4 Constructing the Liberty Machine

Let us bring together all of science
before we exhaust our patience.
—Angel Parra, June 1972

Constructing Cybersyn was a complex affair. In addition to building the actual system, members of the Cybersyn team needed to create a work culture, transfer expertise and technology from Britain to Chile, and gain the support of factory managers and production engineers. The Cybersyn team viewed their work as helping the Allende government improve its control of the economy and raise production levels. Some members of the team also saw technology as a way to build Chilean socialism. Indeed, the Allende government had made technology political. In addition to Project Cybersyn, it supported the creation of low-cost consumer goods for mass consumption. It also emphasized the use of Chilean resources in national research, development, and production activities and oriented Chilean science and technology toward meeting national needs.

However, Beer argued that technology could be political in other ways. He believed that creating a technological system entailed developing a technology that could be integrated into a social and organizational context. Thus, engineering a technology also provided opportunities to engineer the social and organizational relationships that surrounded it.

Beer saw Cybersyn as a way to reengineer the relationships between white-collar technologists and blue-collar workers, workers and the state, and the state-run enterprises and the national government and to reconfigure these relationships in ways that were congruent with Chilean socialism. Sociotechnical engineering gave Cybersyn technologists a way to embed political values in the Cybersyn system. In this chapter I discuss several examples of how Cybersyn technologists tried to make Cybersyn socialist by engineering the social and organizational relationships that surrounded the system. At times, the methods and practices that Chilean technologists used to build the system contradicted the political aims of the Allende government as well as the rhetorical connection between technology and politics that Beer and others articulated. The construction of Project Cybersyn illustrates how difficult it is to build political values into a technological system.

Beer's two visits thus far had largely focused on the design of Project Cybersyn and getting the work off the ground. By April the team had decided on a design and divided the responsibilities for the different subprojects. Building the system now became the central priority of the Cybersyn team.

This chapter encompasses the six-month period from April 1972 to September 1972, when the team made the greatest progress in building the four components of Project Cybersyn: the telex network (Cybernet), the statistical software (Cyberstride), the economic simulator (CHECO), and the control room (Opsroom). Members of the Cybersyn team were still optimistic about the potential of these components for effecting revolutionary change, despite the worsening economic situation and increased political polarization.

In fact, the economy was already in dire straits. On 1 April the rightist Chilean newspaper *El Mercurio* announced: "The economic state of the country cannot be worse." The headline, though intended to strengthen anti-Allende sentiments among the Chilean people, also signaled that Chile was facing a deteriorating balance of payments; declining savings, investment, and production levels; the beginnings of consumer shortages; and inflation.[1] Meanwhile, the position of Allende's political coalition, Popular Unity, grew more precarious each day. In early April the Leftist Radical Party (PIR), a small center-leaning member of Popular Unity, broke from the coalition—a sign that Popular Unity was losing the center. In addition, Popular Unity had not won over the working class as Allende had predicted. May elections for the leadership of the National Labor Confederation, the national federation of labor unions, gave 25 percent of the vote to the Christian Democrats. Since the Christian Democratic Party had always had worker support, this in itself was not surprising; however, it was surprising that more than a year into Chile's revolutionary process Popular Unity had still failed to attract one quarter of Chilean workers to its program of socialist change.[2] Meanwhile, the deteriorating economic situation pushed growing numbers of the middle class toward the opposition. These trends suggested that Popular Unity would not be able to hold, let alone increase, its support base and called the viability of the Popular Unity program into question.

Nevertheless, at this point the political situation did not even give the Cybersyn team pause. After reporting the election results to Beer in a letter, Cañete observed that "the political situation does not alter our project because we are 'in' with the man himself [Allende] and *he* is staying, no doubt about that."[3] Cañete could not have imagined that in less than two years Allende and Chilean democracy would come to a violent, brutal end.

Creating a Culture

In April Flores asked Beer to spend more time in Chile working on Cybersyn and Cyberfolk and thinking of other ways to apply cybernetics to government. The invitation proved irresistible to the cybernetician. After a short trip to Saint Simon Island, Georgia, for an invitation-only conference on speculative technology hosted by the U.S. National Aeronautics and Space Administration, Beer canceled all but two of his other scheduled consulting jobs for the remainder of the year.[4] He estimated he would spend "total formally 20 weeks to year end" on the Chile project but noted, "As usual, it would actually be more."[5] The Chile project now accounted for the majority of Beer's income until 1973, which made him nervous. The Chilean government had not yet paid Arthur Andersen for its work on the temporary suite, and no one knew what would happen to Chilean exchange rates in light of the economic problems and the U.S. blockade. Because of this uncertainty, Beer requested "substantial advance payment" for his work.[6] He also asked for a formal letter from Allende that Beer could use to help "get out of many small commitments" while preserving his professional reputation. The president sent the letter, but it did not reach Beer until the end of May, well after he had canceled his contracts and felt some professional embarrassment.[7]

When Beer returned to Chile in mid-May, he did so not as a foreign consultant but as the official scientific director of the Cybersyn project. In the new management hierarchy that Beer had devised, Flores assumed the role of political director, and Raúl Espejo, the industrial engineer and operations research scientist who had worked with Flores at the Catholic University and then at the State Development Corporation (CORFO), became the project coordinator.

As scientific director Beer created a work culture closer to the startup culture of the 1990s than to the chain-of-command bureaucracy that flourished in the 1960s and 1970s and was characteristic of Chilean government agencies. He viewed his position as scientific director more as that of a "free agent" than a micromanager. After establishing offices at the State Technology Institute (INTEC) and the Sheraton, he informed the team that he would work at either location at his discretion and call on project team members as required. Moreover, he refused to stick to a traditional nine-to-five work schedule. Team members often found themselves working alongside the bearded cybernetician into the wee hours of the morning. This schedule enabled them to attend to other projects at their regular jobs during the day and helped create an informal camaraderie among team members that bolstered their enthusiasm for the project. On the other hand, the long hours affected the home lives of the Chileans. Isaquino Benadof noted, quite diplomatically, that the project made his marriage an "interesting experience." He quickly learned that if his wife didn't understand what he was doing and that he was "really passionate, putting [his] heart into it," she might feel abandoned or unloved. So Benadof tried to make her a member of the team by extension. "I shared with her all of the problems, all of the talking, all of the expectations," he recalled. He also introduced her to his fellow team members, including Flores and Beer. Benadof recalled that she did not much care for Flores's gruff style and even told him so to his face.[8]

As the project team grew, Beer worked increasingly with a core group of Chileans, most of whom were the directors of the different subprojects. By May 1972 the core group included Fernando Améstica, who concentrated on building the telecommunications infrastructure for the telex network; Jorge Barrientos, who was charged with defining production indicators for the textile and forestry sectors; Benadof, who directed the development of the Cyberstride permanent suite; Gui Bonsiepe, the head designer of the operations room; Roberto Cañete, who was coordinating the construction of a central telex room at CORFO; Espejo, the project coordinator; Humberto Gabella, who studied cybernetic principles to determine how they could improve the government's control of the economy; Mario Grandi, the Chilean director of the CHECO (Chilean economic) simulator; Hernán Santa María, who was in charge of data management; and Alfredo del Valle, who defined production indicators for the energy sector.

The work culture Beer created put human dynamics before solving technical problems and resulted in a team that, at least initially, had a shared vision of risk taking and cybernetic possibility that transcended political differences. When Beer interviewed Benadof for a spot on the team, he first asked Benadof how he learned new things and whether the computer scientist was interested in undertaking an adventure. Beer "felt that if he didn't have a team with the spirit to break in a new paradigm, the whole project would fail," Benadof noted. "He was more interested in the power of the person than what he knew about the [particular] problem."[9] Beer brought to Santiago a copy of the popular novel *Jonathan Livingston Seagull* by Richard Bach and wrote the names of different team members on the seagulls drawn on the cover. He charged those listed with reading the book and asked them to place an *X* by their name once they finished. The book tells the story of a seagull who struggles to do something different and breaks from the conventional behavior of the flock. Beer hoped the book would give the team a shared reference point for what they were trying to do.

Beer and Flores also began cultivating a "unique friendship" grounded in mutual respect, a shared intellectual curiosity, and a common goal. "A level of sympathy was developed," Flores recalled, despite the differences between the men: "I was a national leader, he was an international leader, and also we were of a different age."[10] While Beer imparted knowledge of cybernetics, Flores sought to educate Beer on Chilean politics, language, and South American culture. At Flores's insistence, Beer read Gabriel García Márquez's masterpiece, *One Hundred Years of Solitude*, and used it as a text for understanding the magic realism of South American life.[11] Beer thereafter referred to Flores as "Aureliano," the name of García Márquez's revolutionary who survived fourteen attempts on his life, seventy-three ambushes, and a firing squad. Flores responded in kind by calling Beer "Melquíades," the name of García Márquez's gypsy who brought news of scientific and technological innovations from the outside world to the tiny imagined Colombian town of Macondo.

Beer's new management structure for the Cybersyn team reflected the five-tier structure of the Viable System Model, another common reference point for the group. The drawing put Flores at the highest level (System Five), placed Beer in charge of future development (System Four), and gave Espejo control of day-to-day activities (System Three). System Two consisted of the directors of the different subprojects, and System One comprised the subproject teams themselves. However, like the democratic socialism of the Allende government and the design of Cybersyn itself, the management structure of the team preserved autonomy, this time among the different subprojects. In a memo to the Cybersyn team, Beer explains that he broke Cybersyn into clearly defined subprojects that small teams could address intensively. This arrangement allowed for a "meeting of the minds" within the smaller group, and because the small team did not need approval from the larger group, it could progress quickly. At the same time Beer insisted that each team keep the others informed of its progress. He arranged large brainstorming sessions that brought together the members of different subteams. In these sessions, he instructed, "sniping and bickering are OUT. Brain-storming is essentially CREATIVE. . . . At least everyone gets to know everyone else, and how their minds work. This activity is essentially FUN: fun generates friendship, and drags us all out of our personal holes-in-the-ground." Project leaders could then take ideas from the brainstorming sessions and use them to improve their part of the project, thus incorporating the suggestions of others. Beer contrasted this "fun" style of management with the more common practice of bringing all interested parties together to make project decisions. That approach, he felt, eventually led to bickering, sniping, or sleeping. It "masquerades as 'democratic,' [but] is very wasteful," he observed.[12] In addition, he required all project leaders to write a progress report at the end of each month and distribute it to the other team leaders. Beer viewed the brainstorming sessions and the written project reports as serving a function similar to the signals passed between the different organs of the body: they kept members of the team aware of activities elsewhere. They also allowed the different subteams to adapt to progress or setbacks elsewhere and helped Cybersyn maintain its viability as a coordinated project while it advanced toward completion.

Beer soon realized that he needed someone to serve as his eyes and ears in Chile when he was in England and asked the administration for an assistant. "She will *not* be a secretary," he specified but rather would assist him and help coordinate the work among the different project teams. Sonia Mordojovich joined the project as Beer's assistant shortly thereafter (figure 4.1). A recent business administration graduate of the Catholic University, Mordojovich had met Flores during an internship at CORFO.[13] She spoke fluent English, having lived a year in Pasadena, California, as part of a high school exchange program. She also understood many technical aspects of the project

Figure 4.1
Stafford Beer and Sonia Mordojovich. Image used with permission from Constantin Malik. Original kept at Liverpool John Moores University, Learning and Information Services, Special Collections and Archives.

because of her university training. Mordojovich arranged Beer's schedule, acted as an interpreter, attended meetings in Beer's absence, and became a liaison between Beer and the team when he was not in Chile.[14] These new management arrangements helped coordinate the work on the four subprojects and allowed the team to work quickly.

Beer created a work culture that emphasized friendship, risk taking, independent learning, and creativity. This culture helped the team make rapid progress in building each of the four subprojects and made those who were involved in the project feel that they were part of something special.

Technology Transfer

In April 1972 Chile hosted the Third United Nations Conference on Trade and Development (UNCTAD III), which Allende hoped would showcase the success of Chilean socialism. Allende's speech at the U.N. conference is perhaps best remembered for its attack on multinational companies and their treatment of Third World nations. However, Allende also used his time at the podium to consider how underdeveloped countries like Chile could have access to modern science and technology. He outlined two ways that Chile might increase its scientific and technological capabilities. The first was to continue policies of import-substitution industrialization and use foreign investments and imported technologies to industrialize the country—policies that historically caused unemployment and underemployment, stressed the value of consumption based on foreign models, and put foreign interests above Chilean interests. The other possibility consisted of "creating or reinforcing our own scientific and technological capabilities," by transferring knowledge from the international community and basing these capabilities "on a humanist philosophy that has man as its chief objective."[15] The Chilean cybernetic project, now entering its sixth month, fit with the latter approach. It relied on foreign expertise but consciously transferred this expertise from the foreigners—Beer; Ron Anderton, a British systems engineer and operations research scientist; and the Arthur Andersen consultants—to the Chileans who were building Cybersyn's various components. The president's insistence that Cybersyn enhance worker participation was another example of how technology could contribute to the construction of a more humane and just society that recognized the dignity of all Chilean people.

