12th Annual Conference of the European Business History Association, Bergen, 21-23 August, 2008

Offshore connections: Flows of information and flows of oil on the Norwegian continental shelf, 1971 – 2005

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Abstract

The production of petroleum on the Norwegian continental shelf began in 1971 and expanded rapidly to cover 52 fields and numerous installations and production facilities today. Early on, these installations were connected to the shore as well as to each other through a number of communication infrastructures, facilitating information flows related to production, staffing and security. This paper explores these flows from the early period of exploration in the late 1960s and up until the near present. It highlights how various organisations and regulatory regimes shaped these infrastructures. Three communication technologies provided the backbone for the information flows on the Norwegian continental shelf; Radio, satellites and fiber optics. Historically, the primacy of each technology varied over time, just as their modes of governance. Firm decisions on integration or disintegration of infrastructural services and ownership has shaped this, just as different regulatory approaches. In this paper, I argue that each of these technologies were shaped by a set of different relations between network operators, production companies and governing agencies of national and international character. Consequently, the connections offshore are seen as shaped by a set of onshore relations. Subsequently, these offshore connections would alter the ties between telecommunication network operators and oil operating companies to such a degree that the oil producing companies would become telecommunication operators in their own right in the early 2000s.

Introduction

In June 1966, the American rig Ocean Traveler started drilling for oil on the Norwegian continental shelf. Three years later, the first large discovery was proven at The Ekofisk field. Ekofisk became the first developed field on the Norwegian continental shelf, initiating

Norway's oil economy as well as drawing large, multinational petroleum companies such as Phillips Petroleum, Mobil and ELF to the area.[1]

While production of oil on Ekofisk began modestly from a floating rig in the summer of 1971, permanent installations and an oil pipeline to Teesside in England were in place four years later. Throughout the 1970s, fixed production was established on several fields in the North Sea, creating a large technological system made up of huge, integrated gravity platforms made of concrete. Its oil was loaded in tankers on the field until the Norpipe oil line to the UK was completed in 1975, creating another large technological system of pipelines facilitating transportation of oil and natural gas to the shore, subsequently also to Norway and Germany.

In parallel to the enlargement of both the production and distribution systems, various communication systems were developed, functioning as pipes for information and communication. Some tied the fixed installations to the shore; others linked installations to each other. Together, they made up a set of large telecommunication networks, some privately operated, some ran in cooperation with the Norwegian Telecommunication Administration (NTA, now Telenor), a state-owned telephone monopoly typical of the era.[2]

Conventional telecommunication technology would often prove inadequate in the hostile conditions of the North Sea. Furthermore, the geographical position of the wells, beyond the optical horizon from the shore, made technology that relied on line of sight useless. Consequently, the environment as well as the particular needs of the oil companies would often be a driving force behind the introduction of new communication technologies, such as satellite technology and fiber optical networks. These processes of technological change are this paper's point of departure.

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[1] For a thorough examination on the early period of the Norwegian oil economy, see Tore Jørgen Hanisch and Gunnar Nerheim, *Fra Vantro Til Overmot?* (1992), Gunnar Nerheim and Frida Dahlberg, *En Gassnasjon Blir Til* (1996). For a summery, see the introductory chapters in Ole Andreas Engen, "Rhetoric and Realities: The Norsok Programme and Technical and Organisational Change in the Norwegian Petroleum Industrial Complex" (RF - Rogaland Research, 2002) and Ole Andreas H. Engen, "The Development of the Norwegian Petroleum Innovation System: A Historical Overview," in *Working papers on Innovation Studies* (Oslo: Center for technology, Innovation and Culture, University of Oslo, 2007).

[2] I have previously presented the history of these infrastructures in Norwegian; see Gard Paulsen, *Informasjon over Nordsjøen: Telekommunikasjoner På Norsk Sokkel* (Sandvika: Handelshøyskolen BI, Institutt for innovasjon og økonomiskorganisering, Senter for næringslivshistorie, 2005). This was elaborated in a general account of the history of telecommunications in Norway. See Lars Thue, *Nye Forbindelser: 1970-2005* (Oslo: Gyldendal, 2006).

In many ways, this particular environment of deep sea, hostile conditions and large, integrated platforms, was a miniature of the radical changes in both technology and governance in telecommunications during its first 35 years of operation: Fundamental technological change, deregulation and the shifting nature of demand were all determinants that were important in deep waters of the North Sea, just as in telecommunications in general. This paper highlights how these general trends were constituted in a set of onshore relations between network operators, telecommunication administrators, oil companies as well as international organisations, and how these relations shaped the communication backbone of the emerging petroleum industry. I also investigate how offshore connections subsequently would shape the relations onshore. For reasons of clarity, I have chosen not to consider relationships between the telecommunication manufacturing industry, even though interesting relationships between oil companies and suppliers of telecommunication equipment were forged and, indeed, important.[3]

The focus on relations might seem a bit at odds with the sources applied, first and foremost because of a considerable asymmetry: It is based on the archives from the NTA. It also lacks of primary sources to investigate the more current events. I have tried to rectify this by a number of interviews of actors from both the NTA as well as the involved oil companies, some in person, others by telephone. Some of the interviewed actors also supplied a number of comments by mail and e-mail, correspondence that has been important to the empirical foundation of this paper. All of the interviewed has read the Norwegian report, and approved the use of citations and references to them. I have also relied on a number of secondary sources, such as trade journals, newspaper and research reports.

