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American and Dutch Coastal Engineering:

Differences in Risk Conception and Differences in Technological Culture

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How is it possible that the USA failed to keep New Orleans dry, when large parts of the Netherlands can exist below sea level? This question, with all its implicit rhetoric about the big and mighty Americans and the small and weak Dutch, generated a flock of American expeditions to the Netherlands in the aftermath of the flooding of New Orleans by hurricanes Katrina and Rita in 2005. The big US television networks, channels such as National Geographic, and political delegations, including the Louisiana governor and members of the US Congress, visited the Netherlands within a few months after the flooding, and all parties returned with spirited reports of how the Americans could learn from the Dutch. Does this suggest that the US Corps of Engineers is less able than the Rijkswaterstaat engineers in the Netherlands? I will argue that something else is going on: that the difference is not one of expertise and competence.

In this paper I compare the styles of US and Dutch coastal engineering, and argue that they express different conceptions of risk management in relation to flooding. These differences can, perhaps, be explained by reference to the wider technological cultures of both countries, rather than to the specific engineering cultures. The core of my analysis, however, is aimed at the styles of coastal engineering. In this paper I am not interested in blaming artefacts or humans – levees/dikes[1] and warning systems – or politicians or engineers involved in their design or maintenance. My conjecture is that even had everyone and everything functioned effectively, the historical style of American coastal engineering would encourage accepting the kind of flooding that occurred after Katrina.

Two Internal Histories as Empirical Base

I will base my comparison primarily on two historical papers. In 1996 the 50th anniversary of the International Conference on Coastal Engineering

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was celebrated with a 'Silver Conference', ICCE96, in Orlando, Florida. The proceedings of this conference document the history of coastal engineering in the 15 countries that have hosted the ICCE since the first one in 1950, in Long Beach, CA. I will compare the American and Dutch papers (E.W. Bijker, 1996; Wiegel & Saville, 1996).

The contributing authors in the volume are all distinguished senior coastal engineers who give fascinating 'internal' accounts of the histories of their respective national practices. All three authors of the two papers that I will analyze are recipients of the International Coastal Engineering Award of the American Society for Civil Engineering: Robert L. Wiegel in 1985, Eco Wiebe Bijker in 1986 and Thorndike Saville Jr in 1991.[2]

The papers differ in some obvious ways, including aspects of form such as length, style and number of references, and figures. The most intriguing differences, however, are in content. None of these differences concern what the authors would undoubtedly agree to be the 'core' of their coastal engineering field, but I will argue that they are fundamental, and hold implications for understanding the flooding of New Orleans.

Coastal Engineering and Society

Though both papers are primarily meant to provide internal histories of coastal engineering, a few non-engineers figure in the narratives. In the American chapter, they are mainly limited to 'beach users' who 'were visitors on holiday, who had little knowledge of what occurred during hurricanes or winter storms (such as "northeasters"), and little interest in funding studies and works' (Wiegel & Saville, 1996: 519).[3] Although some of the coast constructions in Texas and Florida are mentioned later in the paper, there is no explicit reference to the two centuries of 'coordinated responses to flooding in the New Orleans area'.[4]

The Dutch paper gives a more prominent role to the citizens living in the region of the Low Lands, and begins with a quotation from the Roman historian Plinius: 'a miserable people [who] live on high hills, or better on man-made mounds, just above the highest water level known by experience' (E.W. Bijker, 1996: 391). The paper continues to discuss the landowners who collectively maintained and managed the levees and sluices. To this end, the so-called 'water boards' were created that are claimed to be the oldest democratic institution in the Netherlands.[5] A ruling by count Floris V in 1280 is quoted to support the claim that these boards exemplified 'the real democratic attitude in the Netherlands at that time'. This ruling stated that everybody had to pay for the maintenance of the dikes: 'the monastery, the knight, the priest, the common man, everybody alike' (E.W. Bijker, 1996: 392).

