTs was that it protected them from the liberalization of the market for customer premises equipment.[63] This had been one of the first targets for liberalization in the UK, allowing customers to attach their own, separately purchased, data processing equipment to the telephone network. ISDN, however, meant that PTTs could offer their own remote data processing services over the network, meaning that customers had less incentive to buy their own data processing equipment. This in turn explains why US information services companies and computer companies, such as IBM, lobbied in Europe for telecom deregulation. Liberalization meant that public ISDNs would be more difficult to roll out and would provide market opportunities for these US firms to offer services and hardware for data transmission and processing.[64]

In the UK, where telecommunications had been liberalized since 1981, and where newly created BT had already been diversifying into specialized data services, the ISDN thus became less important. By 1981, after significant lobbying from business users in the City of London, BT had finally launched its fully-fledged packet-switched data network, PSS.[65] Alongside PSS, BT launched a range of data services called X-Stream Services. BT explained that the "X," connoting its System X digital exchange, signified "*digital* services," while "stream" indicated "the flow of digital information through the network."[66] X-Stream comprised KiloStream and MegaStream, low-capacity and high-capacity data services provided using rented private networks. Another service, SatStream (explored in more detail in chapter 7), opened in 1984 using satellites.[67] BT also rebranded PSS as SwitchStream One to align with X-Stream marketing. In 1984, BT finally launched an ISDN trial, marketed both as Integrated Digital Access (IDA) and SwitchStream Two, which at long last achieved the business's goal of providing telephony and data over the circuit-switched telephone network using System X.[68] But, as liberalization had already happened, ISDN no longer occupied pride of place for BT. Having read the cards ten years earlier, telecom management had long since turned to prioritizing its business customers with specialized services. This turn is explored in more detail in chapter 7, but for now this chapter stays with Britain's transmission infrastructure to explore the Post Office and BT's last remaining hope for a general-purpose transmission infrastructure: building a network that could expand into television transmission.

COAXIAL: CABLE TV

The Post Office's interest in providing television, along with data and telephony, over cable networks stretched back to its early integrated digital network trials in the 1960s. Cable television first appeared in the UK in 1951 as a method to extend television coverage to areas with poor reception.[69] In the 1960s, telecom engineers found that advanced cables could provide up to nine television channels, along with voice and data, over their networks. At that time, however, unfavorable economics meant that the Post Office used a lower bandwidth cable for its integrated digital trials in Washington, Irvine, Craigavon, and Milton Keynes.[70] In the mid-1970s, the Annan Committee, a review of broadcasting in the UK, reignited the Post Office's interest in cable television. Harold Wilson's Labour government convened the Annan Committee in 1974 to review the creation of a fourth and final terrestrial TV channel. By this point, the BBC and Independent Television Authority were using the remaining available TV broadcasting bandwidth. The Annan Committee had only one technical expert, Professor Geoffrey Sims, head of the Electronics Department at Southampton University, and so the Managing Director's Committee for Telecommunications saw an opportunity, under the guise of technical advice, to lobby for a Post Office cable television network.

Post Office management interpreted the Annan Committee's investigation into broadcasting as an opportunity to expand cable television, believing that, technically and legally, the Post Office had the right to develop and administer a national cable network for television, telephony, and data.[71] The Post Office viewed itself as the network provider, leaving "operation," meaning broadcasting and programming, to broadcasting corporations like the BBC and ITA. Merriman's evidence to the Annan Committee, submitted on behalf of the Post Office, outlined its previous experience with cable provision in its early integrated digital network trials. Merriman argued that "the transmission of information was PO business," viewing a national cable television network as a means for the "integration of a wide range of service options in the PO telecomms network."[72] Merriman summarized the Post Office's evidence with the argument that "present and future telecoms services, together with TV broadcasts, could most economically and conveniently be carried on a single wideband network provided by a single administration," which aligned with the Post Office's existing vision of an integrated digital network. The Annan Committee elected not to review cable television, but, apart from its main recommendation to set up an independent fourth broadcast channel, which became Channel 4 in 1980, also recommended that the Post Office provide any potential future national cable television network.[73]