The transfer of technology and expertise from Britain to Chile played a central role in the development of the Cyberstride statistical software. So far British and Chilean software developers had written the software code for Cyberstride in parallel on opposite sides of the Atlantic. In May, Arthur Andersen sent consultant Giles Hemmings to Santiago to assist the Chilean programmers with coding the permanent suite. Hemmings stayed in Santiago from 7 to 12 May, and his observations were mixed. "The work has not progressed sufficiently far," he wrote, but "this does not mean, nor does it imply, that we expect our work or the Cyberstride System to be anything but a success."[16] Although the work was not up to the standards Hemmings expected, it was still fixable.

In the process of pointing to a number of things that required attention, Hemmings painted a picture of how software was being developed in Chile in the early 1970s. He felt the Chilean team gave too much attention to programming and not enough time to the administrative aspects of the software project. "We would allow and expect 20 percent of the effort [on Cyberstride] being expended in project administration—overall planning, organizing the effort, preparing detailed work programs, recording usage of time and progress, and progress reporting and progress meeting," he wrote. Hemmings also chastised the Chilean programmers for not properly documenting the programs they coded and for not having a standardized procedure to test the code they generated. "It is difficult to judge the status of the programming . . . because the documentation and development procedures which are to be followed are not clearly defined," he observed. "With regard to program testing there are no standards of which we are aware."[17] He quickly realized that the Andersen consultants needed to teach these skills to their Chilean counterparts if such practices were to become part of Cyberstride's development in the future.

The Andersen consultants thus taught the Chilean programmers practices that were standard in the British computer industry but were not yet standard practice in Chile. This included how to document code, write testing programs, number punch cards, prepare biweekly progress reports, write a general description of the system in the form of a manual, and prepare work programs that listed individual tasks, the person responsible, and the estimated date of completion. According to Benadof, the skills imparted by the Andersen consultants were invaluable: "They gave us a structure, how to work with discipline in order to have a good product at the end with quality assurance." He added that this approach was "not like the Chilean way," a reference to the unstructured, undocumented trial-and-error approach that had been in place at the National Computer Corporation. Yet the Chileans did not embrace the British approach fully. Benadof enjoyed working alongside the Andersen consultants but found their demeanor more formal than what he was accustomed to, qualities he lumped under the heading of "too British."[18]

Scholarship on technology transfer has shown that artifacts are not the only things needed in order for a technology to be taken up elsewhere: people, patents, expertise, manufacturing capabilities, networks of support, economic and legal frameworks, political aims, and cultural values also play a fundamental role. In the Chilean case, developing software required not only the acquisition of mainframe technology and the training of programmers to use that technology, both of which began in the 1960s, but also the movement of people, in this instance between Chile and England, and the sharing of work practices, which improved the quality of the software and the speed of its completion. In the process, the Chilean programmers learned skills that were not necessarily technical—such as producing documentation—but that were nonetheless necessary parts of successful software development. The exchanges that occurred between the Chilean programmers and the Andersen consultants raise important points. First, although the physical transfer of mainframe technology took place in the 1960s, the transfer of technological capability was an ongoing process that extended well beyond the acquisition of computer technology and its use by the Chilean government. Second, although the Cyberstride software had a short lifespan, the practices taught by the Andersen consultants were internalized by the Chileans, who taught them to subsequent generations of programmers. Such practices, which according to Benadof were not standard at the National Computer Corporation before the arrival of the Andersen consultants, are among the more valuable legacies of Project Cybersyn.

The work completed by the Arthur Andersen consultants came in under budget. After the Chilean government paid the bill and closed the contract, the consultants remained intrigued by the unorthodox computer system they had helped build. "We hope the project continues to go as it should," wrote senior consultant David Kaye to his friend Beer. "We are of course enormously interested to know how it develops and any progress reports would be most gratefully received."[19] Beer thanked Kaye for the professionalism displayed by the Andersen consultants and predicted that by late October the system would be "handling some two-thirds of the economy through Cyberstride."

Although Cyberstride is an example of how technology transfer occurred during the Allende period, the emphasis I have placed on the role of the British consultants should not detract from the accomplishments of the Chilean programmers. By early July, Benadof and his team had the temporary suite software checking thirty production indicators for anomalies—significant progress but still a far cry from the "two-thirds of the economy" that Beer predicted would be running through the system by October. Real-time data-processing remained a pipe dream, but the team found a way to shorten the time it took to process factory data. Thus far, Project Cybersyn had used one of the government's top-performing computers, an IBM System/360 mainframe. But the government used this machine for a range of data-processing tasks other than Project Cybersyn, and it was constantly in use at the National Computer Corporation. Due to this high demand for the machine, the agency could not process the indicators it collected from the enterprises for twenty-four to forty-eight hours after they were received. If an emergency arose, the government would be unable to process useful data until a computer became available. To surmount this problem, Benadof worked night and day to rewrite the temporary suite code so that it might be run on the less-used Burroughs 3500 mainframe.[20]

Beer also recognized the accomplishments of the Chilean data management team. In his August letter to Kaye he praised Benadof's recoding of the temporary suite for the Burroughs mainframe. Beer also recognized the work of Hernán Santa María, the head of the data management team, who successfully oversaw the writing of software code to analyze production data from three textile enterprises, one cement enterprise, and one coal mine. Santa María's team then "tuned" these statistical programs, or tweaked them, so that they could reproduce the past behavior of an indicator. Once tuned, the program would be used to predict the future behavior of the indicator. "Hernan [Santa María] and his men have really advanced the theory of 'tuning' the series, picking up where Alan [Dunsmuir] left off; they will contribute an important new chapter to the Bayesian theory in general, if I ever give them time to write it," Beer told Kaye.[21]

Technology transfer from Britain to Chile also played a central role in building the CHECO simulator. Members of the CHECO team aimed to map the larger macroeconomic picture and create a functioning model of the Chilean economy. The model went beyond production to include such considerations as the currency supply, investment, and inflation. It also included factors more directly related to production, such as demand and industrial productivity levels. The CHECO modelers looked at the general behavior of the entire economy and hoped to gradually increase the simulator's specificity by modeling additional economic factors.

Until now most of the work on coding the CHECO simulator had taken place at Queen Mary College in London. In Chile, Mario Grandi and the rest of the CHECO team were still mastering concepts from economics, cybernetics, and industrial dynamics. This changed in May when Espejo wrote to Beer, "We are interested in developing our own simulation language for the Chilean economic characteristics."[22] Beer suggested that the Chilean government send someone to London to study the DYNAMO programming language with Ron Anderton. The government chose Hernán Avilés.

Beer's records suggest that Avilés became well versed in both the DYNAMO programming language and the CHECO model during his stay in England. He worked from 3:30 p.m. to 11:00 p.m., the only period when he could get time on the university computer. He also worked closely with Anderton and even lived with him for a stretch while the two prepared a report on CHECO for Avilés to take back to Santiago. Anticipating Avilés's return to Chile at the beginning of July, Anderton observed, "I think we can achieve shortly the aim of this first phase—the 'take-off' into self-sustained activity of the Santiago team."[23] His use of the term *take-off* echoed the rhetoric of many development policies implemented in Latin America during this time, based on the idea that transferring technologies from the developed world to the developing enabled poorer nations to take the path to progress pioneered by nations such as the United States and England.

After Hernán Avilés returned from Queen Mary College, he resumed his work with the Santiago CHECO team. Perhaps because the team now had someone who felt comfortable with the technical aspects of building dynamic models, members began to focus greater energy on understanding the complexities of the Chilean economy. They expanded the project team to include an economist and an economics student, as well as experts in engineering, systems analysis, statistics, and psychology—almost the same disciplinary range found in the larger Cybersyn Project. They held twice-weekly seminars in which members of the team led discussions of economic theory, and they started studying structuralist inflation models that linked inflation to insufficient production levels rather than to an increase in the money supply.

The CHECO team also started to recognize the fundamental reasons for the difficulty of modeling Chile's socialist economy, which had nothing to do with mastering a new computer language. Instead, the main problem was that the team could not acquire the economic information it needed to build a model and test the model's accuracy. Nor could the information the team collected accurately capture the rapid changes taking place in the Chilean economy. In some cases, the team had to use data from 1964 to 1970, the period marked by the presidency of Allende's predecessor, Eduardo Frei, and predating the economic changes set in motion by Popular Unity. In some cases the information simply did not exist, for the new structure of the state-controlled economy grouped together enterprises that had never been under the same management before. Little was known about "the functioning of the sectors taken separately and about the existent relationships among the different sectors of the Branch."[24] How, Grandi wondered, could his team accurately model the behavior of economic divisions that had not existed nineteen months earlier?

In mid-August the team wrote, "It is very difficult to obtain economic information when in the middle of a revolutionary process such as the present one in which the fight is given in [*sic*] many fronts. . . . There are not efficient information centers and we cannot even glimpse the possibility of having them available in the near future, although we are making efforts to do so."[25] Before the Cybernet telex network was up and running, the data available on Chilean industrial performance lagged by a year. Macroeconomic data and mining data lagged by two years, and data on the agricultural sector were scarce. Although copper mining and agriculture were not part of Cyberstride, they formed a key part of Chile's economic activity and shaped Chilean import-export activity. Therefore the CHECO economic model needed to include data from these areas. The information available on industry, mining, and agriculture was often scattered among internal documents and reports published by a multitude of government agencies and offices. Much of the team's time was spent locating these data and figuring out ways to make use of incomplete or contradictory data sets. Although the transfer of expertise from Anderton to Avilés helped the Chilean team master the DYNAMO programming language, such expertise was of limited value if Grandi's team could not amass the data needed for economic model building.

The Chileans remained in contact with Anderton as they built a simple model of inflation. The team planned to gradually increase the complexity of the model as it shed light on the inflationary process. In their correspondence with Anderton the Chileans now displayed a more nuanced understanding of the Chilean economy, and how to model it, than their British mentor. For example, in September 1972 they identified sixteen rules for modeling inflation specifically in the Chilean context.[26]

Anderton still advised the Chileans to pursue basic principles, such as locating which factors created exponential changes in economic behavior, which factors contributed to economic stability, and which changes could not be measured with the data available. "As I see it from 8,000 miles away," Anderton wrote, "the center of the problem seems to be in the response of investment to shortages and needs."[27] And from his vantage point across the Atlantic, he thought that rectifying consumer shortages might be possible if the administration focused its investment in the right areas—and the CHECO models might assist in the identification of those areas.

Something Anderton couldn't know, but which was becoming increasingly clear to those living in Santiago, was that the absence of investment, rather than its improper use, was at the root of the problem. And the problem had been caused by the unseen hand of the U.S. government. Decreases in foreign aid and foreign credit, the flight of foreign capital, plummeting international demand for Chilean copper (which had drastically cut the funds available for Chilean foreign trade), and the unwillingness of

U.S. companies to sell machinery and spare parts to Chilean industries all contributed to consumer shortages. Chilean industries had historically relied on imported machinery, much of it from the United States, but the U.S. government had cut economic aid to Chile from $80.8 million in 1969 to $3.8 million in 1973.[28] Moreover, the U.S. government also put pressure on banks to cut credit to Chile. For example, in 1970 the U.S. Export-Import Bank dropped Chile to its lowest credit rating category. The level of available short-term U.S. commercial credits dropped from $300 million during the Frei government to $30 million in 1972. The U.S. Export-Import Bank itself cut credit to Chile from $28.7 million in 1969 to $3.3 million in 1970 to zero in 1971.[29] The inability to secure foreign credit forced the Allende government to pay for imports using cash from its foreign exchange. This put the government in a difficult situation. As mentioned earlier, wage increases from Allende's income redistribution program had created a dramatic increase in demand for many consumer goods. To meet this demand, the government increased its importation of food, fuel, and other goods and, in the process, quickly depleted Chile's foreign exchange, which the government could not replenish because of falling copper prices. While the economic policies put in place by Popular Unity were in part responsible for this imbalance of supply and demand, consumer shortages also stemmed from factors that were beyond the control of the Chilean government, including the openly hostile stance the United States had taken toward Chile.