The Beginning of Coastal Engineering

A large part of the early history in the American papers is devoted to beach and sand transportation studies. ('Sand transportation' refers to the transport of sand along the coast, resulting from tidal and wave movements.) The emphasis is on scientific research, publications and laboratory facilities. A key role is played by the Beach Erosion Board (BEB) of the US Army Corps of Engineers (USACE), which was established in 1930. A variety of studies was carried out under the aegis of the USACE. These ranged from 'a reconnaissance of beaches, inlets, and harbors of the Pacific coast from the Strait of Juan de Fuca at the Washington–Canadian border to the Tijuana Slough at the California–Mexican border', and 'field studies of water particle motions in breakers and waves nearshore and sand movement' along the New Jersey coast, to laboratory studies at MIT and at the BEB facilities at the University of California at Berkeley (Wiegel & Saville, 1996: 521).

In contrast, the Dutch paper only gives research a prominent place towards the end, when describing the post-war period, and describes the beginning of coastal engineering in the Netherlands in very different terms. The unfinished manuscript by Andries Vierlingh (1507–79) is centre stage. Vierlingh was a well-educated patrician and gentleman farmer, who also served in high-level public offices. He was, for example, a *dijkgraaf* (literally 'count of levees', translated as 'dike-grave', 'dike-reeve' or 'dike-warden'): the highest officer serving the previously mentioned elected Water Boards. Vierlingh was engaged in all sorts of hydraulic engineering activities: river works, polders, sea defence and the closing of dike breaches that resulted from storm surges (Vierlingh, 1920, 1973 [1579]).

Making Vierlingh's work central in the early history of coastal engineering in the Netherlands implies that a certain style of engineering *practice*, rather than scientific *research*, was central. This style of practice is captured by Vierlingh's adage '*niet met fortsigheit maar met soetigheit*': not with force, but with sweetness. Or, in the translation of the Dutch coastal engineering papers: 'Don't fight the sea with brute force but with soft persuasion' (E.W. Bijker, 1996: 395). The author observes that this 'actually is still characteristic for the coastal defence policy in the Netherlands'.[6] He refers, for example, to the strategy of sand suppletion: the Dutch coast of sand dunes is to be maintained by joining hands with nature – engineers will supply extra sand at strategic locations along the coast, and the tidal sand transportation processes will deliver the sand at the required places and thus broaden and strengthen the beach and dunes. This was not an exclusively Dutch practice, though: such 'beach nourishment' projects were also carried out in the USA. And, as we shall see, modern Dutch coastal engineering did not hesitate to use brute force at times, such as when all tidal outlets of the rivers Maas and Rijn were closed off in the Deltaplan from 1953 to 1986.

Coastal Engineering and Natural Disasters

A common element in the American and Dutch coastal engineering histories is the central role played by natural disasters. I was surprised to find that these two histories are exceptional in that regard: none of the other 13 country studies in this memorial volume – from Australia to Denmark to Taiwan – pays as much attention to storm surges, floods and hurricanes as key elements in the development of the national coastal engineering practices. Several hurricanes are mentioned specifically as spurring concrete coastal engineering projects. The 8 September 1900 hurricane that killed about 6000 people in Galveston, TX, led to a major hurricane and storm surge protection project: the Galveston Grade-raising, Seawall and Revetment. The 21 September 1938 hurricane and Hurricane Carol of 31 August 1954 led to the decision to construct the New England Hurricane and Coastal Storm Surge Barriers. This system of five hurricane and storm surge barriers on the southern coast of New England (New Bedford-Fairhaven, MA; Fox Point, RI; New London, CT; Pawcatuck, CT; and Stamford, CT) was built in the mid-1960s and consists of a combination of dikes, walls, navigation gates, conduit gates, pumping stations and other appurtenant structures and equipment.