This paper proceeds in five short parts. First, I relate my empirical study some more general questions related to of technological change in infrastructures. Second, I identify the organising principles and decisions that led the oil companies to use traditional maritime radiotelephony and coastal radio in the early period of exploration and production of oil. Third, I investigate the extensive use of satellite technology from around the mid 1970s. I point out the main drivers behind this change and some important events that reinforced the

[3] Innovation studies, and in particular research following the innovation systems approach, has emphasised user-producer relationships as an important part of the transformation of telecommunications. See B. A. Lundvall, "Innovation as an Interactive Process: From User-Producer Interaction to National Innovation Systems," in *Technical Change and Economic Theory*, ed. G. Dosi, et al. (London: Pinter, 1988).

relationships between the NTA and the oil companies. Fourth, I discuss how the relationship between the NTA and the oil companies substantially changed when fiber technology became a feasible solution to the gradually more extensive technological demands from the mid 1990s. In my conclusion, I point to possible links between technological choices and governance models and assess the impact of the three technological systems to the operations on the Norwegian continental shelf.

Telecommunications and technological change

In essence, this paper examines choices about technology. While these choices were played out in hostile conditions, they were also part of a more general transformation of telecommunications, both organisationally and technologically. Among other things, this involved the demise of national champion manufacturers and the liquidation of monopolistic regimes. This change has in general been understood as a radical transformation induced by digital technology, and as intertwined with a general political will to liberalise the state-owned monopolies dominating telecommunications.[4] Another dynamic in this broad transformation involved the changing roles of users of telecommunications, and especially large user organisations creating integrated networks bypassing the public networks dominated by state-owned monopolies.[5]

The evolutionary economist Christiano Antonelli has pointed out some characteristics of this process: ”The new cluster of technological change introduced in the telecommunications service industry from the late 1960s and until the mid 1980s had […] all the characteristics of a localized process of innovation led by large, advanced users.”[6] Furthermore, Antonelli has pointed out that during the 1970s, an innovation system dominated by interactions between network operators and manufacturing firms was challenged by a triangulated system where large users increasingly focused and directed innovations together with and in some cases, in opposition to, operators and producers.[7] Within Antonelli’s framework of localized technological change, the distinction between innovation and diffusion is blurred, and

[4] One sufficiently broad account of this is presented in Martin Fransman, *Telecoms in the Internet Age: From Boom to Bust To...?* (Oxford: Oxford University Press, 2002).
[5] Eli Noam, "The Tragedy of the Common Netwrok: Theory for the Formation and Breakdown of Public Telecommunication," in *Private Networks, Public Objectives*, ed. Eli M. Noam and Aine Nishuilleabhain (Amsterdam: Elsevier, 1996).
[6] Cristiano Antonelli, *The Microdynamics of Technological Change*, Routledge Frontiers of Political Economy (London ; New York: Routledge, 1999), 141 - 42.
[7] Ibid., 133 – 42.

consequently, the adoption of new technologies by users of telecommunication services could be viewed as a complementary component of a broader process of innovation.

The sudden demand for telecommunication services on the Norwegian continental shelf provides an ample opportunity to point out some salient features of such a process. The oil companies that first started drilling in the North Sea was certainly large users, such as the American companies Phillips and Mobil, and French ELF. Furthermore, their counterpart, the NTA was in many ways a traditional telecommunication monopoly that could be expected to be in opposition to the demand of large users, while lacking a manufacturer of national champion proportions.[8]

However, the conventional wisdom on the history of satellite communications has typically been a history not concerned with localized technological change and user organisations. More conventionally, research has pointed out the role of government funded research and development, international cooperation and additionally the innovativeness of American manufacturers of satellite technology. All in all, it had all the characteristics of technology push.[9] Similar, but often more nuanced arguments could be easily found within the history of fiber optical technology.[10] However, when looking closely at technological choices at the local level and in particular in periods where different technologies exhibited considerable degrees of fungibility, the changing role of large users becomes more apparent.

In the following, technological choices are considered intertwined with organisational ones. The localized technological change embodied in the evolution of the communication infrastructures can be analysed within a framework that has emerged in the intertwined literature concerned with the transactional and capability considerations in the micro-analysis of firm decisions.[11] At this intersection, transaction costs and capabilities are analysed as

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[8] On the history of telecommunications in Norway, see Thue, *Nye Forbindelser: 1970-2005*.. On the structure of the Norwegian telecommunication industry, see Sverre A. Christensen, "Switching Relations: The Rise and Fall of the Norwegian Telecom Industry" (BI Norwegian School of Management, 2006).