Even if members of the CHECO team had somehow been able to identify the extent of U.S. meddling in Chile's economy, how could they have modeled it? By September 1972, the economic model described by the CHECO team, which by its own admission was "relatively simple and incomplete," included an inflation model that took into account the levels of goods and services, productive capital, available capital, investment funds, prices, and total currency in the economy. But the inflation model was based on assumptions of structuralist economics—"inflation is generated when the quantity of goods demanded cannot be equalized by production"—and ignored other causes of inflation, such as the government's printing money to make up for the shortages in industrial investment caused by U.S. economic sabotage.[30] Furthermore, these models did not take into account other causes of Chilean consumer shortages, such as black-market hoarding and labor strikes that slowed production.

But Anderton, back in London, was unaware of what was happening to Chile's economy, much less why, and persisted in his efforts at technology transfer, even as it was dawning on the Chilean team that what he was recommending did not apply to their situation. Anderton had described training Avilés as a form of "take-off" because it allowed British expertise in the DYNAMO programming language to travel to Chile. He believed this transfer would give Chileans the skills to build economic models on their own and subsequently improve the productive capabilities of their country. Implicit in this framing are the beliefs that advanced computer-modeling technologies could make Chilean life better and that Chilean technological competence in this area would be able to improve the government's ability to formulate sound economic policies. However, members of the CHECO team could not make full use of the techniques Avilés passed on if they could not amass the data they needed to build and test a model. Nor was Chile fully in control of its own destiny; rather, it was subject to foreign policy (and dependent on money) from nations that openly wanted the Chilean socialist experiment to fail.

Were the CHECO models useful to the Chileans even so? In his account of Project Cybersyn, Beer notes that by September 1972 the CHECO team was running experimental models of national income, inflation, and foreign exchange, as well as a more general model of the entire economy. They had also started building models of the light industry branch and the automotive sector that the team hoped to eventually transform into components of the macroeconomic models. These are substantial accomplishments, considering the short time frame for the project, and the team ran simulations showing what would happen years in the future. Yet the team viewed the simulations as more of a learning experience than hard numbers on which to base policy. According to Grandi, CHECO was "extraordinarily useful for understanding dynamic systems with positive and negative feedback." But as a mathematical model, CHECO "was a failure."[31] Beer agreed, stating that "no one was anxious to place reliance on the results."[32]

Cyberstride and CHECO illustrate how difficult it was for Chile to dismantle relationships of imperialism. Foreign expertise played a central role in both projects, even though the goal of Project Cybersyn was to help manage a growing nationalized sector of the economy, increase national production levels, and diminish Chile's economic dependency on other nations. Moreover, Anderton and the consultants from Arthur Andersen viewed as part of their contract the training of Chilean technologists to imitate practices and use technologies that originated in other parts of the world. The tension between the desire for greater economic independence and the continued reliance on foreign expertise and foreign technology also appeared in the Popular Unity program. Although Allende emphasized the need to develop Chilean capabilities in science and technology and to better harness the use of national resources in Chilean industrial production, he also recognized, as shown in his speech at UNCTAD III, that bringing foreign experts and foreign technology to Chile was essential to national development.

Project Cybersyn needed to draw heavily on foreign expertise and imported technology. But as the history of the CHECO project shows, Chileans could not simply imitate the techniques used in more industrial nations. Chilean modelers could not follow Anderton's recommendations because Chile had different recordkeeping practices than Britain and had less control over its domestic affairs due to U.S. attempts to set up the overthrow of Allende. Through its international exchanges Chile succeeded in creating and strengthening its national technological capabilities, per Allende's dictum. However, the techniques and technologies that Chileans studied were not necessarily suited for the Chilean political context.

Socialism by Design

Of the four subprojects that composed Project Cybersyn, the operations room best captured the vision of an alternative socialist modernity that the project represented. The futuristic design of the room, and the attention it paid to its human user, would never have come about if the State Technology Institute had not had its own team of professional designers that it could assign to the project. Because this team did not exist before Allende's election, it is worth taking a moment to describe how it came to be and the role industrial design played in the creation of Chilean socialism.

The industrial production of goods for mass consumption constituted one of the central goals of CORFO under Allende. Beginning in 1971, the agency pursued a number of programs to "augment the production capacity of goods for popular consumption," including plans for the design and manufacture of low-cost automobiles, bicycles, motorcycles, sewing machines, household electronics, and furniture, among other items.[33] For example, Citroën of Arica began constructing a new "automobile for the people" at the government's request, a Chilean version of the German Volkswagen.[34] Using funding and technology from its parent company, the Chilean Citroën plant drew up plans for a utility vehicle modeled after the Citroën Baby Brousse, a jeeplike conveyance that the French manufacturer had designed for public transportation in Vietnam. Citroën christened the new design Yagán, after a Chilean Indian tribe indigenous to Tierra del Fuego (figure 4.2). Cristián Lyon, then director of Citroën Arica, remembered that the designers "wanted to see [a vehicle] that was native like the Yagáns."[35] Another example was the manufacture of low-cost televisions for popular consumption produced between 1971 and 1972 by the mixed-area enterprise Industria de Radio y Televisión S.A., or IRT.[36] The IRT Antú was a black-and-white unit with an eleven-inch screen. Production of the Antú meant that television, previously obtainable only by well-to-do Chileans, became available to the masses for the first time.

Projects such as the Antú television and the Citroën Yagán paralleled UP policies for income redistribution and represented a "diversification and decentralization" of property, distribution patterns, and commercialization practices within Chilean industrial firms.[37] As a result of these efforts, poor Chileans and members of the working classes gained access to products and services previously reserved for the elite, a maneuver that raised levels of popular support for the UP, particularly during 1971 and early 1972.

The State Technology Institute also wanted to change Chilean material culture to reflect the goals of Chilean socialism. In an interview with *Science* magazine reporter

Figure 4.2
Pedro Medina sits in the driver's seat of the Citroën Yagán. Image used with permission from Editorial Planeta.

Nigel Hawkes, the deputy director of the State Technology Institute explained, "it is important for Chile to be selective about the technologies it adopts, because in the long run they may determine social values and the shape of society—as the automobile has in the United States, for example."[38] In addition to fostering the manufacture of low-cost, durable goods for popular consumption, Popular Unity's technological goals included decreasing Chilean expenditures on imported technologies and foreign patents, using science and technology to satisfy the specific biological and social needs of the Chilean people, producing a greater number of consumer and capital goods domestically, and improving both education and the dissemination of technical knowledge at Chilean universities, industries, and research institutes.

The State Technology Institute created the Industrial Design Group to assist with these efforts. In her study of the history of design education in Latin America, Silvia Fernández writes that Chile during the Popular Unity period was "the most advanced example in Latin America of design successfully integrated into a political-economic project in support of a social program."[39] The state support for design during the Allende years and its place in the Popular Unity program resulted from a series of coincidences and personal connections—although in hindsight design clearly forms part of a larger set of political, economic, social, and technological changes that were linked to Chile's revolutionary process.

Gui Bonsiepe, the head designer of the operations room, had studied at the Ulm School of Design (Hochschule für Gestaltung Ulm) in Germany beginning in the mid-1950s. One of the most influential design schools in Germany, perhaps second only to the Bauhaus, the Ulm School began in 1953 as a center for design education in industrial design, visual communication, industrialized architecture, and information design. From its inception, the school melded design education and practice with the social and political goals of European postwar reconstruction, including the promotion of democracy. The Ulm School also argued that design should be integrated into industrial production processes, where it would improve the production and use of material artifacts ranging from "the coffee cup to the housing estate."[40] The Ulm School moved design closer to science and technology and melded the visual aspects of design with scientific ideas, mathematical analyses, and user studies. Cybernetics, semiotics, systems theory, operations research, analytic philosophy of language, and Gestalt psychology all influenced the design methodology practiced at the school. The regular arrival of new guest instructors and visiting lecturers, such as Norbert Wiener and R. Buckminster Fuller, made student education in this range of areas possible.

Bonsiepe studied in the Design of Information Department, a program that taught the design of products and forms of visual communication. He first encountered cybernetics there. After he graduated from the program, he continued to work in a research and development group at the Ulm School and designed one of the first interfaces for an Olivetti mainframe computer.[41] Ulm professor and fellow designer Tomás Maldonado was Bonsiepe's intellectual mentor, and he made his first trip from Germany to Maldonado's home country, Argentina, in 1964 to work on design projects. Bonsiepe returned to Latin America for four months in 1966 as a consultant for the United Nations International Labor Organization (ILO). During this time he gave a seminar on packaging design and developed a curriculum for an Argentine school of design.[42] "In Latin America I discovered the political dimension of design," Bonsiepe said, "not in the sense of political parties, but in the sense that professional work [in this area] can have a social dimension."[43]

In 1968 Bonsiepe accepted a more permanent position with the International Labor Organization to work with Chile's State Development Corporation to introduce industrial design in small- and medium-sized Chilean industries.[44] (His departure coincided with the closing of the Ulm School.)[45] Industrial design was a new field in Chile, and at the University of Chile it was being developed by a core group of undergraduate students who lacked a formal mentor. Fernando Shultz, Alfonso Gómez, Rodrigo Walker, and Guillermo Capdevilla were students at the College of Applied Art at the University of Chile, which had advertised a program in design. Only after they arrived on campus did they learn that the program existed in name only, there was no curriculum, and they were among its first students.[46] Since the college did not have a good understanding of design, the students bore the burden of forming their own program. The new design students faced a considerable challenge: none of the faculty at the College of Applied Arts specialized in design or had a design background (most worked in the fine arts or architecture). The university "didn't know what design was, and we didn't have a clear idea either," Shultz said. "But we [the design students] knew that there was something else; that there was another alternative. And that was what we were looking for, to be designers."[47] They pushed the university to create a design department with programs in textile and garment design, landscape design, interior design, graphic design, and industrial design.[48] The students found faculty from various parts of the university to teach classes in all these areas but one: industrial design, the area that most interested them. They realized they needed to look beyond their home institution for the education they wanted.

After meeting Maldonado at a 1968 UNESCO-sponsored conference in Buenos Aires, the students learned of Bonsiepe's impending arrival in Chile. When Bonsiepe's boat arrived at the port city of Valparaíso, the four students were there to meet him. They convinced him to take a role in their education, and he, in turn, became a demanding taskmaster who pushed them to read widely and cultivate competencies in a range of areas, including engineering, economics, the social sciences, and design.

In 1970 Bonsiepe accepted an offer to teach design at the School of Engineering of the Catholic University. Bonsiepe's move presented new opportunities for this particular group of design students. They began working as teaching assistants for engineering classes at the Catholic University, even though they were officially enrolled as students at the University of Chile, a rival institution. Teaching engineers led them to appreciate the benefits of combining design with engineering. "The engineers had the know-how," Shultz noted, but in his opinion they were like catalogs that contained a rigid set of solutions. In contrast, designers looked for different solutions but lacked the technical expertise the engineers possessed.

While at the Catholic University, Bonsiepe extended his role as teacher and mentor to a group of four graphic design students from the School of Communications. Unlike the industrial design students and the majority of students at Catholic University's engineering school, the four graphic design students—Eddy Carmona, Jessie Cintolesi, Pepa Foncea, and Lucía Wormald—were all female (figure 4.3). "In the school where we studied [the School of Communications], there were almost no men," said Foncea. "So, rightly, we were girls, just like they [the industrial design students] were the ones who worked with hard things, materials." In Foncea's opinion, this gender divide was "part of a [social] reality that, in a certain form, still exists today in Chile," where science and engineering are male-dominated fields.[49] These two groups of students, the industrial design students and the graphic design students, would contribute to the design and construction of the Cybersyn operations room.

In 1970, Flores was still the director of the engineering school at the Catholic University, and he met Bonsiepe through a mutual friend. Years later Flores confessed to

Figure 4.3
Graphic design students (left to right): Pepa Foncea, Lucía Wormald, Eddy Carmona, and Jessie Cintolesi. Personal archive of Pepa Foncea. Image used with permission from Pepa Foncea.