The Earthquake in the Aleutian Trench, Alaska, on 1 April 1946 generated a large tsunami that caused loss of life and much damage on Hawaii and along the coast of California, and led to the establishment of the Seismic Sea Wave Warning System, later extended into the International Tsunami Information Center. Evidently, disasters prominently figure in the thinking of American coastal engineers: 'It is important to collect information on natural disasters shortly after their occurrence, to document events and effects' (Wiegel & Saville, 1996: 550). They recognize the boost that disasters can give to public awareness and coastal engineering and research, which 'often is the case after a natural disaster occurs which affects adversely lives and property of many people' (Wiegel & Saville, 1996: 549). In contrast, once the disasters have passed into history, little effort is made to evaluate the functioning of coastal projects: 'Owing to the costs of monitoring, and the seemingly [sic!] lack of interest of politicians to have follow-up studies made of government funded projects, little monitoring is done' (Wiegel & Saville, 1996: 559).

Central in the papers on the history of Dutch coastal engineering, as much as in the general public's consciousness, is the 1953 storm surge disaster, generally known in the Netherlands as '*De Ramp*' – 'The Disaster'.[7] In the early morning of 1 February the dikes in Zeeland, at the southern end of the Dutch coast, broke: sea level reached the top of the dikes, waves started to nibble at the back slope of the dikes, which are not armoured by stones, undermining the structure of the dike from the rear, and eventually the sea pushed through. The seawater rushing into the polders several meters below sea level quickly scoured the breaches wide open. Analyses later showed that it had not been a particularly high spring tide, nor an exceptionally strong storm. Crucial for generating the disastrous effect were the long duration of the storm and a very particular and sudden change of its direction at the worst possible moment. This underlines the inevitably statistical nature of forecasting such phenomena. It took several days before the size of the disaster became clear to the rest of the Netherlands: communication channels had been broken, and there were no helicopters and only a few aircraft. In one week, 1835 people drowned, more than 750,000 inhabitants were affected and 400,000 acres of land were inundated. The effects have been traumatic – at the individual level, for the Netherlands as a country, and for the coastal engineering profession.

The last five decades of coastal engineering, as well as the general Dutch perception of and methods for dealing with the risks of flooding by storm surges, can only be understood by reference to *De Ramp*. It provided an enormous boost to both the research and the practice of coastal engineering. It also spurred a rather drastic reaction in the form of the *Deltaplan*, comprising the already mentioned closure of the tidal outlets of the rivers Maas and Rijn. This certainly was a more forceful strategy than Vierlingh's 'soft persuasion'. By the 1970s, however, other societal developments, related as much to increased environmental concerns as to a general decrease of respect for authorities, in the Netherlands had begun to challenge both the stature of the coastal engineers and the authority of the national agency *Rijkswaterstaat*, which was responsible for the *Deltaplan*. A national controversy developed about whether to close the last remaining open outlet *Oosterschelde*. The solution to that controversy was a storm surge barrier that remained open under normal circumstances, but could be closed by a series of sliding doors when a storm surge was forecasted. This not only seemed to restore Vierlingh's principle of *soetigheit*, but also constituted a 'sweet technology' in the sense of a very challenging, advanced and exciting piece of science and engineering. Once it was built, and the controversy left behind, the Dutch did not hesitate to advertise this structure as the 'eighth wonder of the world'.

Flood Hazard Mitigation or Keeping the Water Out?

I am now getting to the crux of the argument. Though the Dutch and American histories of coastal engineering stand out from the other histories by the central role that natural disasters played in shaping the coastal engineering practice, the way they did so is strikingly different. The American practice focuses on predicting disasters and mediating the effects once they have happened, in brief: on 'flood hazard mitigation'.[8] Dutch practice is primarily aimed at keeping the water out.

