

# DUTCH, DIKES AND DEMOCRACY

## An argument against democratic, flexible, good and bad technologies

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and  
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### Prologue

Friday 22 November 1991, 0:30 am. In Zeeland, the Dutch coastal region south of Rotterdam, lights are still on in many houses and farms. During the next hour this dispersed blanket of tiny lighting points will grow, covering the entire countryside which hides behind the dunes and dikes. Many people in Zeeland seem to be wide awake.

The wind, force 11 on the Beaufort scale, howls over the country and drives huge waves against the dikes. Trees are uprooted, tiles fly from roofs - but it is not these small accidents which are keeping the Zeeland people from their sleep. At 1:30 am it will be high tide. Yesterday was full moon, so tonight is a spring tide. The north-western storm, which has raged for two days, has forced the North Sea into the narrow funnel of the English channel and high up against the Zeeland coast - some 3 to 4 meters higher than normal.

Fear of the sea is keeping the inhabitants awake. It was almost thirty-nine years ago, in February 1953, that Zeeland was flooded during a similar combination of spring tide and storm surge. That night 1835 people drowned, more than 750,000 inhabitants were affected, and 400,000 acres of land were inundated. Since then, Dutch engineers have closed the tidal inlets through which the North Sea could penetrate the Rhine delta, deep into Zeeland. They have raised the dikes and reinforced the dunes. Science-fiction types of high-technology have been employed to defend this part of the Dutch coast. But who can guarantee that tonight will not be that one night in four thousand when the sea sweeps over the dikes again?

### Introduction

The central theme of this session is "new theoretical frameworks for democratization of technology." In this paper we will explore some of the implications of recent social and historical studies of technology for this issue. The main body of the paper consists of sketching the construction of one large technical system - the Flood Barrier in the Oosterschelde, the Netherlands - and asks whether this may be an example of democratic control of technical design. We are not yet able to give a satisfying answer, but will focus on the theoretical and methodological aspects of the issue. We will thus propose that it is misleading to think about this question in terms of intrinsic properties of technology - technical artifacts and technological systems are not *per se* good or bad, flexible or non-flexible, democratic or authoritarian. Instead of taking technological artifacts or systems as our unit of analysis and trying to characterize them in any final way, we will suggest to focus on sociotechnical ensembles and the processes by which these are socially constructed.<sup>3</sup>

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<sup>3</sup> See for a first discussion of these issues, using the historical case of fluorescent lighting and the contemporaneous case of PTCA (percutaneous transluminal coronary angioplasty) Bijker (1989); see also Schot (1992) applying these perspectives especially to cleaning and cleaner technologies.

<sup>4</sup> See Hughes (1983) for the fullest presentation of this approach, which is developed in a comparative analysis of the electricity distribution systems in New York, London and Berlin. Hughes (1987) explicity makes the argument against a more sociological perspective, combining qualitative and quantitative methods, but from a more social perspective, the technical, the scientific, etc. Shum (1985) also studies large technical systems and networks, clear examples of this approach are Callon (1980, 1981, 1986), Law (1987) and Latour (1987, 1992). See for more references Law (1986), Bijker, Hughes and Pinch (1987), Law (1991), and Collins and Heaney (1992a, 1992b) and Callon and Latour (1992) for a debate.

In the social construction of technology approach, Pinch and Bijker (1984) take "relevant social groups" as their starting point. Artifacts are, so to say, described through the eyes of the members of the non-human world with the same conceptual framework; in other words, when explaining the development of socio-technical ensembles do not recur to either technical or social reductionism. A pre-modern rooting<sup>6</sup>, A "principle of generalized symmetry" is adhered to: analyze the human and western sociology and indeed to most post-Kantian thinking, the actor-network approach is based on accepting a fundamental distinction between human and non-human actors, which is central to the numerous other network vocabularies in STS studies, is its ontological basis. By not from the perspective of the actor-network approach, and one by which it can be distinguished control. A characteristic of the actor-network approach, but originates from the networks they can sometimes special about those individuals or institutions, but a Maffia leader) is not of actors (such as a Captain of Industry, or the European Commission, or a Mafia leader). The power of society is brought about by reshuffling and transforming machines, institutions, actors. The power concept of translation is the crux of the actor-network approach - is used to analyze how an ordering other actors to different positions, thereby translating the meaning of these actors as well. The ensembles as heterogeneous networks of human and non-human actors.<sup>5</sup> The development of these ensembles describes socio-technical approaches, associated with Callon, Latour and Law, describes socio-technical

The actor-network approach seems directly applicable in the Delaplan case. One of the ways in which these systems build up momentum is through economies of scale. Both relates to (private) business systems - Edison and Siemens as entrepreneurial system-builders. Also, systems (Mayntz and Hughes, 1988; La Porte, 1989; Weingart 1989). Hughes' specific framework (Pinch, 1989). The thrust of the research programme however still is in the study of large technical physically small technical systems such as missile guidance systems (MacKenzie, 1990a) and space shuttles electricity distribution systems, rallyway systems or telephone networks, the approach can be applied to approach was developed by analyzing technical systems that are in a physical sense large, such as an intrinsic property, but slowly built-up during the system's development. Though the seemingly autonomous nature of technical systems, while at the same time showing that it is not and Dutch flood barrier design styles. The concept of "technical momentum" nicely captures the engineering, this would mount up to the extreme of clear differences between, for example, English idenitification of national styles in the development of technological systems. In the case of coastal barriers, channels, lakes, water levels, salt-fresh water regimes, navigation routes, and rules for closing and opening the sluices and barriers. The shaping of technology is analyzed in this paper as being considered as such a system. It consists of a heterogeneous set of elements such as dikes, flood technology, Th.P. Hughes (1983). The Delaplan which we will discuss extensively in this paper can be with a certain autonomy. This approach is associated with the work of the American historian of their development, a technological momentum that seems to drive them in a specific direction. The systems approach analyzes technology as heterogeneous systems which acquire in the course for the apparently obdurate character of many technologies.

Through, for example, not accepting a simple technological determinist view, they all try to account approaches which view technology in this way. Some themes are common to all the approaches. interconnected, heterogeneous ensemble of technical, social, political, etc. elements. There are several systems was synonymous with "authoritarian technology" (Mumford 1964) and technology out of some optimism as to a possible future with more democratic control of technology, though without control (Mumford 1967, 1970; Wimber 1977, 1986). At the same time, these authors also expressed specificity in what form that future might come.