Bonsiepe that he did not have a high opinion of the design profession until he visited Bonsiepe's home and saw one of Stafford Beer's books on Bonsiepe's bookshelf. As Bonsiepe tells it, Flores remarked, "'There were probably only two people in Chile who knew this book at that moment [Bonsiepe and Flores], and I thought that if a designer reads Stafford Beer, the design profession must have something serious in it.'"[50] Bonsiepe credits Flores for promoting industrial design education in Chile when it was still in its infancy. "This also happened in Brazil and Argentina," Bonsiepe noted. "Engineers with decision-making power created the conditions for the field of industrial design. This is not a well-known historical fact."[51]

When Allende came to power, Flores used his positions as both general technical director of CORFO and president of the board of the State Technology Institute to create the first state-sponsored industrial design group, which was to be housed at the State Technology Institute and led by Bonsiepe. The four industrial design students also moved to the institute. For Shultz the move meant not finishing his undergraduate degree at the University of Chile, a sacrifice he was willing to make. Higher education was far less attractive to him than the possibility of contributing to the Chilean road to socialism. Shultz noted that at the time finishing a degree was seen as bourgeois, or akin to having a "title of nobility," which was not appealing to the young design student. In addition to Capdevilla, Walker, Schultz, and Gómez, Bonsiepe assigned additional designers and mechanical engineers to the Industrial Design Group, including three Ulm School graduates (figure 4.4). Outside the institute Bonsiepe continued to work with the four graphic design students from the Catholic University; the four women contributed to several institute projects from 1970 to 1973, including the design of the institute's logo. Although the State Technology Institute benefited from the contributions of the graphic designers, the four women were not formally invited to join the institute. Foncea believes this was because graphic design had a less obvious connection to improving Chilean production capabilities than the field of industrial design.[52]

From 1971 to 1973 the State Technology Institute developed nearly twenty products, including inexpensive cases for electronic calculators; agricultural machinery for sowing and reaping that furthered the agrarian reform by raising the productivity of the land; spoons for measuring rations of powdered milk given to children through the National Milk Plan; a collection of inexpensive, durable furniture for use in public housing projects and playgrounds; and a record player inexpensive enough for popular use (figure 4.5). These goods were simple in design, easy to construct, inexpensive, and

Figure 4.4
The State Technology Institute (INTEC) Industrial Design Group. Front row (seated, from left): Rodrigo Walker, Gustavo Cintolesi, and Fernando Shultz Morales. Second row: Alfonso Gómez. Back row (seated, from left): Gui Bonsiepe, Pedro Domancic, Werner Zemp, and Guillermo Capdevila. Not pictured: Michael Weiss and Wolfgang Eberhagen. Image used with permission from Gui Bonsiepe.

Figure 4.5
An inexpensive record player designed by the Industrial Design Group. Image used with permission from Gui Bonsiepe.

of good quality, all important considerations for the majority of Chilean consumers. These products also illustrated the political dimensions of design. A piece of agricultural machinery that cut grass to feed livestock was Bonsiepe's favorite product "because it was directly related to the production of food—in this case, milk," and would raise levels of Chilean nutrition.[53] Taken together, these projects illustrate a shift in the definition of industrial success and the considerations driving technological innovation. Instead of giving priority to the production of capital-intensive goods and the maximization of profit, as private companies had in the past, the government emphasized accessibility, use value, and the geographic origin of component parts. These new considerations reflected the economic policies of Popular Unity and the social goals of the Chilean revolution. Far from being neutral, the technologies described here intentionally reflected the philosophy of the Allende administration and became tools for revolution.

Building the Opsroom

The Cybersyn operations room fit with the political mandate of the Industrial Design Group, but it was unlike anything else it created. While its other projects were closely tied to the day-to-day life of the Chilean people, the room was more of a futuristic dream. However, it did incorporate elements characteristic of the Ulm School of design and reflected the merging of engineering and design that had taken place at the Catholic University. The designers paid great attention to ergonomics and concerned

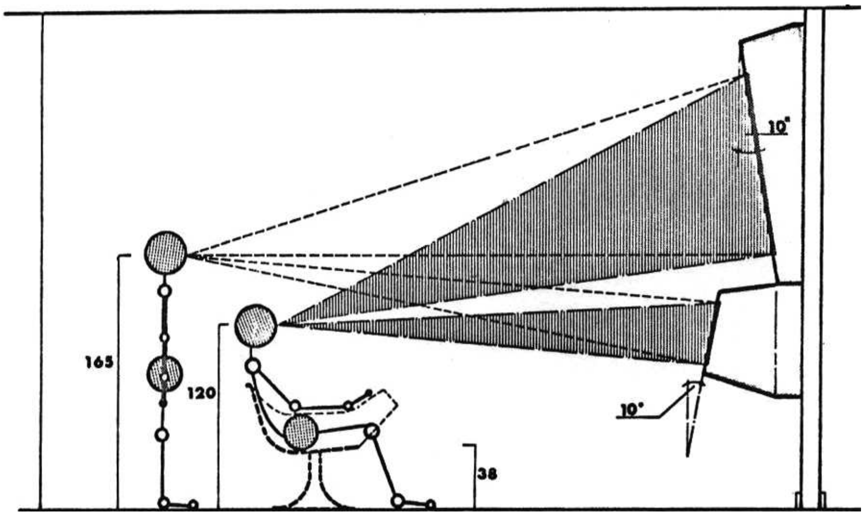

Figure 4.6
Design sketch for the Cybersyn operations room. Image used with permission from the State Technology Institute, Santiago, Chile; Gui Bonsiepe; and Constantin Malik.

themselves with such questions as the best angles for a user to read a display screen (figure 4.6). They studied aspects of information visualization and wondered how they could use color, size, and movement to increase comprehension or how much text could be displayed on a screen while maintaining legibility. The operations room offered a new image of Chilean modernity under socialism, a futuristic environment for control that meshed with other, simultaneous efforts to create a material culture that Chileans could call their own.

Beer gave the design team general instructions about the type of control environment he wanted to create. He asked Bonsiepe to create a relaxing environment, akin to a British gentlemen's club. The designers drew up plans for a "relax room" that used indirect lighting to simulate a "saloon" atmosphere.[54] The plans included space for a bar where room occupants could make pisco sours, a popular Chilean cocktail. The design also represented the future of Chilean socialism. "I believe that the original idea was Stafford's own," said designer Fernando Shultz, "that we are looking toward the future," and creating an aesthetic that would break with the way things were done in the past.[55] Rather than replicating old designs of control rooms or gentlemen's clubs, the designers gave the room a futuristic flair. For example, they proposed that the chairs and screen cases be made out of fiberglass, a relatively new construction material that lent itself to organic curved shapes that were difficult to achieve with more traditional building materials.

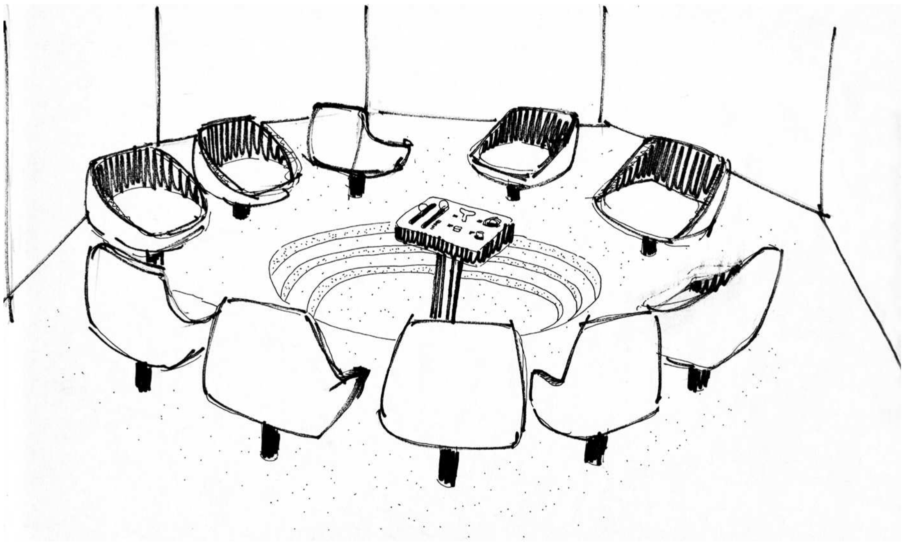

Figure 4.7
Design sketch by Werner Zemp showing ten chairs placed around a single control mechanism. Image used with permission from Gui Bonsiepe and Constantin Malik.

In April Bonsiepe sent Beer sketches of a circular room with ten chairs placed around a single control mechanism (figure 4.7). The circular arrangement meant the seating arrangement could not be hierarchical, and the central control mechanism determined which data sets appeared on the wall displays. One wall contained a representation of Beer's five-tier Viable System Model. A series of slide projectors placed behind a wall projected slides of economic data onto acrylic screens, which Beer called "datafeed." These back projections created the effect of a high-tech flat panel display.

By mid-June the team had located a small space (approximately 24 feet by 12 feet) where the room could be housed. The small dimensions required the industrial design group to rethink its original layout (figure 4.8). Among the changes they made, the designers put the screen for the five-tier Viable System Model on a rail so that it could easily be moved out of the way; they reduced the number of chairs from ten to no more than four; and they nixed the bar. These changes concerned Beer, who described the new space as claustrophobic and unable to accommodate enough people in decision making. Moreover, he felt the smaller space did not do an adequate job of selling the project. "We already have a selling problem in principle," Beer wrote. "This [small room] aggravates it."[56] As Beer saw it, Project Cybersyn aspired to fundamentally change management practices in the enterprises and government offices. People would need to be convinced of the superiority of this cybernetic approach, and he hoped the modern-looking control room would offer an effective form of visual persuasion.

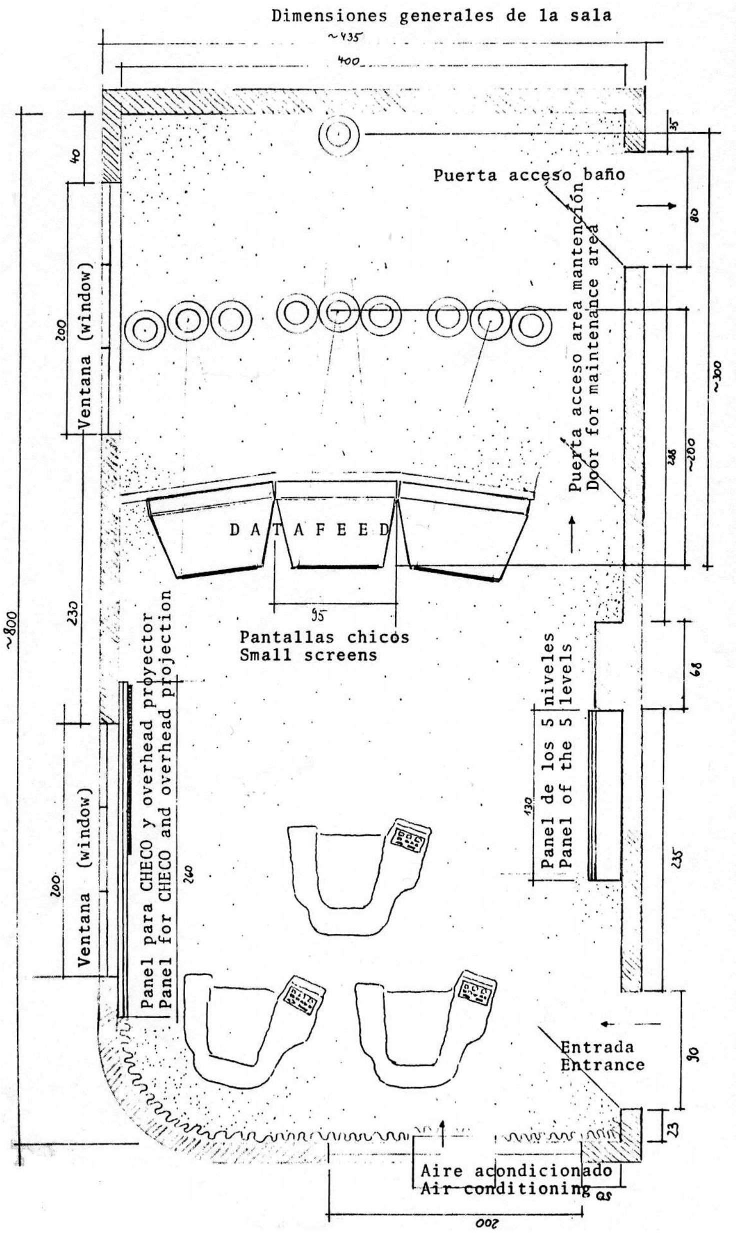

Figure 4.8
An alternative design to make the operations room fit in a small space. Reproduced with permission from Constantin Malik. Original kept at Liverpool John Moores University, Learning and Information Services, Special Collections and Archives.

In August the team finally located a more suitable space for the operations room, an interior patio of a downtown building that previously had been used to display automobiles. The space offered a number of advantages, including four hundred square meters (4,303 square feet) of open space with no columns, the opportunity to construct a ceiling at any height necessary, and a central Santiago location in a building several stories tall "so nobody will be able to actually see us working" in the patio area.[57] As an added perk, the National Telecommunications Enterprise (ENTEL) owned space in the same building and had wired it with telecommunications capabilities. CORFO arranged for the room's construction, and Bonsiepe began working with the architect on the room's design, which could now accommodate a greater number of people and display screens than would have been possible in the tiny space the team had found back in June.