[9] A short historiographical overview is found in David J. Whalen, *The Origins of Satellite Communications, 1945-1965*, Smithsonian History of Aviation and Spaceflight Series (Washington, D.C.: Smithsonian Institution Press, 2002).

[10] A journalistic account is Jeff Hecht, *City of Light : The Story of Fiber Optics*, Rev. and expanded ed., The Sloan Technology Series (Oxford ; New York: Oxford University Press, 2004)..

[11] While often considered separate strands of research, their co-evolution is sought out in Michael G. Jacobides and Sidney Winter, "The Co-Evolution of Capabilities and Transaction Costs: Explaining the Institutional Structure of Production," *Strategic Management Journal* 26 (2005).

fundamentally intertwined in the determination of vertical scope of the firm, such as whether or not oil companies should or could integrate or outsource the operations of infrastructures. Jacobides and Winter has argued that radical technological change often leads to a period of vertical reintegration, often rendering prevailing transacting practices obsolete.[12] As such, one would expect that radical technological change would lead the oil companies to integrate communication systems, and more incremental ones would make disintegration and transactions possible. Indeed, the technological changes that occurred in the communication systems applied offshore oscillated between incremental and radical, just as the dominating governance models oscillated between integration and disintegration. However, this latter oscillation was more often than not determined by a larger regulatory regime rather than firm decisions. To understand these changes, one has to analyse the changes in governance as shaped by a larger set of determinants than those proposed in the co-evolutionary framework of Jacobides and Winter.[13] One such approach is found within the socio-technical literature on large technical systems (LTS), which at least in passing has related their studies of infrastructures to organisational set-ups and governance.[14] Where both transaction costs and capabilities are frameworks concerned with decisions at the firm level, the LTS approach is one which explicitly are concerned with infrastructures. In the following, I highlight how the changing relations between offshore and onshore organisations and technologies necessitate an understanding of decisions both at the firm level and at the infrastructural level, an understanding that are strengthened by an eclectic approach.

The following limited study of communication networks and the emerging Norwegian petroleum industry has both theoretical and empirical relevance to numerous fields and research traditions. However, this is primarily an historical study which put emphasis on a set of different factors and determinants, rather than one limited to one theoretical framework. I will proceed with what primarily is a narrative history of the development of technology, regulatory regimes and the involved parties and an analysis of that history.

Radio to the shore

From the mid 1960s, a growing amount of exploration drilling and seismic trials was conducted on the Norwegian continental shelf, involving jackup drilling platforms and ships.

[12] Ibid.: 409.
[13] Ibid.
[14] Contributions to the large technological systems literature that explicitly adopt the governance term are found in Olivier Coutard, *The Governance of Large Technical Systems* (London: Routledge, 1999).

Naturally, this involved the employment of marine communication technologies, such as marine VHF radio and mobile radio telephony. However, as the activity increased, both oil companies and the NTA understood that these systems would not meet future needs, even though the future of the Norwegian petroleum industry was still up in the air. Nevertheless, NTA started searching for new solutions during the summer 1965, but private, licensed channels and public radiotelephony would have to suffice in the initial exploration phase and up until the mid 1970s.[15]

The oil companies were forced to comply with a regulatory regime designed for the shipping industry, something that also continued when fixed production facilities started operating from the early 1970s. Among other things, this involved a strict demand for radio operators on every installation, even on installations within easy reach of each other. All installations were required to staff their radio facilities 24 hours a day, so they could monitor the international calling and distress frequency. Initially, this was perceived as too strict and too demanding by the oil companies.[16]

Adjustments made to the agreements between the NTA and the oil companies would gradually loosen up the demands on radio operators and equipment, such as radio installations on lifeboats. Simultaneously, the oil companies started arguing that a substantial improvement to the communication infrastructures was needed. One important part of the argument was the envisioned way of production, which involved a considerable degree of remote coordination and supervision. One example is found in a letter from Phillips Petroleum to the NTA sent in 1972:

> A high degree of automation remote control and monitoring will be required. This will necessitate substantial channel capacity for data transmission, supervisory control functions, facsimile, status reporting and voice communication as well as communication status, alarm signalling and service channel.[17]

[15] The following is based on documents found in the archival holdings of the Norwgian Telecommunication Administration (Teledirektoratet), now deposited to the national Archives (Riksarkivet) in Norway. In the following, I denote Teledirektoratet as TD and Riksarkivet as RA. The references to particular archival documents follow the references used by the NTA and are abbreviated in Norwegian.
[16] Thor Aresvik, former head of telecommunications in Phillips Petroleum Norway, correspondence with author, 5th January 2005.
[17] J. F. Walker, Radio Equipment Supervisor, Phillips Petroleum – P. Mortensen, Radio Department, NTA, 30th October 1972, Dcm 0311, A, TD, RA.