A long string of hurricanes in the 1950s in the USA gave rise to a major effort by both the USACE and the Weather Bureau to develop warning systems and protective measures. Several surge prediction models were developed, with differences resulting partly from different needs of the modellers: USACE for protection, Weather Service for warning, Federal Emergency Management Agency (FEMA) for insurance. The resulting 'present day warning systems, and evacuation programs, … have largely prevented loss of life despite increasingly higher density population of coastal areas' (Wiegel & Saville, 1996: 538). In the 1970s and 1980s coastal regulations were established by some states and by the federal government, of which the National Flood Insurance Program (NFIP) appears to form a centrepiece. The intent of NFIP is to:

> … reduce future damage and provide owners with protection from financial losses through an insurance mechanism that allows a premium to be paid by those most in need of this protection. This program is based on

> the agreement that if a community will practice sound floodplain management, the Federal Government will make flood insurance available. (Wiegel & Saville, 1996: 555)

The key phrase in the USA is 'flood hazard mitigation', and the key ideas in this discourse are 'prediction' and 'insurance', which suggest that the very fact of flooding is accepted. The risk criterion that is used in designing levees and other coastal defence structures in the USA is a 1:100 chance, or a 'hundred year flood'.[9] This criterion is a technical norm, carrying important professional 'weight' among coastal engineers, but it carries no legal authority.

How different is the practice in the Netherlands. I can still remember my father pleading, when looking back to *De Ramp*: 'whatever – that never again!' Those words by the first professor of coastal engineering in the Netherlands effectively and emotionally capture the *credo* of Dutch engineers since the 1950s. The water should be kept out. In the *Deltaplan* law, the criterion of 1:10,000 was specified: not merely as a technical norm, but as an obligation embedded in the 'Delta Law', unanimously approved by parliament. The 1:10,000 criterion specifies that levees in central Holland have to be designed 'for a surge level and wave condition occurring with a 1:10,000 probability'. Under these conditions, the defence system should not fail. The lessons from *De Ramp*, however, showed that it is not enough to reckon with only a chance of high waves; one needs to be prepared for different combinations of circumstances. Therefore, Bijker continues,

> … the scientifically right method is to calculate the failure probability under a range of combinations of surge level, wave condition and foreshore condition.

The failure probability calculated by this method:

> should have an acceptably low level. Roughly this probability is a factor 10 lower than the before mentioned probability of the design level of the storm surge. This results for central Holland in a 1:100,000 probability for failure of the defence system. (E.W. Bijker, 1996: 406)

For less populated areas, the legal 'Delta level' is 1:4000, resulting in a failure probability level of 1:40,000.

Coastal Engineering and Different Technological Cultures?

To conclude this comparison between American and Dutch coastal engineering, I want to stress that my analysis is about differences in *style* of coastal engineering, not about differences in *quality*. The one is not better than the other, but they are quite different – possibly more different than the coastal engineers themselves realize. Thus, both engineering communities can and should continue to learn from each other, as they have been doing ever since the International Coastal Engineering Conferences started in the 1950s. For example, after Katrina and the flooding of New Orleans, an evaluation of Dutch evacuation plans showed that they were insufficient. The Netherlands seemed insufficiently prepared for a real emergency, such as when the water cannot be kept out. The Dutch can learn some flood hazard mitigation from the Americans.

One intriguing question remains. Is it possible to understand the sources of the observed differences? And, even when we understand some of the historical roots, why have the practices of coastal engineering not converged more? Certainly, the problem is not from a lack of communication and sharing in the international professional community during more than 50 years of ICEC meetings. I can only offer a tentative, if not speculative, response to these questions.