The new design allowed for seven chairs arranged in a circle in the middle of the room. Putting an uneven number of individuals in the room meant there would be no tied votes. In deciding on this number, the team also drew from the influential 1956 paper "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," by Princeton psychologist George A. Miller. Miller suggested that human beings could best process five to nine information channels, seven on average.[58] The team felt that limiting the number of occupants to seven would allow a diversity of opinion but still permit each voice to be heard. Paper was explicitly banned from the room, and the designers did not provide a table or other area for writing. Beer believed the use of paper detracted from, or even prevented, the process of communication; writing was strictly prohibited in the operations room.

The designers originally wanted to make the room circular as well, but when this proved difficult, they opted for a hexagon, a configuration that permitted five distinct wall spaces for display screens plus an entrance (figure 4.9).[59] Upon entering the room, a visitor would find that the first wall to the right opened up into a small kitchen. Continuing to the right, the second wall contained a series of four "datafeed" screens, one large and three small, all housed in individual fiberglass cabinets (figure 4.10). The large screen was positioned above the three smaller screens and displayed the combination of buttons a user needed to push on the armrest of his chair to change the data and images displayed on the three screens below. The armrest also included a hold button that, when pushed, gave that user control over the displays until the button was released. Although the dimensions of the room had changed, the new space still placed a series of slide projectors behind the wall and used them to back-project slide images onto the datafeed screens, thus simulating flat-panel displays. The armrest buttons sent signals to the different projectors and controlled the position of the slide carrousel. Slides displayed economic data or photographs of production in the state-run factories.[60] Rodrigo Walker, a member of the Industrial Design Group who worked on the design and construction of the operations room, said the user's ability to create his own path through the data was "like a hypertext" but one that preceded the invention of the World Wide Web by more than twenty years. While the parallel with the Web is not

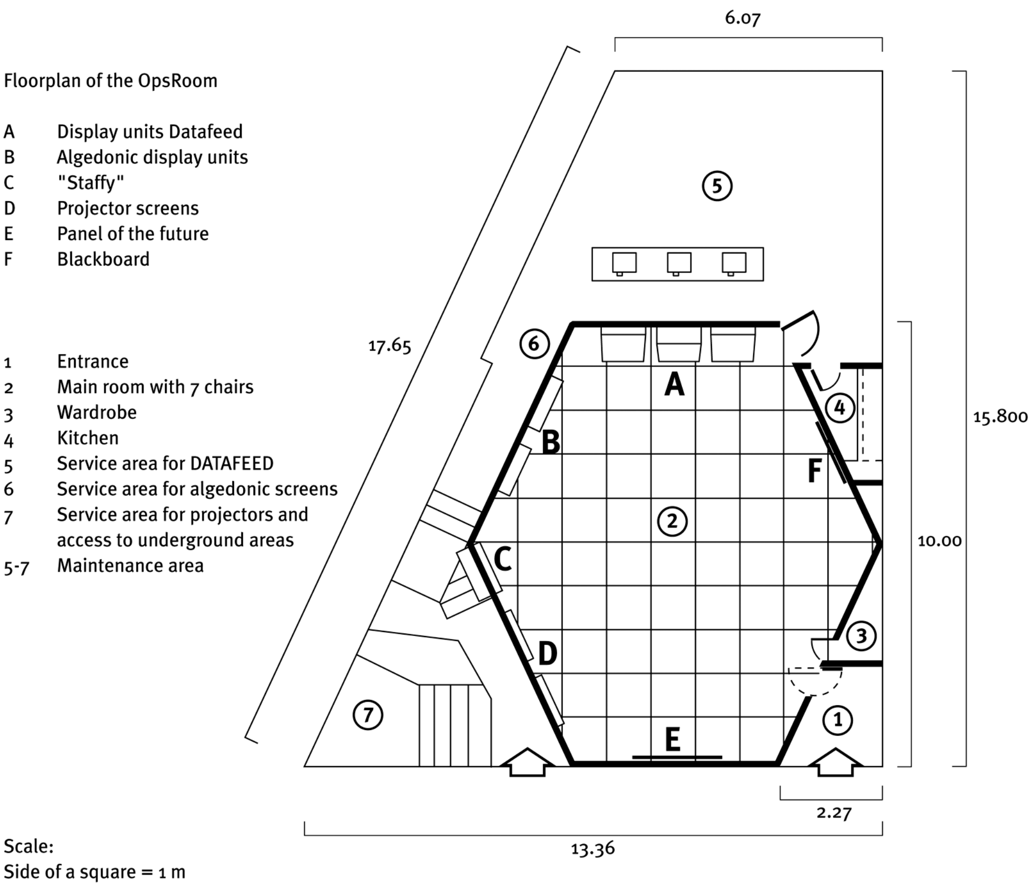

Figure 4.9
Floor plan for the final version of the Cybersyn Opsroom. Image redrawn and translated from the original. Image used with permission from Gui Bonsiepe.

exact, the room did offer a nonlinear way of seeing the Chilean economy that broke from the presentation of data in traditional paper reports. The three screens contained a mix of flow diagrams, graphs of actual and potential production capacities, and factory photographs, an intentional mix of quantitative and qualitative data designed to give the occupant a "physical relationship" to the enterprise being discussed.[61]

The third wall held two screens for recording Beer's algedonic signals, which would warn of trouble in the system. The screens displayed the overall production trends within different industrial sectors and listed urgent problems in need of government attention. A series of red lights appeared on the right-hand side of each screen and blinked with a frequency that reflected the level of urgency that a given problem posed (figure 4.11).

Figure 4.10
Close-up image of the datafeed screens. Image used with permission from Gui Bonsiepe.

Figure 4.11
The algedonic screens from the Cybersyn operations room. Image used with permission from Gui Bonsiepe.

The fourth wall held a board with a large reproduction of Beer's Viable System Model (figure 4.12) and two large screens that could show additional information of use to the occupants. Beer insisted that the Viable System Model appear in the room to help participants remember the cybernetic principles that supposedly guided their decision-making processes. However, interviews revealed that few team members—let alone factory managers and CORFO employees not directly involved in the project—truly understood the Viable System Model. Some found it strange that such a theoretical representation appeared in a room dedicated to concrete representations of data and decision making. The board was so closely associated with Stafford Beer that the project team referred to it as "Staffy."

Occupying the final wall was a large metal board covered in fabric (figure 4.13). Here users could change the configuration of magnets cut in various iconic forms, each of which represented a component or function of the Chilean economy. This physical model served the same basic purpose as the model being developed by the CHECO team; both offered policy makers an opportunity to play with their policies and visualize different outcomes, but unlike CHECO the metal board was the epitome of low tech.

The British company Technomation completed four screens for the datafeed display. However, import licenses were difficult to acquire from the Central Bank: "I have had the [word] IMPOSSIBLE written in red tape and with flashing lights on every step of the bureaucratic way," Cañete complained, alluding to the flashing red lights in the operations room that signaled trouble.[62] He thus conceived of an elaborate plan to smuggle the screens into Chile marked as donations from "Artorga," a reference to the British cybernetic investment club ARTORGA (the Artificial Organism Research Group) to which Beer belonged. But at the eleventh hour the Central Bank came through with the import licenses, and the screens reached Chile in September.[63]

The Chilean government dedicated some of its best resources to the room's completion. Its futuristic design, which borders on science fiction, was unlike anything being built in Chile at the time. It is often compared with the style of design found in Stanley Kubrick's classic movie *2001: A Space Odyssey* (1968), although the designers vehemently dispute that they were influenced by sci-fi films. "There was no reference point for this project," asserted Rodrigo Walker. "If I told you, 'Let's go build a movie theater,' you would have a reference point, you could begin to imagine what it would look like. But there was no operations room [in Chile], there was nothing that we could look at."[64] So they looked at design styles elsewhere and found inspiration in the work of Italian designers who used unorthodox materials, such as plastic and fiberglass, to create furniture with a sleek organic form. Only a few people in Chile knew how to work with fiberglass, and it had previously been used to construct swimming pools, not furniture, but the designers felt the material gave them the practical and stylistic elements they desired. "I think the room looked the way that it did because of the

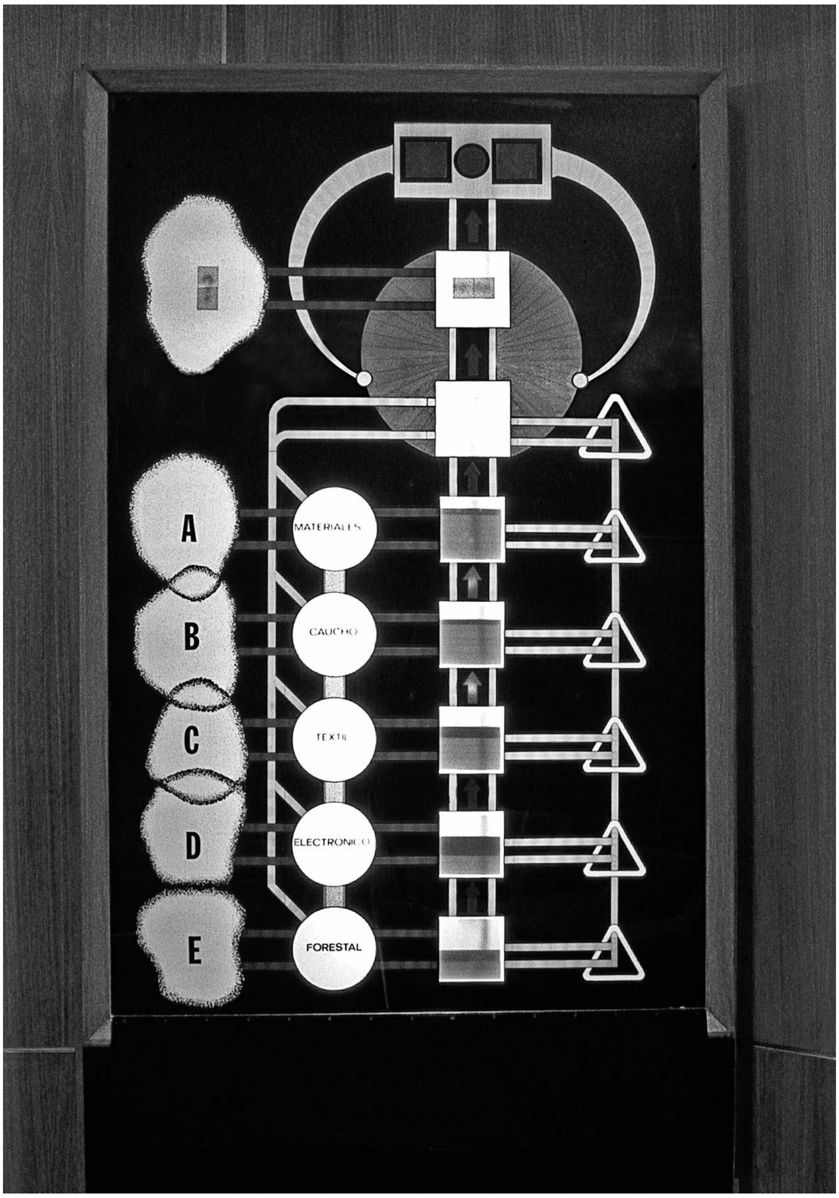

Figure 4.12
The operations room housed a reproduction of the Viable System Model, informally known as "Staffy." Image used with permission from Gui Bonsiepe.

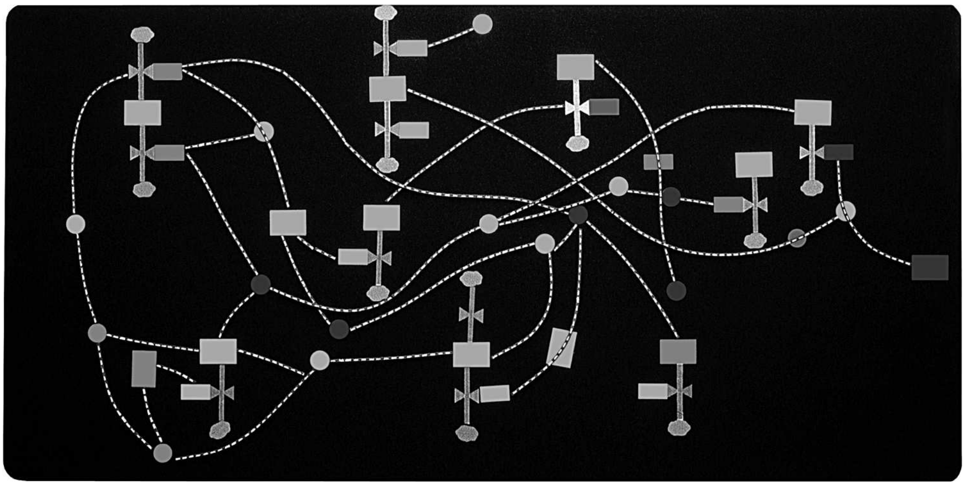

Figure 4.13
The team constructed a low-tech economic simulator using magnetic pieces on a cloth-covered metal board. Image used with permission from Gui Bonsiepe.

materials that we used . . . polyester with fiberglass, an organic material that allows you to do anything that you want," Walker noted.[65] Using these new materials allowed the designers to project a new image of socialist modernity that rivaled science fiction.[66]

The operations room also gave the designers opportunities to form new working relationships, which they viewed through the lens of socialist change. For example, the designers wanted to attach the fiberglass form of the seat to a metallic base that swiveled. However, the swivel mechanism they envisioned was not manufactured in Chile, and the designers could not import the mechanism because of the government's shortages of foreign credit and the invisible blockade. So the designers consulted with workers in their metal shop, who devised an alternative design that used grease alone and allowed the upper part of the chair to move without friction. Thus, Chilean socialism not only inspired the use of new materials but forced Chileans to develop innovative ways of working with old materials. Ideas that originated on the shop floor mixed with those of the professional designers, and, in the context of the Chilean road to socialism, this mixing had new significance. One designer, Fernando Shultz, said that Chilean socialism opened up a new awareness of worker participation that was "very subtle" but still part of the government's program. For Shultz, asking for workers' suggestions to improve the design team's work was not a simple act but rather the result of "a mental process, a process of conscience and commitment" that was set in motion by the Popular Unity government.[67] In the area of industrial design, Cybersyn thus resulted in more inclusive and participatory design practices.