This was practically impossible to achieve with regular marine VHF radio or radiotelephony. Therefore, the oil companies planned on using troposcatter to reach the shore with dedicated, private lines. By scattering radio signals into the troposphere, these radio transmitters could reach beyond the optical horizon, and had a large capacity. However, the NTA was reluctant to employ troposcatters, on regulatory and technological reasons:

> Use of troscatterlinks are related to numerous problems, as it uses a large proportion of the available spectrum, it involves a high degree of health risks to be in the proximity to the transmitter and above all, two relatively large parabolic antennas has to be mounted on the platforms, which will involve a lot of problems on the platforms.[18]

At the same time, the NTA argued that troposcatter links would breach the existing regulatory framework:

> According to Norwegian law there is a monopoly situation where Televerket (NTA) can issue a license according to certain rules for a limited, single private communication system, - but not for a private carrier where several users are involved. This means that a troposcatter system from mainland out to one platform with a distribution via line of sight (or tropo) links for several users, would have to be established, owned and operated by NTA.[19]

What was the alternative? In one letter from Phillips Petroleum to the NTA, the most likely candidate, satellite communications, was dismissed. It stated the following: "It is highly unlikely that the present satellite capabilities would be consistent with out pipeline communication needs."[20] In part, the Phillips' representatives were right. At that moment, Norwegian satellite capacity for domestic use did not exist, and the international satellite capacity was restricted to international traffic. Consequently, and for the time being, the NTA reluctantly accepted the troposcatter alternative, but insisted that the link would have to be owned and operated by the NTA. During 1973 and 1974 the NTA called for tenders for the troposcatter link equipment.[21] Nevertheless, actors within the NTA continued to argue against the use of troposcatters. Their alternative was still satellites. Would it be possible to draw support to this, when the oil companies were sceptical and no domestic alternative existed?

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[18] Note, 13th May 1974, TR/74/637,57/JVE, Samband til Svalbard og oljeindustrien i Nordsjøen, Dib 0735, Teknisk avdeling (T), TD, RA. [My translations]
[19] Ibid.
[20] Letter from J. F. Walker, 30th October 1972 to P. Mortensen, Radio Departement, NTA. Dcm 0311, A, TD, RA.
[21] Note from Administrasjonsdirektøren – merknad til notat av 8. mars 1974 – TRS/74/Trn – vedrørende oljevirksomheten i Nordsjøen – anskaffelse av troposcatterutstyr for permanente sambad til Ekofisk- og Frigg-feltet, Dcm 311, A, TD, RA.

Satellites in orbit

To pave way for the satellite alternative, both international relations and internal resources within the NTA had to be mobilised. First and foremost, the NTA had to align their preferences with the internationalised and institutionalised satellite communications cooperation that emerged during the 1960s and 1970s.[22] As the US Congress decided to create "its own 'chosen instrument" to develop the global communications satellite system and funded the establishment of Comsat in 1962, an international system for satellite communications were put into existence in the first half of the 1960s under the name Intelsat.[23] Partly as an extension of the U.S. government-sponsored organisation Comsat, and partly built as an reaction to the Comsat by the European PTT administrations, Intelsat was formed in 1964 to own and operate the global satellite system.[24] This system provided satellite capacity suitable to the oil companies, but Intelsat would initially not approve the use of their satellites to meet domestic needs, as the system was restricted to international traffic. As long as the Norwegian continental shelf was considered a part of the domestic telecommunication system, Intelsat's policy would be difficult to bypass.

Another prerequisite for paving the way for satellite communications to offshore installations was strictly local: The NTA needed employees with knowledge about the technology. The NTA hired John Ragnar Veastad in 1962, the first engineer with responsibilities related to satellite technology in the NTA. During the 1970s, John Ragnar Veastad became an important spokesperson for all things satellite within the NTA, as well as one who could actively lobby for a change in Intelsat's policy towards domestic traffic by actively participating in the international organisation.[25] During the early 1970s, it became clear that other members of Intelsat were interested in a similar policy change: USA wanted to use Intelsat's satellites to reach Hawaii and Alger wanted to reach their southern oases by utilising the international satellite system – both examples of what basically was domestic use. The Norwegian representatives would take advantage of this.

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[22] A historiography as well as an interpretation of the history of satellite communications is provided in Whalen, *The Origins of Satellite Communications, 1945-1965*..

[23] Ibid., 17.

[24] Ibid., 155. To fairly contemporary expositions on Intelsat are Michael E. Kinsley, *Outer Space and Inner Sanctums : Government, Business, and Satellite Communication* (New York: Wiley, 1976), Judith Tegger Kildow, *Intelsat: Policy-Maker's Dilemma* (Lexington, Mass.,: Lexington Books, 1973).

[25] For travel reports minutes of the Intelsat meetings, see the following archival series: AFU ISCS 1965 – 1968, Dcp 0336, Utenlandsk seksjon (AFU), A, TD, RA; ICSC – møter, 1965 – 1967, Dm 0790, T, TD, Ra; ISCS-møter, 1963 – 1973, Dm 0791, T, TD, RA.