My suggestion is that the differences between American and Dutch coastal engineering styles are related to the differences between American and Dutch societies, or rather technological cultures.[10] It would be a standard STS point to stress that the development of a national style of coastal engineering is related to the national society and culture.[11] What then are relevant characteristics of American and Dutch technological cultures? A few differences pertain more to what could be called the respective 'geographical bases' than to the cultures themselves: The Netherlands just is a more watery country than the USA, with more sea coast and more river borders per square mile, more 'man-made mounds, just above the highest water level known by experience', to quote Plinius again. The Netherlands just does not have any mountains, or deserts or 'great plains'. A striking difference in political culture is the role of the state. Mukerji (2006) characterizes US political culture as neo-liberal, without belief in the common good as something that the government should define and protect; there is an inclination to privatize and individualize public functions, rather than to defend their value. Although recently such neo-liberal tendencies have been emerging in the Netherlands too, the political culture is quite different, with a much more accepted central role for the national state in all sectors of society: from healthcare to infrastructure, from education to cultural politics, from economics to coastal defence.

An intriguing question remains whether this difference in technological culture also shows itself at the level of the general public's technical literacy in matters of hydraulics and coastal engineering. Measures to secure lower probabilities of flooding, including high taxes and imposing infrastructures, may be more acceptable when citizens better understand the risks and the technical means of coastal engineering defense.[12] My intuitive answer is that, indeed, the Dutch public generally understands more of basic coastal engineering. I base this intuition on the active role that citizens, both as action groups and as unorganized individuals, play in public debates, hearings, or on the discussion pages of national newspapers. It seems that the US public (and its political representatives) is willing to spend massively on 'defence' against foreign powers and anarchic terrorists, rather than on systems designed to defend against natural hazards. So, it may be a matter of the historical salience of one kind of 'threat' or 'risk' than another, and of the campaigns that have effectively raised or lowered the salience of competing risks, that have produced this difference between the two technological cultures.[13]

What then are the implications of my analysis for the case of New Orleans? What are the implications for the restoration and building up of New Orleans? I want to suggest that it is, in principle, possible to start using a different concept of flood defence: keeping the water out, rather than mitigating its hazards. But my analysis also shows that this is not merely a matter of using different engineering concepts. (Coastal) engineering styles do not develop in isolation from the technological cultures in which they are embedded. Changing a water management style thus also calls for changing the relevant political culture, and it calls for a much more active engagement of civil society.

Notes

1. I will be using 'dike' and levee' as interchangeable. Both refer to elevated structures (mostly human-made, but sometimes natural) of sand, clay, and/or stone; positioned along river or sea sides, or around polders. Levee probably derives from the French *levee*, or raised (*Chambers 20th Century Dictionary*). Dike (or dyke, dik) is similar to the Dutch *dijk*, which is thought to derive from the Latin *figere*, cut and then connect; it thus seems related to 'digging in'.
2. Eco W. Bijker is my father. Only during the research for this paper did I discover that he received the International Coastal Engineering Award of the ASCE.
3. The parentheses are in the original.
4. See also (Wetmore, 2006) and (Mukerji, 2006).
5. For a more comprehensive account of the early history of water boards, see Kaijser (2002).
6. Vierlingh's adage is also quoted by authors such as the novelist and *chroniqueur* A. den Doolaard (Doolaard, 1948; Doolaard & Mussey, 1948), who provided one of the most engaging and accurate accounts of Dutch coastal engineering practice; and by the chief engineer of Rijkswaterstaat and Deltaplan director Ferguson (Ferguson, 1991).
7. For a more detailed account of the role of this disaster in the development of Dutch coastal defence and its relation to Dutch democracy, see W.E. Bijker (2002).
9. See also Wetmore (2006).
10. The common phrase 'hundred year flood' is deceptive if understood to mean that such a flood will only occur once every 100 years. The problem of misunderstanding probabilistic reasoning in this way by the general public certainly exists as much in the Netherlands as in the USA.
11. For an introduction to my use of the concept of 'technological culture', particularly in relation to risk and vulnerability, see W.E. Bijker (2006).
12. See, for example, Thomas Hughes' (1983) classic study of different styles of electrical engineering and electricity distribution networks.
13. Thanks to Harry Collins for raising this issue in the panel on Katrina, 4S annual meeting in Pasadena, CA, 2005.
14. Thanks to Mike Lynch for making this observation.

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