This recommendation remained the case until a flurry of cable television reports under the Thatcher government in 1982 and 1983. The first report was undertaken by the Cabinet Office's Information Technology Advisory Panel (ITAP). The BT board again lobbied the panel, keen to establish a broadband cable network for television, telephony, and interactive information services for banking, advertising, and entertainment.[74] In the short term, BT envisioned using coaxial cable, but in the medium term planned to use optical fiber. The BT board was aware that the Thatcher government's liberalizing stance meant it was doubtful that the ITAP report would recommend creating a public national cable infrastructure, and so the board also accepted that, at the very least, a private venture partnership would be necessary. The board also tried a tit-for-tat approach, suggesting that it would be much more amenable to privatization, which was still not set in stone, if it meant in return that BT could develop a national cable network.

The ITAP report, released in 1982, did not favor BT, instead recommending the expansion and liberalization of cable TV so that customers could receive multiple channels and interactive services from private regional cable TV operators. The report recommended that BT have only a limited role in setting technical standards, explicitly rejecting BT's proposal for a publicly funded national network.[75] The ITAP report was, however, only advisory, and so BT lobbied the government again as a second official review into cable television, the Hunt Committee, began. BT board members particularly criticized that the ITAP report collapsed cable providers and cable operators into one group, arguing that the government needed to consider cable TV in the broader context of a national information infrastructure:

> Broadband links provided initially for entertainment TV should be seen in the context of a national strategy for developing information technology infrastructure; network configuration and technologies should be adopted which were capable of carrying broadcast TV distribution, TV narrow casting, a wide range of interactive services, two-way video switched services and interconnection with national and international telecommunication networks.[76]

Again, however, the report ignored BT. The Hunt Committee's report also did not distinguish between cable provision and operation, meaning that, to the BT board's lament, "the concept of a totally integrated system would not be achievable."[77] The review also ignored BT's argument that a national cable network could provide telecommunications as well as television, instead recommending that the government franchise out regional cable TV systems. As compensation, the report recommended that cable TV franchises not provide telephony, but it left the door open for data provision. BT tried to point out to the government, however, that this latter recommendation was nonsensical, as digital encoding meant that it was impossible to differentiate between voice and data.[78] The government formalized the Hunt Committee's recommendations, which effectively repeated the ITAP report, in a 1983 government white paper, *The Development of Cable Systems and Services*.[79] Cable networks rolled out as regional franchises, but BT and Mercury's duopoly over voice and data was preserved, restricting the cable networks to television. The government permitted BT to participate in consortia bids for cable franchises, and BT consortia successfully secured five: Aberdeen, Coventry, Ulster, Merseyside, and Westminster.[80]

HIGHWAYS: OPTICAL FIBER

In the background, while the Post Office explored waveguides and coaxial cable networks as solutions for its integrated digital vision, researchers at the Post Office and around the world were hard at work developing the next high-bandwidth transmission medium. Optical fiber transmission uses laser-generated light waves to transmit communication signals down ultra-transparent glass fibers, which guide light waves through internal reflections from their interior surface. Optical fiber was the next step for high-bandwidth transmission because it uses near-visible light, which, because it occupies a higher frequency band in the electromagnetic spectrum, could carry even more information than millimetric microwaves. While optical fibers look quite different to millimetric waveguides, they thus work on the same principle of guiding electromagnetic waves with tubes.