However, it was not the question of getting modern communication technology to the concrete platforms in the North Sea that would prove decisive. Early on, John Ragnar Veastad had established an informal contact with Joachim Kaiser, an American researcher at Comsat Labs, the American part of the Intelsat organisation. Kaiser became increasingly interested in another communication problem that was particular to Norway's geography: How to reach the archipelago of Svalbard, Norway's northernmost outpost halfway between Norway's mainland and the North Pole. To a satellite engineer, Svalbard posed a particular technical challenge, as its geographical position between 74 and 81 degrees north was thought of as unreachable because it would involve a very low elevation angle for the transmitting parabolic aerial.[26] To the population on Svalbard, the interest in satellites was, on the other hand, primarily related to their need for communications to the mainland. By aligning technical interest with Intelsat's dominating party, Comsat, with that of policy change, NTA hoped they could solve two problems: The "Svalbard problem" as well as the possibility to use satellite communications to reach the concrete platforms that was beginning to pop up in the North Sea.

In 1972, Comsat agreed to assist the NTA in assessing the probability of using satellite communications in an arctic environment. Joachim Kaiser and Dave Reiser joined a team of researchers and engineers from the NTA during the summer months of 1974 at Svalbard to research the possibility of transmitting and receiving satellite signals in such conditions. The results, and their initial scepticism, were reported in the internal Comsat publication Comsat News in the following manner:

> The very low elevation angle of a little over one degree, together with our 'ocean view', produced severe fades – a phenomenon we had to come to study and measure. However, with a little extra margin from our equipment, we established a good quality channel for telephone and Xerox telecopier facsimile.[27]

[26] Within the NTA, research on the possibility to utilize satellite communications in Svalbard had been going on since the late 1960s. NTA's research establishment, Norwegian Telecommunication Research (NTR), was among the skeptics. Indications on this is found in internal research reports, published in Norwegian. See Odd Gutteberg and Håkon Nymoen "Fjernsynsoverføring til Svalbard via geostasjonær satellitt: En vurdering av systemparametre", Intern rapport, IN 18/69, 8. mai 1969, TF; See also Odd Gutterberg, "Fjernsyn- og eller telefonoverføring til Svalbard via Intelsat IV", TF-rapport nr. 41, 1971.

[27] Joachim Kaiser, "A measurement experiment in the land of the midnight sun", *Comsat News*, november-desember 1974, p. 2-3.

The experiments were successful.[28] The trials in Svalbard proved it possible to use a very low elevation angle to send and receive traffic, and consequently made satellite communication a viable solution to the communication problems for the Svalbard islands. Within the NTA, this increased the viability of offering a solution based on satellite communication to the oil companies in the North Sea, partly because it could influence Intelsat on changing their policy, but more importantly because it could provide a solid financial argument for purchasing satellite capacity.[29] As such, Svalbard and the concrete platforms of the oil companies were intimately bundled together.

Negotiations regarding a change in Intelsat policy were advanced on a broad front already prior to Kaiser's experiments at Svalbard. The Algerian representatives fronted this within Intelsat, arguing for the possibility of using Intelsats capacity to transmit telecommunication to their southern oases. The economist Marcellus Snow quotes sources in the Intelsat-system regarding this change:

> The Finance Subcommittee, considering the Algerian request, stated that "most" of its representatives 'agreed it would be in the interest of INTELSAT to establish […] a new type of space segment utilisation for domestic services, using spare capacity at a reduced charge. It seemed reasonable […] to expect that by this means traffic could be attracted to, or retained by, the INTELSAT system on a scale which would improve the financial position of INTELSAT as a whole and effect a reduction in the space segment cost for each user in the whole system.[30]

By pointing out the existence of surplus capacity, as well as strengthening the financial position of Intelsat, both Algerian and Norwegian representatives were able to create a new type of space segment, namely one intended for domestic services in 1973 and 1974.[31] However, in the Norwegian case, NTA had to strike a delicate balance: Since the oil companies' concrete platforms were not formally part of Norway's territory, Norwegian representatives had to push the Svalbard-argument within Intelsat. When dealing with government relations in Norway, the opposite would be the case: Funding for ground stations were sought as a part of facilitating the emerging oil economy. Nevertheless, it became

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[28] A technical report is found in "Measurements of tropospheric fading and crosspolarisation in the arctic using orbital test satellite", TF-rapport nr. 9, 1981, presented at the Second International Conference on Antennas and Propagation, York, England, 13th - 16th April 1981.
[29] Veastad and Håkonsen, Kommunikasjon til oljeplattformer i Nordsjøen og til Svalbard, April 8th 1974. Dib – 0736, T, TF, RA.
[30] BG/F-2-3. 1st October 1973, paragraph 35, p. 15. Here quoted from Marcellus S. Snow, *International Commercial Satellite Communications : Economic and Political Issues of the First Decade of Intelsat* (New York: Praeger, 1976), 67.
[31] The Norwegian part of the agreement is found in TR 655.2 Intelsatavtalen, Dh 0673, Divisjon for radio, T, TD, RA.