In the 1980's research got under way which analyzed technology and society as an intimately connected, heterogeneous ensemble of technical, social, political, etc. elements. There are several approaches which view technology in this way. Some themes are common to all the approaches. For a long time, technological development and especially the development of large technical systems was synonymous with "authoritarian technology" (Mumford 1964) and technology out of

relevant social groups. The interactions within and among relevant social groups constitute the different artifacts, some of which may be hidden within the same "thing." In that case, the "interpretative flexibility" of that "thing" is revealed by tracing the different meanings attributed to it by the various different relevant social groups. This demonstration of interpretative flexibility is a crucial step in arguing for the feasibility of any sociology of technology - it shows that neither an artifact's identity, nor its technically "working" or "non-working", is an intrinsic property of the artifact but subject to social variables. The next step then is to describe how artifacts are indeed socially constructed, thus tracing increasing (or sometimes decreasing) degrees of stability of that artifact.<sup>7</sup> The concept of "technological frame" is then proposed to explain the development of heterogeneous sociotechnical ensembles, without recurring to a form of social reductionism (Bijker, 1987, 1992). A technological frame structures the interactions between the actors of a relevant social group. A key characteristic of the concept of "technological frame" is that it is applicable to all relevant social groups - technicians and others alike. It is built up when interaction "around" a technology starts and continues. The early Deltaplan technology can, for instance, be said to have further shaped the coastal engineers' technological frame, strongly influencing the choice for an ambitious "high tech" solution for the Oosterschelde, rather than merely heightening all dikes around the Oosterschelde basin. Existing practice does guide future practice, though without logical determination. The concept of "technological frame" forms a hinge in the analysis of sociotechnical ensembles: it is the way in which technology influences interaction and thus shapes specific cultures, but it also explains how in a specific way new technology is constructed by a combination of enabling and constraining interactions within relevant social groups.

The body of work summarized in these three approaches resulted in a critique of the "standard image" of technology. In this standard image technology is conceived as a separate societal factor; it is primarily developing according to its own dynamics along fairly linear paths; technology is having an impact on other domains such as the economic, the social and the political, rather than being influenced by those other domains. Closely connected to this image is, in economic analyses of technical change, the consideration of technology as an exogenous variable: technology is something off the shelf, not to be analyzed as part of economic change. Similarly, in ethical studies, technology is something pre-given, with intrinsic values that are outside the scope of the analysis. In political sciences and policy studies, technology often is viewed as an autonomous societal sub-system that can hardly be controlled. Finally, in technology assessment work the standard image of technology resulted in the hope for early warning methods and for assessment instruments which would be able to make decisions about technological choices in an early stage.

The standard image of technology supports the "control dilemma" as identified by Collingridge (1980: 11): "When change is easy, the need for it cannot be foreseen; when the need for change is apparent, change has become expensive, difficult and time consuming." The customary response to the control dilemma, Collingridge argues, has been to look for better ways of forecasting the social impact of technologies - a response which clearly draws on the standard image of technology. Collingridge's main project is to point to the impossibility of this response, due to the high complexity of the relationship between technology and society. His own research is directed towards understanding the "roots of inflexibility" of technology that give rise to the control dilemma. In this paper we want to suggest another response to the control dilemma.

What remains of the optimistic perspective to develop instruments for the assessment and control of technology or the pessimistic view of autonomous technology, now that the standard image of technology has been criticized? This is the main focus of this project. How can we mould the processes of social construction so as to incorporate democratic decision making of some sort? This project uses the recent history of Dutch coastal engineering to pursue questions such as this. The social shaping of technology and the technological shaping of society are two sides of the same coin.

<sup>7</sup> Pinch and Bijker (1984) use the high wheeled bicycle of the 1870's as an example. The first step in their descriptive model is a sociological deconstruction of the artifact (by the analyst). In this case this results in showing that "hidden within" the high wheeled Ordinary were at least two vastly different artifacts: the Unsafe Machine for women and older men, and the Macho Machine for "young men of means and nerve." The second step is to trace the social construction of these artifacts (by the relevant social groups of actors). Several "closure mechanisms" can be identified that bring the interpretative flexibility to an end and start the process of stabilization of the artifact within the relevant social groups. The third step is to generalize beyond one case study to form a theory of socio-technical ensembles.

spokesmen for upgrading the state of the Dutch dikes.  
 very poor condition. Van Veen himself had warned the government already a long time ago that the dikes and sluices were in a  
<sup>9</sup> "undeserved" because engineers had already a chief engineer of the Rijkswaterstaat (see below) one of the principle  
 points for measures to control the technology's development. The control dilemma disappears.  
 related firms, consumers - all play a role in the shaping of technology and thus may all form focal  
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 instead, the seamlessness web character of technology's development. The socialy constructed character  
 indicate a multitude of opportunities to influence the development of technology (and society), and  
 ...). In this research project we will try to trace how these opportunities were created, used or missed  
 in February 1953. This section is to provide some technical background for the  
 discussion of the coastal engineering system that will be the main topic of this paper. Then we shall  
 continue by outlining the political-technical solution, called "Detraplan", by which the Dutch  
 parliament sought to defend The Netherlands more effectively against future attacks by the sea. We  
 shall trace the Deltraplan's history to show a rather dramatic change of priorities in 1976 when the  
 Netherlands: since the country is below ordinary sea level, the sea will not retreat at all. On the  
 contrary: the tides will continue to run in and out through the gaps in the dikes, thereby further  
 widening them every six hours. The technology and costs to reclaim such inundated lands are  
 comparable to making completely new polders. The cost of reclamation of the most difficult parts  
 that were flooded in 1953 were about five times as high as the ordinary selling price per acre.  
 viewed from a narrow economic standpoint, this is ludicrous.

In the early Sunday morning of 1st February 1953, the radio warned: "Many dikes have been  
 broken. All soldiers on leave have to return immediately. There is a special danger at Oudekerk.  
 There is a wide breach at Oudekerk." The dike of the river Rhine at Oudekerk was a crucial  
 protection for central Holland and its cities like Rotterdam, Delft, The Hague, Leiden, Gouda, and  
 Amsterdam. That, nevertheless, central Holland was not flooded, was due to a combination of a  
 navigating on the river which was woven through the Netherlands in earlier centuries. A small old dikes remaining  
 quick "Hansje Brinker" type of reaction<sup>9</sup> and the existence of some of the small old dikes remaining  
 meters wide. She was grounded just in front of the breach, on the dikes' threshold; citizens and  
 soldiers then filled the gap with sand sacks and blocks of concrete waste; before nightfall the breach  
 was closed and central Holland was saved. During that day, the old inner dikes held out, which was  
 considered by Van Veen as "sheer undeserved luck" (Van Veen, 1962: 177). Almost a year later, on  
 6 November 1953, the last and largest of the 89 tidal breaches was closed - just before the winter  
 placing a lung in a hole in the dike when he saw the sea coming through. Only after a long, cold and stormy night,  
<sup>8</sup> Hansje Brinker is the mythical figure of an 8 year old boy who rescued the city of Haarlem and surrounding polders by  
 艺术 for him and was rescued.