Standard Telecommunications Laboratories, in Harlow, Essex, pioneered optical fiber in the 1960s. The key figure at STL was Charles Kao, a Chinese-born engineer who, in 1969, created ultra-transparent glass and proved its viability for low-loss laser communications, and later won a Nobel Prize in Physics in 2009 for this breakthrough. The Post Office had a significant influence on STL's research, as STL's parent company, STC, was a manufacturer and not a network provider, and so needed partners and customers. The Post Office, as both a domestic telecom operator and research organization, was an ideal partner. To complement the envisioned trunk waveguide network, the Post Office wanted a local transmission system with a maximum signal degradation of twenty decibels per kilometer, which set Kao's targets for his research.[81] Post Office research staff collaborated with STL, working on new ways to synthesize glass fibers and setting benchmarks for optical fiber's credibility. For example, Post Office researchers verified the purity of glass fibers synthesized by Corning Glass Works in 1970, another breakthrough following Kao's proof of ultra-transparent glass.[82]

These breakthroughs triggered a race through the 1970s and 1980s to create practical optical fiber. Laboratories worldwide created new fabrication techniques for optical fiber and developed small, reliable lasers so that, by 1977, the Post Office had two working trials, a 13km low-bandwidth 8.448 Mbit/s link and a high-bandwidth 7.25km 140 Mbit/s link.[83] In 1979, the Post Office placed orders with STC, GEC, and Plessey to begin fiber-optic installation in fifteen routes across Britain.[84] Several routes tested experimental low-bandwidth links in different environments, such as Welsh lakebeds, but three links were high-bandwidth 140 Mbit/s cables, including a Reading–London link. Only a year after the Post Office canceled the Bristol–Reading waveguide, preliminary tests took place to standardize optical fiber systems. By the 1980s, BT was breaking fiber-optic world records. In 1982, research staff tested a 140 Mbit/s link over 102km, the longest in the world, and BT completed a London–Birmingham fiber-optic link.[85] The following year, BT placed the first order in the world for a commercial fiber-optic link, running between Milton Keynes and Luton.[86] In 1985, another record followed, the fastest transmission rate ever achieved over optical fiber, 2.4 Gbit/s over 32km of cable, and BT research staff received a Queen's Award for Technological Achievement.[87] The late 1970s and early 1980s have been called the "Fiber-Optic Performance Olympics," with records frequently set and broken worldwide.[88] In the UK, these breakthroughs lent additional weight to the Post Office board's decision to cancel the Bristol–Reading waveguide, effectively canceling the waveguide altogether. Through most of the 1970s, the waveguide had been the "information highway," the "big brother" to optical fiber. But, just a decade after Charles Kao's 1969 breakthrough, the Post Office installed its first trunk network fiber-optic trials, and only four years later, BT was ordering and installing commercial systems.

As BT rolled out optical fiber throughout the 1980s, hope remained for a nationwide integrated digital network, coupled to a new metaphor of an optical fiber "national grid." The national grid was an evocative analogy with the United Kingdom's power network, known as the national grid for much of the twentieth century, and attempted to draw parallels with the near-universal connectivity of the power network, as well as its public ownership.[89] Where highways have often stood as symbols of individual freedom and mobility, grids are a communal infrastructure that bind users together.[90] Several government reports in the mid- and late 1980s addressed the idea of a national fiber-optic "grid." In 1986, the Peacock Committee, ostensibly reviewing the BBC's financing, recommended that the government permit BT to construct a fiber-optic national grid for TV and telecommunications.

In 1988, two further reports addressed this recommendation. The first, *Opto-electronics: Building on our Investment*, a report by the Advisory Committee on Science and Technology (ACOST), argued in favor of a state-funded national grid, while the second, *The Infrastructure for Tomorrow*, an official policy report from the Department of Trade and Industry (DTI), concluded that the government should not fund a national grid.[91]

The DTI's main reasoning was that funding BT's national grid would harm competition, but the report developed an interesting secondary argument about the relationship between the fiber-optic national grid and the ISDN digital standard. The report argued that infrastructure policy should not only take into account competition between firms, such as BT and Mercury, but that it should also consider competition between technologies. The government should thus not "pin its colours" on a particular technology.[92] The report, turning BT's ambition for an integrated digital network against itself, drew attention to how development of the ISDN meant

> the barriers between services are crumbling (voice, vision and data are indistinguishable in digital form; films made for the cinema may receive their first showing on TV or on video-cassette). The barriers between delivery mechanisms should also crumble. The screen and telephone are oblivious to the technology that lie behind them—as are their users! Thus a call to a mobile telephone in the field of a farm might come by a satellite from Hong Kong to a Mercury dish, through a BT line onto a cellular radio system.[93]