increasingly obvious that the Norwegian government would not fund such an endeavour as other infrastructural undertakings were considered more important.[32]

Consequently, the NTA turned to the oil companies to get funding. Not only would the oil companies have to purchase the equipment needed on their own installations, they would also provide substantial funding for the earth station on the shore, which would be owned and ran by the NTA, as well as provide a point of entry to Svalbard. While this proved to be a point where the […] initially would disagree, an agreement between the oil companies Phillips Petroleum, ELF and Mobile on the one hand side and NTA on the other were signed in the summer of 1974, creating the Norsat system.[33] One of the arguments that would convince the oil companies was financial: Intelsat-ready small earth stations would amount to approximately the same as a troposcatter terminal, according to NTA's experts.[34]

According to the agreement, the earth station would become a property of the NTA, while the oil companies got a license to set up and operate terminals on their own installations. The agreement also opened for licenses to operate and establish local radio relays on the various platforms. This latter part paved the way for a "private" telecommunication network *between* the installations offshore, mainly consisting of microwave- and troposcatterlinks owned and operated by Phillips Petroleum.[35]

In turn, this rested on an increased use of the offshore communication system. Just six years after being put into operation, Phillips Petroleum operated a network that consisted of more than 1000 telephones and 13 local switches, a considerable private network at that time. One contemporary observer stated that these systems constituted an essential part of the production systems and that a blackout would immobilise the activity on the platforms immediately, mainly because of a steady development of telemetry systems that depended on data communication networks.[36]

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[32] John Ragnar Veastad, interview with author, 10th September 2004.
[33] John ragnar Veastad, "The Norwegian Domestic Communication Satellite System," *Telektronikk*, no. 1 (1978).
[34] Hans M. Fjøsne, "Bruk av Intelsat IV for kommunikasjon til Nordsjøen og Svalbard", TF-notat 10/4 1974.
[35] Øyvind Roth, interview with author, 5th October 2004 and Thor Aresvik, interview with author, 21st October 2004.
[36] Øyvind Roth, "Telekommunikasjoner i Nordsjøen", *Telektronikk*, nr. 3/4, 1982, p. 238 – 243. Another similar and contemporary observation is found in Thor Aresvik, "Datamaskinene vet alt!", *Ekofisk*, nr. 1, 1984, p. 8-9.

Kommer…[37] More importantly, administration systems was slowly moved offshore…

Summing up, the constellation of changing relations between the NTA and Intelsat proved decisive when novel technology like satellite communications was introduced to the petroleum industry in the mid 1970s.[38] Initially, the oil companies argued for troposcatters, but would later on prove an important financial backing for satellite alternative. The setup of a NTA-ran earth station, and the privately operated networks offshore, would both prove important when a considerable redesign of the organisational and technological setup were started in the early 1990s.

Fiber-optical networks on and under the seabed

The petroleum industry operating at the Norwegian continental shelves during the 1970s was largely foreign controlled. However, during the 1980s, this was slowly transformed into a system also consisting of Norwegian oil companies, as well as a large domestic based supplier industry. Among other things, this involved the emergence of the state owned oil company Statoil and a concession system that would gradually strengthen Statoil to totally dominate the development on the Norwegian continental shelves in the late 1980s. One obvious example was the development of the large oil field Gullfaks, where production started in 1986. Located in the northern part of the North Sea, Gulfaks epitomes what has been described as a Norwegianisation of production and technology, often illustrated by the large, integrated Condeep (concrete deep water structure) platforms. It has also been described as […] "a purely political project in which considerations of employment onshore dominated concerns about technical and economic factors offshore."[39] Arguably, Gullfaks (and in particular the C part of the field) revealed a strong connection between public officials and operators, as well as between operators and local and national industry. However, the onshore relations between Statoil and the NTA would be altered in quite a different manner at Gullfaks.

Because of its geographical position, north west of Bergen, the use of a radio relay link was possible. Initially deployed as a backup to the Norsat-system, the radio relay link were put into operation under license from the NTA. However, it proved the first step towards a breakdown in a constellation mainly dictated by the NTA; Statoil gained competence in new

[37] Øyvind Roth, "Satelitter og plattformer", *Elektro*, nr. 4, 1983, p. 20 – 27.
[38] Another take on this is found in John Peter Collett and Arne Gundersen, *Making Sense of Space: The History of Norwegian Space Activities* (Oslo: Scandinavian University Press, 1995).
[39] Engen, "The Development of the Norwegian Petroleum Innovation System: A Historical Overview," 23.

technology linking the shore to their installations rapidly, a competence the company would use to gain control over their own communication system.