## The 1953 Flood Disaster

This paper reports about work in progress. It will be raising questions rather than answering  
 them. In the first section we will briefly describe a flood disaster which hit the Dutch coastal region  
 in February 1953. This section is to provide some technical background for the  
 discussion of the coastal engineering system that will be the main topic of this paper. Then we shall  
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The whole gamut of technologies that had been developed during centuries of fighting the sea was employed to reclaim the lost land. First of all, time was crucial. Tidal currents quickly widen all gaps. The largest gap in the 1953 disaster was 100 meter wide and 15 meters deep on February 1, but a few months later it had grown to 200 by 20 meter. If the gaps had not been closed before the next winter season, this damaging process might have been irreversible. Also on a scale of minutes time is crucial. Currents rage at their fastest when gaps are at their smallest. So, the right moment to close off a final gap is in the few minutes of slack water. The age-old technique is to build the dam by working continuously until the last gap, then close it in the minutes of slack water<sup>10</sup> with a dam which is only a few inches above sea level. Finally the dam can be heightened and finished off.

For centuries the key material to strengthen and repair dikes has been sandbags. On the night of 1st February 1953, the sandbags were made available from emergency depots and played their crucial role. Only since the closure of the Zuiderzee in the 1920's boulder clay came to be used to build dikes that were too large for sandbags. The allied invasion of Normandy was made possible by caissons that have been increasingly used to close a tidal gap suddenly and to build the basic structure of the dike. Since the 1920's huge supplies of "unpacked" sand, dredged or sucked from the sea bottom, have been used to strengthen the framework of a dike. More recently (in the 1960's) huge blocks of concrete have been employed - dumped by special ships, from cable trains, or even from helicopters.

In 1953, as in the centuries before, human power was the energy source which did most of the work. This was the only power source that was distributed widely enough through the Dutch coastal area to act adequately at short notice. Human power was aligned with the skills of transporting the sacks by human chains and dumping them in the right positions. For the final closures of the 1953 breaches, motor dredges, tugs, ships and cranes were used, but on that 1953 February night it was human power that saved the day.

An armored foundation is necessary to build a dike in a gap with tidal currents - the natural seabed of sand will not do, as it will be scored away resulting in an undermining of the dike. Since centuries fascine mattresses have been used for this foundation. Such a mattress consists of a net structure of about 20 centimeter thick, some 100 meters long and 20 meters wide. A series of such mattresses lowered onto the seabed provides a foundation for the dike to be built. Until the 1970's, when synthetic mattresses were used in the large tidal closures, such dikes in the Netherlands (and at all sandy coasts throughout the world) were built on mattresses, woven by hand from branches of willow (or similar) trees. After prefabricating the mattresses on land, they are towed out into sea where they are sunk by carefully dumping quarry stone on them. This used to be done by hand, to guarantee a gradual and controlled lowering onto the right position.

Scientific research started to play a role in the 1920's: the physicist Lorentz was asked to make mathematical predictions about the tidal effects caused by a closure of the Zuiderzee. Hydraulic research received a boost during World War II when it was called upon to investigate the conditions under which harbors could be built for the invasion of Normandy. Empirical research with scale models had already started in the 1930's, but was intensified immediately after the war. Such scale models played a crucial role in the closure of the last gap of the 1953 Disaster. The closure with caissons in Zierikzee for example was carried out some hundred times in the scaled-down reality of the laboratory.<sup>11</sup> Engineers' using force measuring instruments held the cables and acted as the tug boats that were holding the last caisson to plug the gap off by the last knots of flood stream. To be finished before the tide returned, the tug boats had to start while the flood was still rather strong. On the day of closure at scale 1:1, the young engineers who had practiced in the laboratory were standing on deck behind the old experienced tug boat captains. When one of the cables snapped and control of the caisson was about to be lost, they could intervene since they had seen that snapping rope a dozen times, and had worked out a scenario to save the caisson. With a series of unusual commands that took advantage of the queer characteristics of the currents they had discovered in the

<sup>10</sup> During "slack water" the direction of the tidal current changes from ebb to flood or vice versa.

<sup>11</sup> Since no sophisticated caissons were available, old barges were used - these were, quite spectacularly, sunk with dynamite.

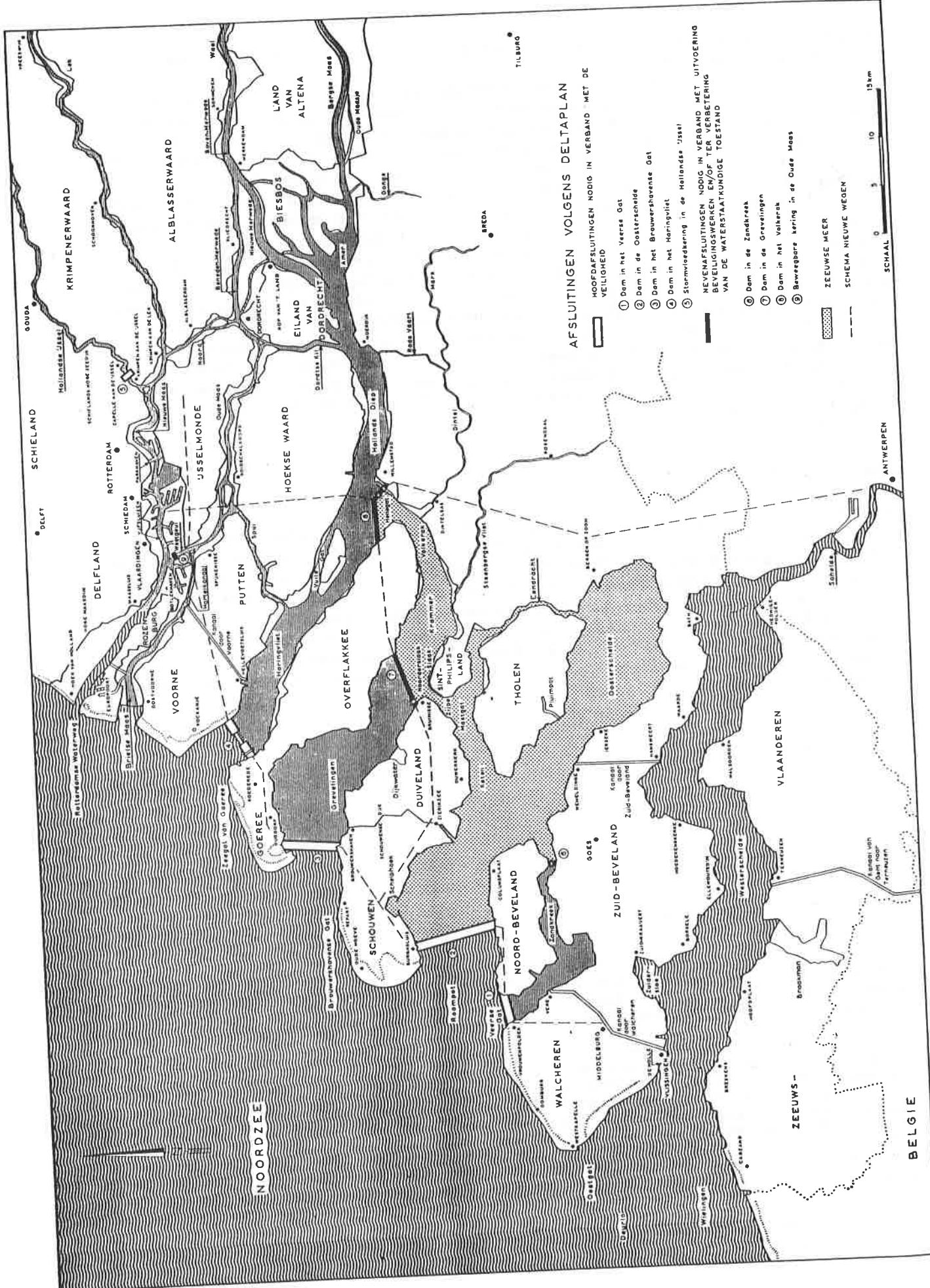
13 I indeed found it quite difficult to avoid similar rhetorics in writing this paper - and I am not sure that I completely succeeded. The "fephilicagagabinti the sea" vocabulary, as well as the rhetorics of the "sweet technology" that was employed in the Oostersechelse closure (see below) are very tempting and threaten to jeopardize my distance to the subject matter. Especially this issue of seductive vocabularies as part of the present research project.