The DTI's report is interesting because it shows the flexibility in how standards can stand in for public policy. Standards have politics. For example, the adoption of a new internet protocol, IPv6, became a vehicle for furthering European integration and promoting economic growth in Asia.[94] The example of ISDN shows that standards' political flexibility can be pushed to contradictory limits. For European PTTs, ISDN stood in for a policy of public monopoly over telecommunications. But the UK's Department of Trade and Industry, rhetorically at least, used the ISDN to apply the principles of a free-market economy to innovation. Its report argued that, because ISDN separated the standard for digital transmission from the physical medium that carried the transmission, whether a satellite or optical fiber, ISDN promoted competition in the development of these media, so furthering innovation. For the DTI, the ISDN thus stood as a vehicle for applying a competitive marketplace approach to innovation policy, wherein the marketplace, rather than a national telecom operator, would determine which transmission technologies would succeed and which would fail.

After the government rejected a publicly funded fiber-optic “national grid,” BT used that metaphor less, but kept promoting optical fiber as “highways” for the nation. BT announced the 1985 Nottingham–Sheffield fiber-optic link as a “high-capacity, long-distance highway,” and BT described its fiber-optic network in 1988 as “a network of super highways of glass fibres for visual communications.”[95] The highway metaphor also extended from the trunk network, which it had described with the waveguide, to the local network. By 1989, BT had installed 600,000 kilometers of optical fiber in the trunk network and so turned its attention to the local network and back to its failed plans to provide digital video services. BT started a fiber-to-the-home trial, or FttH, in 1989 in Bishop’s Stortford, a market town approximately 30 miles north of London. One of the trial’s novel features was providing broadcast TV and a video library, which meant that, alongside telephony and data, customers could also receive up to thirty TV channels and play TV shows and movies on demand.[96] This trial was advanced but not out of step with the ambitions of the time. Similar trials happened in Japan, Canada, France, the Netherlands, and the United States from the late 1970s to the early 1990s.[97]

This deployment of TV over optical fiber was a step toward BT’s long-held ambition to incorporate TV and video services into its communication infrastructure, but not for long. In 1990, the Department of Trade and Industry began reviewing its competition policy for telecommunications. This included several topics, such as the BT/Mercury duopoly, but it also included the policy over whether BT and Mercury, as telecom operators, would be permitted to expand into cable TV supply. Concerned that the government would block this expansion, BT began slowing the deployment of optical fiber before any formal decision was announced.[98] This was reinforced in October 1990 as Peter Lilley, the secretary of state for trade and industry, announced that the government would be admitting more telecom operators, but gave no further details.[99] These details finally emerged in the government’s 1991 white paper, *Competition and Choice: Telecommunications Policy for the 1990s*.[100] The white paper ended BT and Mercury’s duopoly, allowing new companies to apply for licenses in local, trunk, and international telecom services. It also prevented BT from expanding into “entertainment services,” meaning cable television, for seven to ten years, but permitted existing cable operators to immediately expand into telecommunications services. And so the DTI's plan for shaking up British telecommunications became clear. The government would not allow BT to expand into cable TV, but it would allow cable TV operators to expand into telecommunications.

This provoked various critiques through the early 1990s, which deployed all sorts of metaphors to advocate for a national fiber-to-the-home infrastructure. In response to the DTI, Alan Rudge, BT's managing director for development and procurement, called for public investment, saying that "telecommunications is the nervous system of society and we must nourish it properly."[101] Moreover, Rudge also made it clear that it would not be cost-effective for BT to roll out an all-fiber network, if it could not use that network to commercially offer entertainment services, including TV, over that network. Articles in the *Guardian* also lamented the government's decision, pointing out that, because there were no bars on foreign ownership of cable TV in the UK, this gave free rein to US-owned cable TV companies such as Pacific Telesis, US West, and United Artists, which had already bought many of the domestic UK cable operators, to expand into telecommunications as well. These articles called for fiber optic as both a "national grid" and an "information superhighway" for the UK, to little effect.[102]