Among the reasons for the use of radio relay links was, according to one Statoil-employee, that there were substantial problems with the reliability of the Norsat ground station.[40] Another reason was a growing interest in utilising data in centralised operation centres, which would be a contrast to the migration of administrative systems offshore, which had taken place since the early 1980s: Remote censoring and supervisory control over production were gradually more important to the oil companies. At first, this made it possible to utilise technology to operate not-manned platforms from adjacent facilities, but later on, this dynamic would move parts of the manned operations onshore. Since satellite connections had too much latency to transmit anything close to real time data, which is a prerequisite for more advanced remote operations, more efficient communication technology was sought out. This was apparent when new radio relay links were deployed on new fields such as Gullfaks. However, it was another technology that became important to pave the way for more integrated operations: Fiber optic communications.[41] This first became apparent when used between installations offshore, among the first fields utilising this was the Statoil-operated Gullfaks field mentioned above. While drastically increasing bandwidth, fiber optic technology also reduced the latency introduced by satellite technology.

While the radio relay links were licensed under the same type of agreement as the Norsat satellite system, the emergence of optical fibres would radically alter the constellation of cooperating oil companies and a pragmatic NTA. The gradual deregulation of Norwegian telecommunication regulations opened up for other interested parties to operate public networks, but also because the competence of the oil companies made it possible to them to integrate long distance communication as part of their running operations.

Basically, the partly privatised PTT, now named Telenor, lost its position as the preferred provider of communication services to the oil companies from the mid 1990s. In 2001, two searchers engaged by Telenor explained it in the following manner: “In parts of the industry,

[40] Gaute Hadland, correspondance with author, january 6th, 2005.
[41] On a brief introduction to the competition between satellite and fiber optical technology, see Barney Warf, "International Competition between Satellite and Fiber Optic Carriers: A Geographic Perspective," *The Professional Geographer* 58, no. 1 (2006).

Telenor has been perceived as arrogant, prone to risk aversion and less than willing to listen to the customer's demand for new solutions."[42] This was particularly the case when dealing with fiber optical networks, which was fully dominated by new entrants and not the incumbent in the later part of the 1990s. Was it only down to arrogance?

It is possible to discern two different paths leading up to fiber becoming the preferred technology linking on- and offshore installations, two paths with different organisational and geographical origins, but that eventually would be tied together: The first originated within Statoil, and was both an extension of the use of fiber between Statoil-operated platforms, such as on the Gullfaks field, as well as the lying of the first subsea fiber cable from the shore to an offshore installations named Troll A. The second originated further south, at Ekofisk, and involved a new constellation of entrants to the newly liberalised telecommunication market as well as the operating oil companies Amoco, BP and Phillips Petroleum.[43] While both paths eventually led to the creation of an independent network operating firm, NorSea Com, the first additionally made Statoil its own operator of a sub sea fiber cables to the shore.

In the following, I will highlight some of the causes to this organisational divergence and convergence. Let us briefly consider the Statoil-case first.

The development of the huge gas field Troll, 80 kilometres west of Bergen, has rightly been described as one of the world's largest energy projects. At Troll, huge investments as well as huge concrete platforms were put into operations in the mid 1990s. Not only huge in terms of financial investments and physical proportions, the Troll project was also considered a technologically advanced one, first and foremost because it utilised new technology for monitoring and controlling the seabed via computers.[44]

Troll also pioneered the use of communication technology, as it was the first installation offshore to use a fiber optical cable on the sea bed to reach the shore. According to Statoil's former chief technology officer Gaute Hadland, the choice of fiber was down to the bottlenecks experienced in using satellites, such as limitations due to latency and the restricted

[42] Pål Bang and Øyvind Roth, "IKT i offshorevirksomheten", Telenor FOU R 35/2000. [My translation]
[43] I have obtained numerous documents and archival sources related to NorSea Com from Ingve Guttorm Lode, formerly of BP, as of 3rd December 2004.
[44] Engen, "The Development of the Norwegian Petroleum Innovation System: A Historical Overview."

bandwidth.[45] However, another cause was the steady build up of operational competence within Statoil, won through the extensive use of fiber between installations that had started at Gullfaks. Organisationally, Statoil was prepared to run and operate the communication networks themselves, while no telecommunication operator was prepared to do it.[46] Consequently, Troll A turned Statoil into a fully fledged operator of their own telecommunication networks in the North Sea, not only a local network operator on the shelves. What is more, as the application of fiber optical cables was an unproven technology in the offshore petroleum industry, seems to resonate with the argument mentioned at the beginning of this paper, that more radical technological change are often related to vertical reintegration.[47]

At roughly the same time as Statoil got interested in fiber optical communication, Phillips Petroleum started developing the Ekofisk II field. To Phillips Petroleum, a subsea fiber-optic cable was considered to expensive in 1993, and the installation was also considerably less advanced than the one planned at Troll. Øyvind Roth, formerly of Phillips Petroleum, described the fiber optical links as "a solution seeking a problem," while some future use as an infrastructure facilitating a move of operations onshore was envisioned by a concultency report.[48]