12 Model research is no guarantee for success. For one, it depends on whether you have modelled all relevant aspects. Though the Zerkleeeze closure first seemed a success, a few days later the caissons started to shift. Since the engineers had not wanted to loose time to lay a fascine matress foundation, the ground was too slippery and the caissons were pushed out of the

The 1953 Disaster hastened the political discussions and decision making that had started already at a slower pace - how to react to the deterioration of the dikes: by repairing and heightening the dikes or by pursuing more radical options?<sup>14</sup> On 18 February 1953 a government committee was set up, its most central report was published in February 1954, work started officially in August 1955, and in 1957 the Dutch parliament followed the committee's advice and opted for the radical solution (see table 1). A law was passed which specified "the Deltaplan" - all ideal ideas in the Zeeland delta, where the rivers Rhine and Maas flow into the North Sea, were to be closed except the Westerschelde (connecting Antwerp to the sea) and the Waterweg (connecting Rotterdam to the sea).

The Delaplaine

water, the last caisson was eased down into the final gap during the crucial few minutes of slack lab, the break was closed, now on a real scale.<sup>12</sup> It is difficult to assess in any specific form the cultural importance of "living below sea level." Only too easily one can slip into the tourist's style of depicting "the Dutch people" in broad strokes that are as grandiose as they are empirically vacuous. For the argument in this paper, it is however important to give some idea of the relative importance of the "safety from the sea issue" for the Dutch. There are two quite different observations to be made - the first in economic terms, and the second in what we will call symbolic terms. Economically the reclamations of the inundated land after the 1953 flood were in several instances irrational - the costs of reclaiming the land were higher than the selling price per acre. It was not necessary to reclaim the land for either agricultural or demographic reasons - in the 1950's the first big polder in the IJssellmeer (the former Zuiderzee, in the middle of the country) was just being cultivated, and the reclamation of the next four polders in the IJssellmeer which were already planned could easily be stepped-up. There evidently were other, more symbolic reasons for recovering the inundated Zeeland islands. Some of this symbolic value can be sensed by reading accounts of the nation-wide helping campaign (with the royal family in its symbolic role *par excellence*) that started after 1st February 1953. Novels and children books, written in the two decades since the flood, give further evidence of this importance of reclaiming what the sea has taken. The rhetorics of the engineers subtly makes use of the same symbolism.<sup>13</sup>



*Original time schedule of Deltaplan: the dates give the starting point of each project. The Oosterschelde dam, the largest and most difficult closure, would be finished last.*

Table 2

1958	Flood barrier in Hollandse IJssel (near Oudekerk; weakest spot in the defense of the densely populated central region of Holland)	Zandkreek dam (small dike at the back of the smallest tidal inlet; most southern)	Veerse Gat dam (closure of small tidal inlet; most southern one)	Grovenhogen dam (big dike at the back of the second largest tidal inlet; second from north)	Volkerak dam (closure of the largest tidal inlet; third from north)	Oosterschelde dam (closure of most northern tidal inlet)	Haringvliet dam with outlet sluices (complex closure of most northern tidal inlet)	Brouwershavense Gat dam with outlets to let out the water of the rivers Rhine and Maas	largest point of each project. The Oosterschelde dam, the
1961									
1965									
1967									
1970									
1971									
1972									

*Summary of key dates in starting the Delaworks*

Table 1

1 February 1953	Storm surge	Delta Commission installed by minister	Intercal start Delta Commission with proposal for Deltaplan	Nonofficial start Delta Commission of work harbors establishment of Deltaengineer ("Delta Service") within Rijkswaterstaat	Delta Law signed by the Queen (after adoption in the Parliaments "Second chamber" on 5 November 1957, and "First chamber" on 7 May 1958)	Final report Delta Commission	10 December 1960
18 February 1953							
27 February 1954							
1 May 1956							
8 May 1958							

This radical choice was explicitly related to a partial abandonment of the decentralized system of dike and water management by small locally embedded public bodies that had - in some form - been used in the Netherlands for over 2000 years. The large, "high tech" closures of the tidal inlets would come under national jurisdiction rather than under the command of the local water boards. One of the conclusions after the 1953 disaster, formulated by the central authority Rijkswaterstaat<sup>15</sup>, had been that this decentralized control system was partly the cause of the bad quality of some of the dikes. Another conclusion, though at that time formulated by only a few, was that the decentralized dike management system had provided the crucial skills, knowledge and technology to react adequately, immediately, and on the spot after the dike breaks. By the Deltaplan, coastal protection by some 1000 kilometers of dikes under decentralized control was now to be taken over by less than 30 kilometers of dikes under centralized control. By the late 1950's, the faith in the Rijkswaterstaat was such that this centralization met with no resistance.

The Deltaplan was explicitly set up as a learning process - the "Delta-school." The first project was a flood barrier<sup>16</sup> in the Rhine, just downstream of the 1953 breach at Ouderkerk, to protect the central region of Holland. Other projects followed in order of increasing magnitude and complexity. Besides the four main closures, a series of secondary inland dams and sluices was needed to control the tidal streams during the main closure works and to manage water levels afterwards. The four main closures were to be three dikes and one discharge sluice for the water of the rivers Rhine and Maas. The safety criteria had overriding priority in deciding on the details of the Deltaplan. The buzz-word in both political and technical discussions was "Delta level" - the water level during a storm surge that had a chance of once in 10,000 year to occur. Dikes were designed with this level in mind.<sup>17</sup>

Flood barriers or sluices to allow the tide to continue were ruled out because these would be too expensive. The Deltaplan would thus create several huge new fresh water lakes without any tidal movement. Though detailed insight in the ecological effects was not available, nor deemed very important, it was explicitly recognized that oyster farms and salt water fishing would have to be abandoned. This price seemed reasonable in the light of required safety and there was no discussion about it, especially since the fresh water would be beneficial to agriculture in the region.