It is telling, therefore, that BT transitioned the "highway" metaphor to a digital network that did enter service, albeit not in the form that BT had hoped. In 1998, BT's national ISDN service finally debuted under the brand name Highway, a broadband service that enabled customers to surf the internet and use their phone line simultaneously. Highway, providing simultaneous voice and data services to its customers, thus partly realized telecom engineers' original 1967 vision for a nationwide general-purpose digital infrastructure, albeit missing video services. Highway, however, also showed the influence of liberalization and business markets on BT since that original vision. Highway adverts told audiences to "find out how the business highway can help you work faster" and to "get on the BT highway."[103] A TV advert started with a car speeding down a road at night, before it suddenly stopped, its headlights illuminating a man sitting at his desk, using both his phone and computer simultaneously. The car reversed its journey until it returned to its starting point, illuminating the word "Drive."[104] In this advert, a physical, road-based journey was interrupted and reversed by a vision of a businessman making two simultaneous virtual journeys, telephonic and computerized. These adverts divorced the highway metaphor from optical fiber and, indeed, all transmission media altogether. Instead, the advert pitted metaphor directly against its real-life counterpart, with the message that the virtual, metaphorical highway was now superior to the material, physical highway, and that BT, in its new competitive condition, was the toll road operator.

This shows quite a different vision of the "highway" from Al Gore's popularization of the term "information superhighway" in the US in the 1990s, which Gore used to promote a national information infrastructure when he was vice president for Bill Clinton.[105] This usage reached its apogee at the 1994 Superhighway Summit at the University of California, Los Angeles. At this summit, Gore outlined his and Clinton's ambition for a national information infrastructure built on competition and private investment, while also ensuring open access and avoiding "a society of information 'Haves' and 'Have Nots.'" For supporters of Gore's highway, the metaphor connoted linearity, high speeds, and continuous flows.[106] Gore, however, also lamented the unexpected usages of the "information superhighway." A high-tech start-up had complained to him about the danger of ending up as "road kill on the information superhighway," while other companies had petitioned him to support their entry into the communications infrastructure market, concerned that they would end up "parked at the curb on the information superhighway."[107] These were not the only opponents of the "highway" metaphor. Contributors to the digital utopian magazine *WIRED* attached the "highway" metaphor as connoting the public ownership, monopoly, and technocracy of the federal highway system, and instead favored evolutionary metaphors that symbolized unpredictable growth and change.[108] BT, on the other hand, inverted the highway metaphor with its ISDN service. For BT Highway, the highway was not just a highway: it was BT's turnpike, and only in this new political economy of digitalization could such a metaphor, positioning private telecommunications above public roads, have appeared.

CONCLUSION

This chapter opened with the myth that Margaret Thatcher killed the UK's nascent national fiber-optic network and used a history of the Post Office and BT's vision of an integrated digital transmission environment to uncover the truth behind the myth. The myth has several inaccuracies. The first is that the 1991 decision was about optical fiber. It was not. Instead, it was about cable television and video entertainment services. For BT, optical fiber was a means to an end, and that end was broadcasting television signals and video services over a national cable network, whether coaxial or optical fiber. During the early 1960s, when the Post Office built a nationwide microwave network that transmitted telephony and television, its engineers and managers showed little interest in integrating television into their network. This changed in the late 1960s, when their understanding of digitalization and integration led them to the conclusion that they could build a network that could transmit video and data services in addition to voice telephony, and that doing so could not just preserve but also expand their monopoly.

This led to early interest in the integrated services digital network standard. This cooled when the Post Office's business customers demanded digital data networks sooner than digital telephone networks could integrate data services, and when transnational standardization efforts focused on integrating only telephony and data, and not video as well. The Post Office and BT remained interested in expanding into television as a way of realizing their original vision of a general-purpose digital infrastructure—this is something that the myth misses. *TechRadar* and Peter Cochrane's story about the 1991 decision to block BT fixates on the idea that this crippled Britain's internet infrastructure, but the decision had nothing to do with the internet and everything to do with television. This is further shown by the fact that in 2001, after the ten-year restriction on BT entering the TV market ended, BT began developing for cable TV. In 2006, BT finally entered the TV market, delivering TV via its customers' internet connections, realizing a level of digital integration that it had aspired to since it was the Post Office in the 1960s.