Work on the slides showing production data and factory photographs was supposed to start in August, and the team secured one of the top photographers in Chile to assist with their production. But the team was not sure how to create a clear, homogeneous representation of factory data that managers and government administrators could easily understand. This uncertainty delayed production of the slides, and the team worried that the photographer would be otherwise engaged by the time they were ready for him.

The slides provided a way for the design team to update the data displayed in the operations room. But the team did not use a computer to generate these visual displays of data, as they would today. Instead, Bonsiepe enlisted the four female graphic design students from the Catholic University to create, by hand, camera-ready versions of the flow charts and graphs that the photographer could convert into slides (figure 4.14). The graphic designers completed the first flow charts showing production activities in September; these gave an overview of production in several nationalized textile enterprises.[68]

Although the operations room presented a sleek, futuristic vision of socialist modernity in which an occupant could control the economy with the touch of a button, maintaining this illusion required a tremendous amount of human labor. In this case,

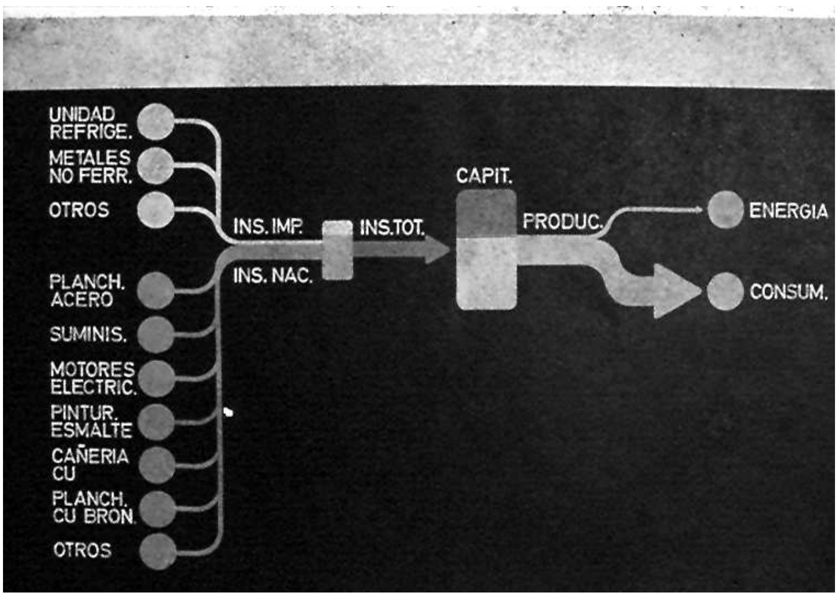

Figure 4.14
A slide image used in the Cybersyn operations room. These flow diagrams were drawn by hand by the four graphic designers. Image used with permission by Constantin Malik.

it required some of Chile's best graphic designers to draw by hand every graph and chart the room displayed. These images needed to change regularly to permit the form of dynamic control Beer imagined, yet there were no plans to automate this process in the future. Although Allende believed that Chile would have a revolution with "red wine and empanadas," this assertion failed to account for the actual complexity that the process entailed. In the same way, the clean, futuristic appearance of the control room obscured the vast network of individuals, materials, expertise, and information required to make economic management appear simple.

Design for Values

Beer and the Industrial Design Group were well aware that design could reflect social values. For example, Beer found the early design sketches for the operations room, which placed a single control mechanism in the middle, to be lacking because the design inhibited democratic participation. As a result Bonsiepe sent Beer a new set of sketches that put the mechanism for controlling the content of the datafeed display screens in the armrest of each chair. Occupants could thus change the data displayed by pushing different combinations of geometric buttons (figures 4.15–4.17). This new design gave all occupants equal access to the data and allowed them to control what was displayed inside the room. The geometric buttons also made the room more inviting by replacing a more traditional mechanism, the keyboard. Beer imagined that the

Figure 4.15
The operations room chair. Image used with permission from Gui Bonsiepe.

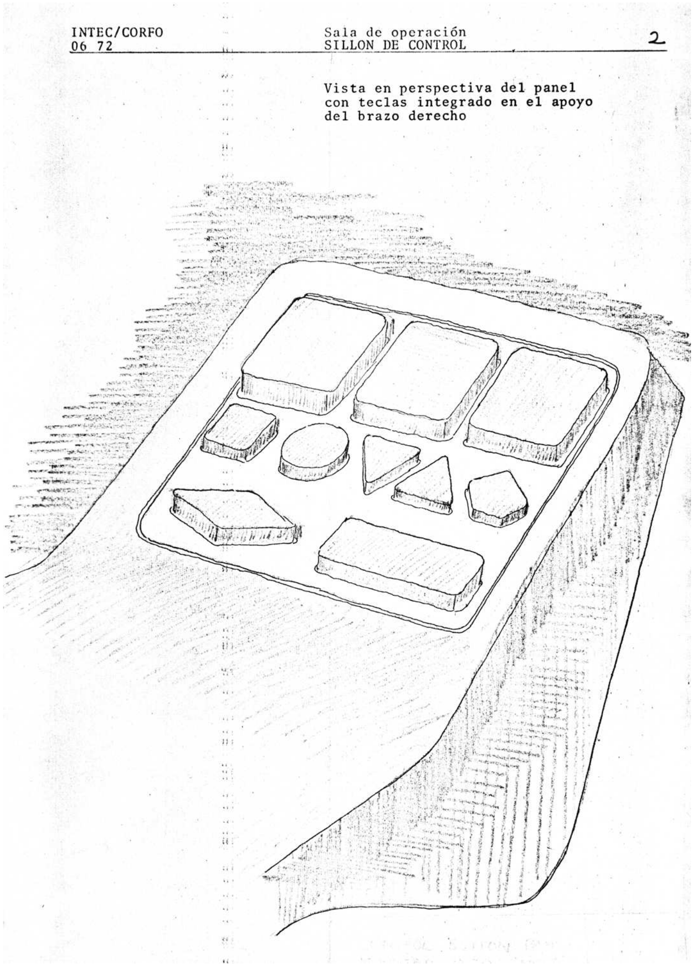

Figure 4.16
A design sketch for the armrest of the operations room chair showing the geometric "big hand" buttons. Reproduced with permission from Constantin Malik. Original kept at Liverpool John Moores University, Learning and Information Services, Special Collections and Archives.

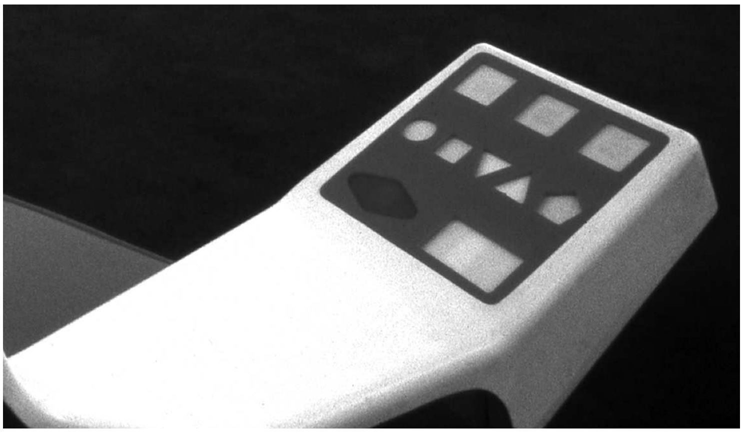

Figure 4.17
A photo of the armrest of the operations room chair. Reproduced with permission from Gui Bonsiepe.

individuals sitting in the operations room would be either members of the government elite or factory workers, individuals who did not know how to type—a skill typically possessed by trained female secretaries. With little instruction, occupants could use the large "big-hand" buttons on each armrest. Participants could also "thump" these buttons if they wished to emphasize a point. Beer claimed that an interface of large, geometrical buttons made the room more accessible for workers and prevented it from being a "*sanctum sanctorum* for a government elite." Through this design decision, the system allowed for worker participation.[69]

While politics favoring class equality influenced the design decision to use the buttons, this design decision was also gendered. Beer stated that the decision to eliminate the need for a keyboard literally eliminated the "girl between themselves and the machinery" and thus brought the users closer to the machine.[70] He was referring to a literal woman, a typist who would navigate the keyboard interface on behalf of the bureaucrats or factory workers occupying the operations room chairs. Other gendered assumptions also entered into the design of the control environment. In addition to eliminating female clerical work, the room was explicitly modeled after a gentlemen's club. It also encouraged a form of communication that bears a closer resemblance to masculine aggression ("thumping") than to a form of gender-neutral or feminine expression. Bonsiepe later acknowledged that "in hindsight I can see a gender bias" in the room's design.[71]

The characteristics ascribed to the room's future occupants reveal assumptions about who would hold power within the Chilean revolution and who constituted a "worker." Generally speaking, factory workers and bureaucrats would have the ability to make decisions affecting the direction of the country; clerical workers, women, and those operating outside the formal economy would not.[72] The operations room also offers a valuable counterexample in the history of technology, a field filled with examples that link female labor to the routinization of work and unskilled labor. Here we see an opposite but no less interesting phenomenon: Beer and the designers viewed female clerical work as *too* skilled; it therefore needed to be eliminated to make the room accessible.

The design of the operations room illustrates that even futuristic visions of modernity carry assumptions about gender and class. Moreover, the design of this control space shows how cultural and political givens limit technological innovation. By treating the design of the operations room as a historical text, we can see how the Allende government framed its revolutionary subjects and ultimately limited the redistribution of power within Chile's socialist revolution.

Politics and Practice

The operations room clearly illustrates how members of the Cybersyn team tried to engineer Chilean socialism into the design of the Cybersyn system. However, in some cases the practices Chilean technologists used to implement the system did not match the politics of the Popular Unity government. Such practices show that historical actors were not consistent in how they portrayed the relationship of technology and politics in Project Cybersyn and bring to light a disconnection between rhetoric and praxis. In some cases, Cybersyn engineers intentionally framed the system as apolitical and technocratic. This helped them persuade members of the opposition to support the project. In other cases, Cybersyn engineers assumed that their own practices were scientific and thus neutral, without recognizing that these scientific techniques also had an implicit bias that ran counter to the aims of the Allende government.

The inconsistent relationship between technology and politics is best seen in the work of the Chilean engineers charged with building models of production in the state-run enterprises. Most of these engineers worked for the State Technology Institute. The models they created identified key production indicators and their range of acceptable values, which were then used as parameters in the Cyberstride software code.

By the end of June Cybersyn engineers had visited enterprises in the textile and agroindustrial sectors and enterprises in the light industry branch. By the end of September engineers at the State Technology Institute had modeled or were still modeling at least forty-eight enterprises and twenty-three plants, models that would later be used to code the Cyberstride permanent suite.[73] Although engineers from the State Technology Institute described the modeling process as "just looking at what was going on," project reports reveal a more complicated process that highlights the marginal role played by workers in Cybersyn's implementation, despite Allende's insistence that the system encourage worker participation.[74]

The engineers began the modeling process by contacting the upper management of an enterprise and arranging to give a presentation to the interventors and the general managers. During this presentation the engineers used a simplified version of the Viable System Model and explained Project Cybersyn. While the presentations were intended to explain Cybersyn, they also were designed to persuade the managers to support the modeling process and recognize the value of the project. The engineers then explained the project to lower levels of management and worked their way down until they reached the production engineers on the factory floor.