The Deltaplan was generally recognized as a technologically unique project of which the final large closures were well beyond the technical possibilities available in 1953 when the plan was adopted. It was realized that the tidal inlets would be much more difficult to close than the large Zuiderzee in the 1920's - the only other project of comparable size. The inlets were so much deeper and the currents so much faster that it was quite clear that traditional technologies such as sand and clay dumping would not work. There was the idea of an open caisson that could be closed once it was moved into position, but this had not yet left the drawing board. The possibility of cable ways across the inlet to dump large concrete blocks with high precision into the water had not even been conceived. Nevertheless, the work actually began before parliament had approved of the plan and the subsequent parliamentary treatment went very smoothly.<sup>18</sup> This can be taken as a further indication of the nation-wide support both for the plan with its safety priority and for the Rijkswaterstaat as the central authority to carry out the plan.

The Deltaplan did not only require technological innovations on an unprecedented scale. The engineers involved also realized that the project required organizational and economic innovations. The first Director of the Deltadienst attempted to negotiate specific organizational forms which would give him direct access to the Director General of the Rijkswaterstaat and the responsible minister. This plan however would place the Deltadienst in too privileged a position as compared to

<sup>15</sup> The Rijkswaterstaat is the national governmental body for water and dike management. Because of its huge size and related political power it is sometimes called "a state within the state."

<sup>16</sup> A flood barrier is a construction which normally is open to let the water pass, but can be closed in case of a dangerously high tide.

<sup>17</sup> In the design practice this so-called "basic level" with a transgression chance of 1:10,000 years did not have the unambiguous hard character it had in the public debate. Various differential factors, among which hydrological coastal variables and an "economic reduction factor", resulted in different design levels along the Dutch coast. The resulting design level for the Zeeland coast was, for example, 1:4000. This meant that dikes and other structures were to be built with a sea level in mind that had a probability of 1:4000 years to be surpassed. Additional conditions result in an inundation probability of the Oosterschelde area of less than 1:400,000 year. (Rijkswaterstaat 1991)

<sup>18</sup> The law was adopted with 149 votes in favor, none against, and one abstention.

The existing departments within the Rijkswaterstaat and it was not accepted. In other respects the Deltidienst was given a special treatment. Although this certainly did not go without criticism and complaints from other parts of the Rijkswaterstaat, the shock of the 1953 flood was still so fresh that the Deltidienst and the resulting competition between different Rijkswaterstaat departments can probably be traced "inside" the various technical designs of the Deltaplan. The over-sized design of the Haringvliet outlet sluices, for example, was determined by specific evaluations of ice risk. Engineers at different positions in the Rijkswaterstaat made different assessments of this risk and another organization of the design team might have resulted in smaller gates.

Other "organizational" innovations included a new hydraulics research department within Rijkswaterstaat, a new relationship with the Delta Hydraulics Laboratory, the on-site training of young engineers to supplement their theoretical training, and new contractual arrangements with the sluice construction and mattress production companies. The latter is perhaps the most penetrative dredging, construction and mattress production companies. The latter is perhaps the most penetrative organization change and here we will restrict ourselves to a brief sketch of its outlines. The Rijkswaterstaat, a new relationship with the Delta Hydraulics Laboratory, the on-site training of young engineers to supplement their theoretical training, and new contractual arrangements with the sluice construction and mattress production companies. The latter is perhaps the most penetrative dredging, construction and mattress production companies. The latter is perhaps the most penetrative organization change and here we will restrict ourselves to a brief sketch of its outlines. The Rijkswaterstaat and asked for a public bid by competing construction companies. The project supervisor at the site by Rijkswaterstaat's engineers checked whether the project was carried out according to its plans and asked the one who had the job. Further negotiations about the price of the project and the details of company was offered the job. Further negotiations about the price of both price and proposed work plan, and then one carefully checked and compared, in terms of both price and proposed work plan, and then one specifically presented a two-sided character (Den Doolard).

1948) - on the one hand the cowboys of the sea, who would try everything to outwit Rijkswaterstaat's engineers who had their professional pride, and on the other hand the experienced civil servants by working cheaper than they were paid for, and on the best coastal engineers in the world, and were committed to delivering a sound coastal defense to The Netherlands. This realization that the usual way of contracting private construction companies would not work: the works were too difficult so as to be designed beforehand with enough detail to allow the normal bidding and contracting procedure. Also, distributing the various projects over many separate companies would severely hamper the "Deltaschool" idea of accumulating knowledge and experience during the development of a new relationship was helped by the events immediately after the 1953 flood. Then Rijkswaterstaat had asked the new form of collaboration, undoubtedly helped by the special symbolic meaning of the table, and this is new vocabulary and more mutual trust. The Deltaworks were all carried out by large consortia of companies, while many companies participated in several contracts - the all-out "nation-wide" effort to save the country by closing the largest gaps before the next storm.

Season, had created a new vocabulary and more mutual trust. The Deltaworks were all carried out by consortia that thus helped to save the experience acquired in earlier closures for later and more difficult projects. Thus the "divide and rule" strategy by which Rijkswaterstaat could keep prices down in the public bidding procedure was substituted for a system in which cost reduction was less of a priority. Also in a second respect the relationship between Rijkswaterstaat and dredging companies changed: in the course of the Deltaworks the companies began to play an increasingly important role in the design of the constructions - the claim of this company that this development, which would have been inconceivable around 1950, was the Osterschelde barrier (see below).<sup>20</sup>

Though the final result of the Delta project is now advertized as the Eighth Wonder of the World<sup>21</sup> and its success figures as an unambiguous proof of scientific and technological progress in this field, insiders point out how there was no simple accumulation of knowledge. Even on such seemingly basic issues as the design of dikes, there are still controversies. It was only after the 1953 Flood, for example, that engineers realized that dike breaches almost always occur from the dike's inside: water flowing over the top of the dike scores the inner slope and only then the dike bursts. Virtually all efforts of dike building and repair since prehistoric times until 1953 had however been directed at the outer slope of the dike. And also after the research into the 1953 dike breaches, the knowledge of dike building was not the set of objective, hard, scientific facts that one might have hoped for. For example, Ferguson (1988: 60) comments on the obvious differences between two of the main Deltaplan closure dikes: "One may think that these [differences] have been caused by important technical considerations. The reason however is, that the designers could not agree about the benefit of an outside shoulder; in the one case the opponents of the shoulder won and the Veere Dam did not get a shoulder; some time later the proponents won, and the Brouwers Dam got a broad shoulder. We still do not know what is best."

The work proceeded well (see table 2 for the original time schedule). By the end of the 1960's, the Deltaplan had been extremely successful and proceeded to its final phase - the closure of the largest tidal basin, the Oosterschelde.

### The Oosterschelde Flood Barrier

For the Oosterschelde dam, a trajectory had been selected which made use of two large sand banks in the Oosterschelde mouth. This resulted in three deep gaps to be closed; the two parts of the dam that ran over the sand banks were considered minor problems. In 1971 it was decided to close these three arms by using the same technique as in the Brouwershavense Gat - a huge cableway to drop from a height of some 30 meters, with high precision, the large concrete cubes that were to form the core of the dike. Three independent cableways were to be constructed in the three gaps. In total twelve pylons were placed in 1971, each designed to match the circumstances at its particular position. The longest was some 80 meters. The costs of designing, making and placing the pylons was 17.5 million guilders. The last pylon was scheduled to be placed in July 1974.