The second inaccuracy in the myth is how close the UK came to having this fiber-optic network. A national general-purpose digital network, which combined telecommunications and television, was only ever a dream on BT's part, and it had only ever been a dream since the late 1960s. BT, by its own admission, could have made the fiber-optic network cost-effective only if it could expand into TV provision. But time and time again, throughout the 1970s and 1980s, the Post Office and BT had lobbied both Labour and Conservative governments to let them expand into television transmission, an effort that had never, at any point, shown any sign of materializing. Indeed, if there was ever a moment where the national fiber-optic network came close to living, it would not be the 1991 decision about cable TV regulation. Instead, it would be in 1988, a moment of genuine conflict between government bodies on the public funding of a national fiber-optic grid. The Advisory Committee on Science and Technology supported the grid, while the Department of Trade and Industry's *Infrastructure for Tomorrow* report advised against it, using the ISDN standard to justify policies of infrastructural austerity and innovation through competition. The DTI, the senior government body, won, and the national fiber-optic grid never lived. The metaphors used throughout this history, highways and grids alike, reinforce the ephemerality of this national general-purpose digital network. These metaphors invoked the envisioned applications of waveguides and optical fibers to national communications, but they were only ever anticipatory. The metaphors that fueled the Post Office and BT during this period, like the other forms of long-range expectations such as the UK Trunk Task Force's modeling studies, reveal the extreme degree to which the Post Office and BT were inventing for the future, rather than for the present.

The third and final inaccuracy is that the 1991 decision was solely about competition. The 1991 decision is historically interesting because it shows an ideological quality missing from earlier decisions in the UK about the regulation of telecommunications. As these chapters explore, these decisions were usually pragmatic and often deferred to the Post Office or BT (as shown in the previous chapter on the regulation of equipment supply). For example, the decision to replace BT's monopoly with a duopoly sufficiently demonstrates that the Thatcher government's decision to privatize BT and liberalize its monopoly was not an ideological decision about turning British telecom services into a hypercompetitive free marketplace. As discussed in chapters 3, 6, and 7, liberalization and privatization were more about enabling BT and the City of London's financial sector to compete on international markets. The 1991 decision did open telecommunications to more competition, but by replacing the duopoly system, comprising majority British-ownership companies Mercury and BT, with a system that opened British telecommunications to foreign-owned cable companies. This was not just about competition but also about denationalization. As commentators both past and present have noted, the regulation of British industry under Margaret Thatcher increasingly showed that it was not the nationality of capital that mattered but attracting investment from international capital.[109]

The 1991 decision also shows a tragic irony in the intersections among digitalization, liberalization, and privatization. In the case of cable networks, it was possible to open telecom markets to cable operators only because digitalization meant that cable operators could integrate telecommunications services into their television networks. From the 1960s to the 1990s, the Post Office and BT hoped that digital integration meant they could expand their telephone network into a data and television network. But by the 1990s, when new cable television networks had appeared, digital integration also meant that these cable operators could expand into telecommunications. In the end, digital integration did not protect the Post Office and BT's monopoly, but instead rendered it more vulnerable to competition from alternative networks.

Integration, however, was not the only way that digitalization intersected with the liberalization and privatization of British telecommunications. The next three chapters use spatiality as an organizing motif to explore how the Post Office and BT's technopolitics of digitalization, nationalization, and privatization unfolded in different places and spaces. A recurring theme is the interplay between techno-nationalism and digital internationalism on these different levels, from the local to international. The next chapter starts with the local, looking at the Post Office and BT's research center in Martlesham Heath, Suffolk, one of the main sites where the Post Office and BT developed and tested waveguides and optical fiber.

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Market and Monopoly in British Telecommunications

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