The Cybersyn engineers talked to a factory's production engineers and then followed the flows of raw materials and their gradual conversion into finished products. The Cybersyn team next created a quantified flow chart of production in the enterprise, which they gave to the interventor.[75] The flow charts helped the modelers identify, on average, the ten most important indicators of factory performance, typically some combination of raw materials, finished materials, energy used, and labor absenteeism.[76]

It is important to note that the Cybersyn engineers were not interested in financial information. With the exception of the CHECO simulator, Cybersyn focused exclusively on industrial production and thus echoed the socialist accounting practices adopted by CORFO as a whole. Such practices gave priority to increased production over profit and accepted financial losses as part of government price freezes. Cybersyn factory models were therefore intended to help the government identify ways to raise production levels, independent of a market and without concern for prices. Since Cybersyn was designed to fight "the battle of production," the bulk of the system did not take considerations such as the price index or the rate of inflation into account.

After the engineers identified the key production indicators, they needed to identify how to collect such data on a regular basis. In many cases, such information collection systems simply did not exist at the enterprise level. The engineers also needed to determine the range of acceptable values for the indicator, as well as how much time the enterprise should be given to correct the indicators that fell outside this range before CORFO intervened from above. Finally, the engineers needed to determine two additional values for each indicator: the "potentiality" value and the "capability" value. Beer defined the capability value as "what we *could* be doing . . . with existing resources, under existing constraints, if we really worked at it." The capability value was the best possible value of the indicator under current conditions. He defined the potentiality value as "what we *ought* to be doing by developing our resources and removing constraints, although still operating within the bounds of what is already feasible."[77] Thus, the potentiality value was the best possible value of the indicator under the best possible conditions. The engineers gave these two values to the Cybersyn computer programmers, who coded them into the Cyberstride software. The computer program could then compare current, or "actual," data with these optimal numbers and create a unitless percentage that showed how close present enterprise performance was to

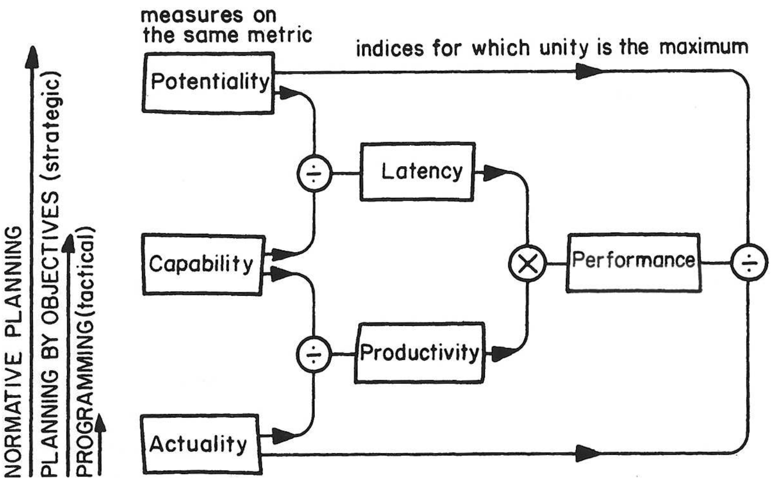

Figure 4.18
Diagram showing how Beer created unitless measures of achievement from actuality, potentiality, and capability values. Reprinted from Stafford Beer, "Fanfare for Effective Freedom: Cybernetic Praxis in Government," in his *Platform for Change* (New York: J. Wiley, 1975), 437. Image reproduced with permission from Constantin Malik.

its ideal (figure 4.18). Beer reasoned that government administrators, with little background information, would be able to quickly grasp these unitless measurements.

A study of the Easton Furniture factory reveals how complicated the modeling process could be. In this report the four coauthors begin their analysis by describing in detail the process of building wooden furniture, each of the machines involved, the humidity levels of the wood, how to apply varnish, and so forth. In addition to a narrative description of the process and a flow diagram, the report includes various tables showing the exact time required for each stage of the production process for 13 of the 150 different products the factory produced. These measurements were then averaged to create a "typical product" and to calculate the idealized capability values. Pages of statistical analysis determine the range of normality for each indicator.[78]

Modeling factories required university-level training in operations research. Although the State Technical Institute employed a number of individuals with this expertise, it did not have a labor pool sufficient to complete the task in the time allotted. In a July report Humberto Gabella complained that he had requested three engineers to model enterprises in the forestry sector and three engineers to model enterprises in the building materials sector but so far had received only two engineers for the forestry sector and none for building materials.[79] To solve this problem, the Cybersyn team recruited engineers from within the enterprises or sectors being modeled or from private consulting firms. The additional hands helped, but it made consistency in the modeling process difficult because engineers used different methodologies to study production and identify key production indicators.[80]

Data collection also proved difficult. Modelers sometimes needed data that the enterprise did not collect, or needed data from the companies that supplied the enterprise with raw materials or component parts. Project notes state that at least one enterprise could not be modeled because of "internal organization problems," a cryptic line that could have referred to a number of scenarios, from a labor force on strike to political battles for representation on enterprise committees that negatively affected factory management.[81]

The engineers also needed to convince the enterprises and the sector committees to support Project Cybersyn, but they were not particularly skilled at public relations. Modeler Tomás Kohn speculated that his presence probably "pissed off" several managers. "We were fairly young at the time," Kohn said. "For most of us it was probably our first job. We were pretty arrogant, not because of any political position but because we thought we had a good model, and we firmly believed in this approach. . . . I suspect that people were really turned off by this group of youngsters."[82] The modelers quickly learned that portraying the project as technocratic rather than political made it easier to gain the managers' participation. Kohn recalled one textile plant manager who, having already spent several years reaching his senior position, was not happy with the changes introduced by the Allende administration. The plant manager was "difficult to deal with," Kohn said, but "when it came to the more technical aspects, he could work quite openly."[83] Other modelers shared similar stories. Although enterprises were often run by Allende appointees (the interventors), much of the management structure within the enterprises had been in place before Allende was elected. These managers had expertise that was important to the modeling process, but political speeches would not convince them to support the Cybersyn project.

In theory, Cybersyn engineers also consulted with members of the rank-and-file. Beer writes that the engineers were expected to create "quantified flowchart models with the *help* and the *agreement* of workers' committees" and to determine the "recovery times for each index on the same terms: that is with help and agreement."[84] The modelers did talk to committees of workers in some cases but not as a rule. More often technocracy eclipsed ideology on the factory floor. Despite the explicit instructions the engineers received to work with worker committees, often the converse occurred, and the engineer treated the workers with condescension or would ignore the workers altogether and deal directly with management. Moreover, the engineers frequently hid or overlooked the political facets of the project in favor of emphasizing its technological benefits, thereby avoiding potential conflicts.[85]

My interviews of Cybersyn engineers, interventors, and workers yielded little evidence that workers were involved in shaping the modeling process.[86] Kohn described the process of modeling a factory as "a fairly technocratic approach," one that was "top down" and did not involve "speaking to the guy who was actually working on the mill or the spinning machine or whatever." Eugenio Balmaceda, another engineer from the State Technology Institute who modeled enterprises within the forestry and construction sector, also reported working exclusively with the directors of the firm, not the workers. Like Kohn, Balmaceda found it easier to avoid the political aspects of the project and concentrate solely on the technical aspects. He remembered giving a general description of the project to groups of workers and that "they were totally in favor of the ideas we wanted to implement." But later in our conversation he told me, "The workers could not have many doubts [about the system] because it was a highly technical subject."[87] In essence, the technical sophistication of the cybernetic system prevented the participation of workers, if they even knew it existed.[88]

Looked at from a different angle, the Cybersyn system could even be read as disempowering Chilean workers. The timing charts printed in the study of the Easton Furniture factory are reminiscent of the time studies that characterized the Taylor system of management, which had been introduced in a number of Chilean factories before Allende came to power. In the 1960s Chilean workers went on strike to protest the accelerated pace of production that Taylorism demanded; it pushed workers to perform beyond their capabilities and worsened factory working conditions.[89] The study of Easton Furniture thus reveals a contradiction in Chile's revolutionary process: although the Allende government wanted to increase worker involvement in decision making, Cybersyn shows that it also continued management practices that had disempowered and dehumanized workers in the past. For example, managers could use the capability values calculated from timing charts to control the means of production. Cybersyn could also give Chilean managers the ability to exert control over labor through an abstract technological system instead of a shop floor manager with a stop watch. In this sense Cybersyn could have followed a path similar to that of numerical control technology in the United States, which gave management greater control of production and disempowered labor—the very thing the Allende government sought to undo.[90]

Social and political considerations clearly entered into the model-building process, prioritizing which factories to model and which elements, such as labor, appeared in the quantitative flow charts. However, the specific techniques used to build these models also had politics, in the sense that they could empower some groups and disempower others—techniques that the young engineers probably learned in their university operations research classes and saw as strictly technical and thus neutral.

Since Project Cybersyn never reached completion, it is impossible to know how such a system would have affected the lives of the rank-and-file or how it might have changed power relations on the shop floor. But it would have been much harder for workers to organize against an abstract technological system, or a factory model, than to stage a protest against a visible production manager holding a stopwatch.

Cybersyn engineers were not consistent in how they portrayed the relationship of technology and politics in Project Cybersyn. Beer believed the system could provide a way to change how white-collar technologists interacted with blue-collar workers, but it was impossible to undo long-standing class prejudices overnight. The State Technology Institute had a rather sophisticated understanding of how technological artifacts could uphold particular configurations of power, either by enriching one class at the expense of another or by promoting unjust economic relations between developed and developing nations. But engineers from the State Technology Institute did not extend such criticism to the scientific techniques they used, which they viewed as free of political bias.

Populist Technology

To increase the political appeal of Project Cybersyn, Beer began developing ways to lay populist overtones on his cybernetic system for economic management. In addition to working with some of Chile's best designers, engineers, and computer scientists, he also formed ties with one of Chile's best-known musicians, Angel Parra. Music gave Beer not only a better sense of Chilean life and culture but also a better idea of how Chileans experienced the revolution taking place around them. By the early 1970s, folk music in particular had proved to be exceptionally powerful for conveying political messages in Chile and throughout the western hemisphere. Folk music presented Beer with new opportunities to translate his cybernetics into forms better understood by the Chilean people.

Angel Parra was a member of one of Chile's most beloved musical families. His mother was Violetta Parra, one of the most famous Latin American folk musicians. In 1965 Angel and his sister Isabel established the Peña de los Parra in Santiago, an artistic space where they could sing for a small audience and experiment with the Nueva Canción (new song) movement, a form of music that linked Chilean folk traditions to the social and political movements of the time. Whereas traditional folk music was suitable for parties or dancing, music in the Nueva Canción vein reflected the lives of Chilean workers, peasants, and shantytown dwellers, and the difficulties they faced, as well as themes such as world peace, friendship, and solidarity.[91] When Allende came to power, the Parra family and the Peña de los Parra became a cultural center for the left and a musical inspiration for the entire country.

Parra was used to meeting famous people and later described himself as "a young person, insolent, and without respect." When Stafford Beer first wandered into the Peña, Parra was not impressed with Beer's reputation as an international scientific consultant. But Beer still managed to make a lasting impression. "He was like how one imagines Santa Claus," Parra recalled: tall, with a white beard, and "bringing this hidden gift, cybernetics," which Parra did not understand.[92] Beer kept coming to the Peña de los Parra with increasing frequency and started hanging out with a small, select group of Angel Parra's friends, including José Miguel Insulza, the future vice president of Chile and secretary general of the Organization of American States.[93] Parra did not speak English, but others at the Peña de los Parra did, including Cañete, who sometimes accompanied Beer and served as his translator. "Beer asked me if I would write a song for [Project Cybersyn]," Parra said. "For me the project was like a pregnancy, a pregnancy of Popular Unity." He deepened the comparison: "If you bring a child into the world, you have to be responsible, you cannot abandon it. I was saying that the computer system was also going to be like this."[94]

In June 1972 Parra completed the lyrics for a song that he wrote in honor of the Cybersyn Project. He titled it "Litany for a Computer and a Baby about to Be Born." As a whole, the song emphasized the importance of technology in bringing about social change and its potential for eliminating political corruption. The chorus of the song similarly conveyed the political intentions of the project:

Hay que parar al que no quiera
que el pueblo gane esta pelea
Hay que juntar toda la ciencia
antes que acabe la paciencia.

Let us stop those who do not want
the people to win this fight,
Let us bring together all of science
before we exhaust our patience.[95]

The lyrics constituted a rallying cry as well as a prophetic warning.