However, the virtually nation-wide support that the Deltaplan had received in the 1950's now started to wear thin. The special quality of the tidal ecology of the Oosterschelde was valued more than before; the polluted waters of the Rhine and Maas suddenly shifted the prospect of the closed estuaries from being transparent water lakes into becoming huge sinks; the butter and wheat "mountains" in the European Community relativized the importance of fresh water to stimulate agriculture, since food production did not seem to be such a primary problem as it had been immediately after World War II. Also other societal changes in the 1970's effected the Delta works - the Rijkswaterstaat's authority (like so many other political institutions in the Netherlands) came into dispute. During the general elections in 1972 the Oosterschelde closure became a political issue. The alternative of leaving the Oosterschelde open and increasing the height of all its dikes was proposed.

The new government, now including the social-democratic and leftist liberal party, decided to investigate the possibility of an open Oosterschelde. A commission was installed in August 1973. In February 1974 the commission produced a report with a very creative compromise. The Oosterschelde was to be closed by a flood barrier which would normally be open, but could be closed in case of a storm surge. While this barrier was under construction, the safety of Zeeland (required by the Delta Law) had to be guaranteed by building a porous dam in the Oosterschelde mouth: this dam would reduce the tidal difference in the Oosterschelde basin with to 50%. After completing the barrier, the dam was to be taken out again.

The commission's report played a crucial role in opening up the discussion about another solution than complete closure, although it was criticized from all directions. Ecologists argued that the commission did not seriously investigate the "null option" (leaving the Oosterschelde open); several

<sup>21</sup> This phrase is specifically applied to the Oosterschelde Flood Barrier, to be described below. The Dutch are never too modest when a potential export article is involved.

22 Vertical down scaling, for example 100:1, cannot be as large as the horizontal down scaling, for example 400:1, because the water's behavior changes fundamentally when flowing in more shallow streams. This is one example of the complicated scaling laws that are involved in all technological modelling. These scaling laws make it hard to translate results from the model cannot be taken to provide an unambiguous answer about Nature's state.

A final plan was presented to the government and approved in June 1976. The core of the model was located in a building situated as a military technical facility. Adopted solution was to make a permanent construction in the Osterzschlede mouth, through which four times per day several tens thousands of cubic meters water would flow, and which could be closed completely in case of a superstorm. The principles of this solution were in all details different from the one that was approved by parliament two years before. And even at this moment of government approval, most of the research and design work still had to start. The engineers of Rijkswaterstaat and the construction companies worked in almost completely integrated teams to this end.

The pylons for the cableway were disassembled, which was a quite difficult job requiring the construction of special equipment, and research with physical models and computer simulations. Brand new matrieeses, that already had been laid as basis for the dam, were dredged away.

Model research played a crucial role in carrying out all works of the Deltaplan. Since the 1920s mathematical models had been used and since the 1940s these were complemented by physical models in which physical dimensions were scaled down by factors 100 and 400<sup>22</sup>, time was scaled up by 1:40, sand was scaled down by using finely grinded Bakelite, water stayed at 1:1. The most complicated models, such as the Oostersechlede model, used a combination of salt and fresh water. For detailed studies of dikes and constructions, wind and wave flumes were used. The organization of this model research was as difficult and crucial as interpreting the scaling laws. Managing the relations between Rijkswaterstaat, the Delft Hydraulics Laboratory, and the private construction firms were thus as much part of the Deltaplan closures as the weaving of mattresses or the design of the discharge sluices. Most research, for example, was carried out by the Delft laboratory, but the translation into design and construction was the Rijkswaterstaat's responsibility. In 1974-1975 the private dredging firms also carried out some scale model studies in Delft to design their cassion flood barriers and later an alternative with pillars rather than cassions. Since they wanted, for competition reasons, to keep these results secret from other firms and Rijkswaterstaat, the hall in which the models were stored was referred to as a mill<sup>23</sup>. Research facilities

(Nobody within government or Rijkswaterstaat argued for a completely open Oosterschelde). As a result of this debate the Netherlands were almost torn apart, on all levels - in parliament the almost unanimous support of fifteen years earlier for this project was now reduced to only 50%, and some of the coastal engineers turned from respecified builders of a safer nation into ecology wreckers, even to their own families. In November 1974 the government decided for the "half-open option", meaning a flood barrier of casings in the Oosterschelde mouth and heightened dikes along the Oosterschelde coast. After much political pressure, parliament approved this decision with a small majority. Three coastals. At the end of the 1980s, as compared to 1985, (3) the extra costs, as compared to a complete closure, should not be finished more than 20 billion guilders. A motion to continue the complete closure was rejected by 75 to 67 votes. Those who were in favor of closure called this "a purely political decision".

Other groups concluded that Zeeland is left unprotected against the sea during a much longer period than was promised in the Delta Law; most engineers criticized the report for being technically impossible; and finally all recognized that it was extremely expensive - some 1.6 billion guilders more expensive than the originally planned closure. Now the dredging companies stepped in and took an important initiative. They made detailed designs and proposed a temporary caisson dam, instead of the semi-permeable block dam, as safeguard while the flood barrier would be under construction. This plan evolved into using the caisson dam as basis for the flood barrier itself; a new type of caisson would be developed that could permanently function in open sea (rather than just for a few weeks before being packed into a permanent sand and clay dike) and have doors to be opened and closed as safety required.

Rijkswaterstaat did not like the caisson flood barrier plan, since it was "technically unfeasible".

Societyal pressure builded further up however, and within the government the minority of "keep it

Intensified research of the tidal streams and sand bottom started. To increase the safety of Zeeland during the delay period the dikes were heightened to a flooding chance of 1:500 years.

It soon became clear that the project was of unprecedented complexity. The Oosterschelde bottom was found to be of an unusually fluid sort of sand, and the tidal velocities and volumes encountered were larger than in any previous project. One of the consequences of the decision to leave the Oosterschelde open was that the flood barrier had to be constructed on the spot, in open water. The only other big mechanical construction previous to this project - the discharge sluices in the Haringvliet dam - had been built in a working polder<sup>23</sup> in the Haringvliet inlet; after completion of the sluices, the polder was flooded, its dikes removed and the remaining gap between sluices and shore closed with a dike. Such a solution was now impossible since the resulting decrease of tidal volume would affect the ecology of the Oosterschelde irreversibly. Several radically different designs were discussed and tried in model research.

The two main problems turned out to be the foundation of the dam (a shift of only a couple of inches would jam the sliding doors of the dam, reducing the flood barrier to a useless ruin) and the control of the budget (parliament had stipulated maximum costs; if this condition could not be met, the closure had to be made with an ordinary dam). The foundation problem was solved partially by building a new ship that used four 40 meter long vibrating needles to condense the sea bed<sup>24</sup>, and partially by using prefabricated mattresses that were sunk by a specially designed ship with a horizontal and vertical accuracy of some inches. The budget problem was solved by a combination of measures: a design adaptation in the latest stage (one sliding door less in the barrier), violation of the non-interfere-in-ecology principle during construction (engineers were allowed "to flipper": to close the barrier several times to facilitate works), and creative accountancy.

The Oosterschelde flood barrier dam was opened by the Queen of the Netherlands on 4 October 1986. This virtually finished the Deltaplan. It was completed some ten years behind schedule, with a budget overrun on the Oosterschelde barrier of 30%.<sup>25</sup> At the same time this technological system is widely acclaimed to be the crown of Dutch coastal engineering. It is, however, still mistrusted by a few experts because of the unprecedented critical nature of its foundation. In the Deltaplan, as perhaps best illustrated by the Oosterschelde barrier, values of safety and environmental protection are built into the very technologies. But also the organization of Rijkswaterstaat, the relationships between dredging firms and laboratories, the financial politics of Dutch parliament are embedded into the technology, just as much as mattresses, concrete pillars, steel doors and control computers. Dutch society shaped the technology of the Deltaplan, as much as the Deltaplan shaped Dutch society for the future.

## Democratic Control of Technology

We now turn to the central question of this paper - what are the implications of a constructivist view for issues of democratic control of technology? Rather than embarking on a theoretical discussion from a political science perspective, we will try to tackle this question through the case of the Oosterschelde Flood Barrier, by asking whether this large technical system may be considered an example of democratic technology. First we shall briefly review the various possibly ways of interpreting the question about democratic control of technology. Then we will focus on the Oosterschelde Flood Barrier, and finally conclude by outlining possibilities for constructivist studies that may contribute to a more democratic control of technology.

<sup>23</sup> A polder is an area of land below sea level, created by building dikes around it and then pumping the water out. Some 40% of the Netherlands consists of polders, in size varying from only a few to many thousands of square miles. In the case of a working polder, it can be quite small - just big enough to build (in this case) the sluices.

<sup>24</sup> The "needles" were drilled into the sand bottom. Their vibration made the sand particles move into a closer packing order.

<sup>25</sup> Other sources mention a 15% overrun. Arguments over such numbers are a fruitful entrance for the ethnoaccountancy studies that I will mention later in this paper.

undemocratic, or inflexible or bad or good) in any final way. Doing so would reinstate the inadequate barrier? First, we have argued that no technological system can be called "democratic" (or, similarly, So, what can be our conclusion as to the democratic character of the Oostersechelde Flood

will probably opt for a lower norm for greater safety.

increases the norm level so that the barrier will be closed less frequently; regional political authorities should be realized during these closures? The old parties take position: environmentalists propose to operational criteria of the barrier - at what water levels should the doors be closed, what tide regime years of operation will be discussed intensively in public hearings before leading to a decision about

insight in the socio-technical system are such that the recently published evaluation of the first five

parliamentary discussion about the operating criteria of the Oostersechelde barrier. Public interest and

specific technical discussion and design choices. Now, in 1992, it makes perfect sense to have a

design and construction period, for example, environmental groups were explicitly involved in

about this coastal defense technology than about any other modern technological system. During the

recognize that it was not developed in isolation. The general public knows much more

and critically followed by various analysts. The Delaphan project was closely

The second line of reasoning yields a more convincing analysis. The Delaphan project was closely

not convincingly make the case of the Flood Barrier being democratically controlled.

Whatever the final result that is now standing in the Oostersechelde currents, this line of arguing does

adequate to take its shape at the moment of parliamentary decision as core characterization.

and with the involvement of a large array of relevant social groups. It is rather artificial and not very

the previous section, the Flood Barrier was constructed, like all technologies, during a long period

follow this route, when thinking the democratic control of the Flood Barrier. As we have shown in

engines who thought that the adopted plan was technically unsound labeled the decision as "purely

the actors involved at the time of the parliamentary debates. As was mentioned before, coastal

technical detail discussed and finally approved by parliament. This view is subscribed to by most of

Flood Barrier clearly is a democratic technological system, since it was explicitly and in much

If we take the first interpretation, of democratic control as parliamentary control, the Oostersechelde

### *The Oostersechelde Flood Barrier: A Democratic Large Technical System?*

contributions to technology assessment.

We will first discuss what these two interpretations of a democratic technology might mean in the case of the Oostersechelde Flood Barrier, and then return to a sketch of possible constitutional

movements, and possibilities to exert control.

government, or ...) will not do. The positive implication is that there are many more actors,

final control. TA as an instrument to primarily strengthen parliament (or company management, or

consequences. The negative implication is that it is principally impossible to find a key actor to exert

groups play some role in this construction process. Such an interpretation has positive and negative

and cannot be characterized in a final way at any moment, and that, second, all relevant social

introduction of this paper, it stresses that, first, technologies are continuously (socially) constructed,

of technology. It draws directly on the constructionist image of technology as outlined in the

A second answer gives a less political and more socio-cultural interpretation of democratic control

parliament) which is to play a priority role in the construction of a technology.

technology. Second, it assumes that it is adequately possible to identify one key actor (the

constitutionalizing the technology - once a democratic technology, always a democratic

implication on the standard image of technology, in two respects. First it presumes that it is possible

mission of the American Office of Technology Assessment. TA initiatives. It draws

control should be exerted. This interpretation of democratic control of technology fits the original

formal democratic procedures that are available. In the case of a large technological system such as

the Oostersechelde Flood Barrier, it evidently would be the Dutch parliament where this democratic

What can we possibly mean by "democratic control of technology"? One answer is to focus on the

standard image of technology. Second, the Flood Barrier was socially constructed by a variety of relevant social groups. But is that synonymous to being democratically controlled? If so, then all technological artifacts and systems deserve that label - since all are, we have argued, socially constructed. That would be highly unsatisfactory, since the whole issue of democratic control of technology would then disappear. We shall now turn to this problem.

#### *Democratic Control of Technology from a Constructivist Perspective*

Is it possible to address political issues related to technology development and can we operationalize criteria such as "democratic control", when using a constructivist view of technology? We already suggested that the answer will have a positive and a negative side. On the positive side, we must conclude that the constructivist view, at least in principle, opens up for many hitherto invisible opportunities to intervene, to control, and to change the construction of technologies. On the negative side, we have to recognize that no priority positions, social groups or sets of criteria exist in any context-independent way. "Democratic control" can be operationalized in the form of facilitating relevant social groups to engage in the construction process of technologies; it cannot mean that the criteria and principles of one particular group (such as the government, parliament, action groups, "the people" or "ourselves") have a privileged role. What then remains to be done? We see three strategies that should be followed. The first relates to general and school education, the second to analytical research, and the third to political systems of control.