Parra never recorded the song but remembers singing it in the Peña de los Parra, and its lyrics remain scrawled in a notebook that holds many of Parra's songs from the Popular Unity era. Beer had greater ambitions for the song, hoping that it would make cybernetics and the Cybersyn Project more accessible and appealing to Chilean workers. As one of the most recognizable voices of the revolution, Parra's voice would frame the system as a form of science for the people, something that was culturally Chilean and that could connect the project to the broader social changes that were taking place. It would also present Cybersyn as a technology that workers could understand and use for their own empowerment.

Implementing Cybersyn went beyond coding software or modeling factory production; Beer felt he needed to link the project explicitly to other forms of Chilean political life. Flores shared this position, and in late September he held a meeting that brought together the diverse groups at work on the project as well as others who were connected to it peripherally.

According to Beer, both he and Flores stressed the political aspects of the project during the meeting. This message distressed many of the professionals involved, who viewed Cybersyn as a highly technical project that was politically neutral.[96] "It became obvious that there would have to be major changes in the management team that was actually implementing the results of the cybernetics," Beer wrote.[97] He and Flores started discussing how they might make Cybersyn less technocratic and more political. These opposing interpretations of Project Cybersyn would resurface repeatedly in the months ahead.

Beer began to explore how concepts and language from the Chilean revolution might be used to communicate ideas from management cybernetics. In September he drafted a small, illustrated booklet titled *Five Principles for the People toward Good Government* that explored how cybernetic thinking could improve government practices in ways that went beyond economic management. The principles contained in the booklet reflected common themes in Beer's writings: the booklet called for an end to bureaucracy, greater transparency, increased personal responsibility, clearer government organization, and planning for the future. Technology played an important role in achieving these goals. "The wishes of the people will be made known to the Government at all times," it read. "We shall use TECHNOLOGY, which belongs to the people, to do it."[98] Beer viewed the booklet much as he viewed the folksong that Angel Parra wrote about cybernetics and social change—another attempt to educate the Chilean people about the promise of cybernetics by putting it into a language that people could understand. For Beer, making Cybersyn populist was central to making Cybersyn socialist.

"Programme Beat-the-Clock"

Thus far I have traced the progress the project team made coding the Cyberstride software, building the CHECO models, and constructing the operations room. From April to September 1972, the telex network (Cybernet) also continued to grow. By early July, the telex network had connected the ministers of economics and finance, the subsecretary of economics, the Central Bank, the National Directorate of Industry and Commerce, the National Computer Corporation, the State Development Corporation, and the National Technology Institute, as well as eight sector committees and forty-nine plants.[99] By August, Benadof and Améstica had started developing software to allow the computer to read signals directly from the telex machines. They hoped such software would eventually eliminate the need for human operators to collect the data from the telex machines and reenter it into the mainframe for processing.[100]

Time was of the essence. The precarious position of the Allende administration and the gravity of the national economic situation pushed the team to work harder. In July, Beer revised the project's work schedule through the end of October 1972 and called the new plan "Programme Beat-the-Clock" (figure 4.19). Among other things, the plan called for a functioning operations room by mid-October. Beer hoped this ambitious schedule would help the administration withstand the opposition's destabilization efforts, and the title of the document was meant as a reminder that the administration was, quite literally, under the gun.

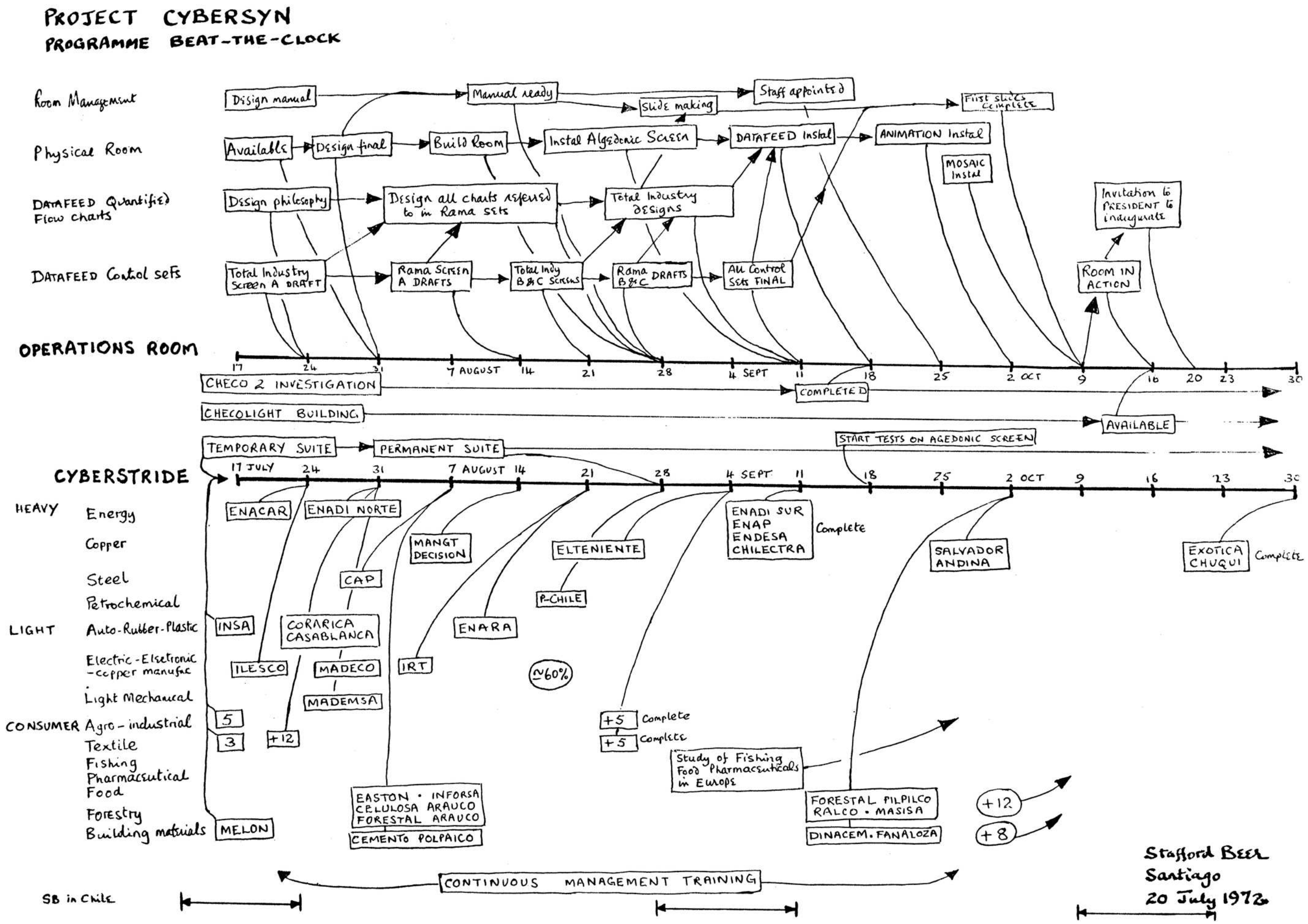

Figure 4.19

The project schedule drafted by Beer in July 1972. Reproduced with permission from Constantin Malik. Original kept at Liverpool John Moores University, Learning and Information Services, Special Collections and Archives.

Nationalization continued to incite controversy and deepen political fissures. In June 1972, the Christian Democratic Party and the Popular Unity coalition failed to reach a consensus on the nationalization issue. This failure to reach a compromise heightened the levels of counterrevolutionary activity in the country, and these oppositional activities increasingly took place in the streets in addition to the Chilean Congress. Yet the nationalization process still continued at a rapid clip. In July and August 1972, the administration brought twenty-five additional enterprises into the Social Property Area. "We have kept on nationalizing industries at a steady pace," Cañete reported to Beer. "The poor owners of industries related to the light industry [branch] do not know what hit them and are right now reeling under a continuous series of blows."[101] Allende continued to support a moderate approach to nationalization and promised the owners of small- and medium-sized businesses that the government would not take their property.[102] But his own Socialist Party did not agree with the president's restrained approach and pushed to accelerate the pace of nationalization and increase government control of the private sector. This gave owners of these businesses another reason to distrust Allende's promises and to align themselves with the opposition.

Chile teetered on the brink of political violence. By August 1972 rumors of a right-wing coup had begun to circulate and continued to gain strength, and they were grounded in truth. In August demonstrations against the government resulted in arrests and injuries and forced the government to declare a state of emergency in the capital city. In September the president publicly denounced an aborted plot by rightist factions to overthrow the government. For the first time Beer started to worry about his safety. On 28 September he telexed Cañete, asking, "Do you regard my [upcoming] trip as secure?"[103] Cañete telexed back immediately, "General news . . . not better nor worse than in any of your previous visits. Your safety absolutely and utterly guaranteed." Trying to make the conversation lighter, Cañete then wrote, "Remember we are starting our spring so there are more interesting matters to worry about. Be sure to bring swimming trunks and light clothes."[104] Beer returned to Chile the following month, after asking his assistant, Sonia Mordojovich, to book him a poolside room at the Sheraton.

Political Challenges, Engineering Challenges

Members of the Cybersyn project team set out to make Cybersyn a socialist technology and accomplished this in multiple ways. In the area of design, the project formed part of a larger effort by the Industrial Design Group to create a new material culture that furthered the aims of Chilean socialism and broke from the aesthetic of the past. The context of socialism also encouraged Chilean industrial designers to solicit worker opinions and incorporate them into the design and construction of the operations room. Unexamined assumptions about who held decision-making power in the Chilean revolution also shaped the design of the operations room. It was inclusive in the sense that it accommodated both workers and high-ranking government bureaucrats. At the same time the room was designed as a gendered space that explicitly encouraged masculine forms of communication, was modeled on a gentleman's club, and eliminated female clerical work. The design of the operations room reveals the gendered limits of power redistribution on the Chilean road to socialism and how preexisting ideas about gender and class restricted the way historical actors imagined the future, even when their visions bordered on science fiction. Beer's own gendered assumptions about decision-making behavior are also evident here.

In addition, Beer attempted to instill political values in Project Cybersyn through sociotechnical engineering. In some instances he designed Cybersyn's technology to encourage certain desired social interactions. For example, he rejected having the display screens in the operations room connected to a single, centralized control mechanism and instead insisted that control mechanisms be built into the armrest of every chair, a design he felt encouraged broader participation in decision making. Beer also tried to engineer the social relationships in Cybersyn's construction by encouraging Chilean engineers from the State Technology Institute to seek input from Chilean workers when creating models of the state-run factories. But, as we have seen, Cybersyn engineers preferred to work with the other white-collar professionals in the state-run factories. In most cases they did not discuss their work with Chilean workers, or if they did, they presented their model building as a technical endeavor that the workers could not understand or question. Class prejudices could not be undone by political revolution or by sociotechnical engineering, despite Beer's considerable influence within the project team.

Project Cybersyn was political in other ways: it advanced Allende's goal of improving Chilean capabilities in science and technology through the transfer of technological expertise to Chile from more developed nations. Examples abound of how Chileans acquired technical expertise through their interactions with British consultants and academics as part of their work on the project, but U.S. and British ideas about dynamic economic modeling were of limited use to Chile. The South American nation had different recordkeeping practices than Britain, had a political and economic context without precedent (which therefore could not be modeled), and was a target of foreign intervention and sabotage. Furthermore, the history of Project Cybersyn suggests a different model of technology transfer, one that was not based on imitation and appropriation. With friendship, collaboration, and mutual respect, Beer and his Chilean colleagues worked together and produced something new.

Constructing Cybersyn posed a number of challenges, some of which are part of any high-risk engineering project, regardless of where it is built or its political context. Like the leaders of Cybersyn, many project directors have to create a work culture that encourages creativity, productivity, risk taking, and teamwork. Yet, as noted previously, Cybersyn technologists also confronted challenges that were related to Chile's status as a Latin American nation. For example, project team members needed to establish channels for technology transfer. Foreign experts such as Beer, Bonsiepe, Anderton, and the Arthur Andersen consultants all played a central role in the construction of the project. Chile's limited technical resources also necessitated creative design solutions.

However, it is important to realize that those involved in constructing Project Cybersyn were also facing extraordinary challenges, which were directly related to Chile's political project. The U.S.-led economic blockade prevented the Chilean government from acquiring the U.S.-made technologies and spare parts on which the Chilean economy had depended before 1970. This lack of resources presented serious obstacles to Cybersyn's design, as well as to the government's winning the battle of production and achieving Chilean economic stability. The U.S. government also supported the activities of the political opposition and threatened Chile's long-standing history of political stability. As rumors of a military coup began to circulate, Cybersyn team members realized that even though they had made substantial progress, they were still engineering against the clock. Ironically, the Chilean political context that had led to the creation of Project Cybersyn also created the most difficult challenges that the Cybersyn technologists faced.