From a constructivist viewpoint, all relevant social groups are able to contribute to the construction of a technology, but not necessarily with the same degree of success. The social constructivist stance does not hold that all groups are equal. We propose that one way of promoting the democratic control of technology is to improve the possibilities for all relevant social groups, but especially for those which are relatively powerless in society, to intervene in the development of technology. The models of technology assessment that have been developed in Sweden and the Netherlands explicitly draw on a similar idea.<sup>26</sup> General education, improved primary and secondary school education and popularization of science and technology would thus, in this view, be crucial elements in a strategy to improve the democratic quality of our technological society. If the Oosterschelde Flood Barrier deserves a positive evaluation as a democratically controlled technology, this is only possible because of the exceptionally widespread knowledge about all aspects of the problem and the various solutions. For the previously mentioned present public evaluation of the Barrier's operation procedures can only become a success, if indeed different groups of "the general public" have a more than superficial understanding of the issues.

Analytical technology studies are the second strategy to support a democratic control of technology. Such studies will generally enhance insight in the relevant processes, but also specifically allow less powerful groups to deconstruct the existing seemingly natural and fixed state of technology in order to get issues on the agenda that threaten the prevailing order. The deconstructive capacity of recent technology studies can thus be effectively used to highlight interpretative flexibility, to suggest alternative technological choices, to debunk the sociotechnical ensembles constructed by the powerful. Not much of this work has been presented with this explicit aim, but the work by, for example, Ashmore, Mulkay and Pinch (1989), Latour (1987, 1992b), Collins (1990), MacKenzie (1990a), Mack (1990), Blume (1991) and Bijker and Law (1992) can be read in this way. More specifically we see four additional distinct foci for such research. Ethical studies of technology could comprise a combination of "ethnographic ethics" and "strategic ethics." In ethnographical studies the co-emergence of values and practices, of ethical vocabularies and technologies, of labor relations and industrial systems is to be investigated. In the day-to-day employment of technology, professional codes and societal values are shaped. Values are, in this view of technology-society-ethics, not pre-given as universal ethical laws but socially constructed together

<sup>26</sup> Leyten and Smits (1987) present a comparative study of different concepts of technology assessment in, among others, Sweden and The Netherlands. For more information about Sweden, see SFS (1982); for more about Dutch "constructive technology assessment" approach, see Daey Ouwers *et al.* (1987), and Schot (1992). Schwarz and Thompson (1990) conclude to "constructive technology assessment" on the basis of their cultural theory which they developed on the basis of the work of anthropologist Mary Douglas (for example: 1970, 1982).

In this paper we have discussed the social constructivist perspective on technology and investigated its implications for technology assessment. Especially we have argued that efforts to characterize specific technologies in a context-independent way as, for example, democratic or authoritarian or

## Conclusion

Regulations and norms are a traditional steering instruments, but almost always used with a mechanistic stimulus-and-response perspective on technology. When examining the analysis of the previous point, regulations and norms can be studied as activating and supporting networks of firms and other relevant social groups that are involved in the construction of a technology.<sup>27</sup> A Zealand environmentalists group intervened in the construction of the Østereschelde barrier by asking the judge in summary proceedings to prevent the dredging of sand at a specific ecologically risky place; the group was subsequently involved in negotiating the dredging location.

The third strategy to enhance democratic control of technology is to structure the control by previous Point in more political terms and operate. Several times may be followed. One would extend the which technologies are designed and operated. Several times may be followed. One would extend the regulations. A second would try to develop rules for projects organization, such as the obligatory involvement of unions, representatives in decision making about technical change in a company. A third might extend the general education strategy by establishing technology for explicit public involvement and control. Such efforts to create new ways for controlling technology, if based on a constructivist perspective, will be principally different from existing procedures. They will not draw on the assumption that there is one pre-given power structure but will assume that a specific power distribution among different social groups is created with the social construction of the technology with which these groups are involved.

Ethno-economic studies apply the constructivist perspective to an analysis of the economics of firms and projects (Mackenzie, 1990b). Investments, costs and profits are not considered as unambiguously available, objective facts. Instead, they are analyzed as socially constructed as a firm and shapings a technology. So, for example, was it possible to "handle" the overrun on the Osterreichische barrier budget by shifting some of the costs to other secondary projects, by redistributing the costs over other Ministries, and by arguing that the costs were actually 20% lower than planned but that "the political decision to leave the Osterreichische open" had caused the increase. Applied to a more macro-economic scale, the reclamaition of flooded paddocks now does not seem as ludicrous as we have suggested in the introduction, only because the cost of reclamation has been made that a large variety of relevant social groups contributes to the social construction of technology. Understanding the role of, for example, consumers in shaping a clinical technology will suggest ways of controlling the development of medical technologies through intervening in the hospital rather than directly in the technology development firm. As will be evident by now, the design engineers: environmentalists succeeded in getting a barrier rather than a dam in the first place, the Zealand region could have as short as possible, the government erased, at the last possible moment, one "Plan safety" would be as short as possible, the government intervening in the design so that the delay in realizing "Deliberation would be as short as possible, the government succeeded in getting a barrier rather than a dam in the first place, the opening in the barrier to limit the budget overrun.

With the technological value of "safety against the sea", was operationalized in a very specific way during the Delta Plan design by the concept of "Delta level" and subsequently incorporated into the design of dams and the management of silvics and flood barriers. In strategic studies of ethics the focus would be on the ethical consequences of such actions to define controversial issues as ethical and subsequent research agendas in such an ethical debate. The tidal ecology of the Oosterschelde got on the political agenda in the 1970's, but only as the result of an array of strategies employed by

<sup>27</sup> See also Jasanooff (1990) who investigates the regulatory process from a similar perspective.

flexible or inflexible is unfruitful. Such an approach obscures many opportunities to influence the construction process of technology. The case of the flood barrier built in the Dutch tidal inlet Oosterschelde to defend the Netherlands against storm surges was used as an example to discuss the issue of democratic control of technology.

We have drawn a partly positive, partly negative conclusion. Taking the constructivist perspective, many more opportunities to intervene in the development of a technology become visible. However, the same perspective does not allow for the identification of "natural" central actors. This "negative" aspect of our analysis deconstructs the power of the presently powerful as a contingent rather than an intrinsic property. For those who do not have much power in the construction of technology this "negative" aspect is thus quite positive.

## Epilogue

In November 1991 the dikes did resist the storm surge described in the Prologue.

In February 2053 there may be a storm surge again. Small chances may combine into big effects. Will the Dutch dikes and flood barriers stand up to this? Or will the global sea level rise, due to the greenhouse effect, cause dangers that were not foreseen when the Delta level was fixed? Will the gradual lowering of Dutch land levels, due to the exploitation of fossil gas supplies, add more to this than presently expected? Will there be lights on during that February stormy night in 2053? How much will Zeeland inhabitants then trust the Deltaplan technology?

We do not know. We can only suggest that if the Dutch coast is defended by democratically controlled sociotechnical ensembles, the feelings of safety or unsafety of the farmers in Zeeland will be based on their participation and insight in the construction process of these ensembles, and not on believing statements by authorities. To contribute to such a form of democratic control of technology should be the task of technology assessment work.

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