The field development at Ekofisk II coincided with the liberalisation of telecommunication services in Norway, with the creation of a competitive market for mobile telephony in 1993 and a few years later the liberalisation of regular telephony.[49] This triggered the interest of the national grid operator Statnett, which had owned and operated their own private telecommunication network as part of their running operations since the 1970s.[50] Statnett wanted to combine the construction of a subsea power cable linking the Norwegian power grid with foreign ones, with a fiber network that could be used to monitor the power cable as well as to be used as a communication network. To Statnett, this project was the beginning of

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[45] Gaute Hadland, correspondance to author, January 6th, 2005
[46] Dag Rydland, correspondance with autoher, February 16th 2005
[47] As argued in Jacobides and Winter, "The Co-Evolution of Capabilities and Transaction Costs: Explaining the Institutional Structure of Production," 409.
[48] Øyvind Roth, interview with author, October 5th, 2004. For the latter, see Tor Wedde, "Let there be Light", Telesafe, 1997.
[49] Thue, *Nye Forbindelser: 1970-2005*, 426.
[50] See Dag Ove Skjold, Lars Thue, and Tone Svinningen, *Statens Nett: Systemutvikling I Norsk Elforsyning 1890-2007* (Oslo: Universitetsforl., 2007).

their short stint as an entrant in the telecommunication market, first as an infrastructure owner and later on as a fully fledged network operator and service provider, a project named and spun out as Enitel in 1996.[51] However, its importance to the oil companies operating offshore was more in terms of drawing together different interested parties towards one network.

Statnetts interest in the oil companies was, however, practical: Subsea fiber-optical cables were already a proven technology for transoceanic communications in the early 1990s, but if used at great depths and over long distances, the signals needed amplification, which necessitated power. If Statnett could use the Ekofisk installations as a repeater and amplifier for their optical subsea cable, the oil companies could get their hands on a infrastructure not available to them otherwise. Initially, Enitel also wanted to use BP, Amoco and Phillips as financial backing. However, while the negotiations between Enitel and the field operators active on the southern part of the Norwegian continental shelf advanced throughout 1996 and 1997, they were also characterised by substantial amount of disagreements on financial and geography.[52]

At the same time, the Swedish telecommunication operator Telia, which just had entered the Norwegian telecommunication market, planned for crossing the North Sea with a subsea fiber optical cable. Furthermore, Statoil were interested in connecting the installations on Draupner and Sleipner to the shore by fiber optical networks.[53] In time, all these plans should be spun into one network: Enitel and Telia created a joint operation called NorSea Com, which operated and owned a fibre network from Lowestoft in Englend, to Draupner, Valhall, Ekofisk and Ula. However, the last miles to the Norwegian shore at Kårstø was owned and operated by Statoil. This last organisational twist was basically an extension of Statoils competence as a network operator on their own fields, as well as the Troll cable.

As a telecommunication company, Enitel expanded rapidly. From around 1999, Enitel changed their focus from that of an infrastructure company to also include end users services.[54] Among other things, this made Enitel aquire the Norwegian subsidiary of Swedish telecommunication company Telia, which already was Enitel's partner in Nor Sea Com.

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[51] On the rise and fall of Enitel, see Thue, *Nye Forbindelser: 1970-2005*, 459.
[52] Documents obtained from Ingve Guttorm Lode, BP, 3rd December 2004.
[53] Gaute Hadland, interview with author, 10th December 2004.
[54] Thue, *Nye Forbindelser: 1970-2005*, 458.

This had implications for the operations in the North Sea: Enitel wanted to be a total service provider for the oil companies, operating networks between installations. In early 2000, Enitel signed a contract with Statoil and Norsk Hydro to lay a new fibre cable between Troll A and other fields in the Tampen area. Furthermore, and in agreement with Enitel's new operational focus, they would operate the full network in this area as well as Statoil's own cable from Troll A and to the shore at Kolsnes.[55] An ambition which was reinforced as In March 2000, former Enitel CEO and now chief of North Sea operations, Olav Harald Nordgard proclaimed that Enitel would be "*the* telco of the North Sea"[56]

One year later, Enitel was far from *the* telco of the North Sea. Instead, Enitel became Norways most prominent casualty of the telecom bust.[57] Just as new entrants such as WorldCom and Global Crossing in the US bursted, Enitel faltered in what was the third largest bankruptcy in Norwegian history.[58]

Just before falling over, Enitel sold their part of NorSea Com to Telia, which consequently became the sole owner of the subsea cable. However, Telia regarded NorSea Como as "non-core business and [would] not make further long-term investmens."[59] Enitel's interest in the Tampen area was taken over by Statoil, after telecommunication operators such as Telenor declined.[60] Subsequently, this resulted in the creation of the wholly owned subsidiary of Statoil named Tampnett.[61]

The result was a constellation of fiber networks owned by oil companies, network operators owned by oil companies and non-interested telecommunication operators, a constellation that created a disintegrated system, a system not perceived as suited for the future of integrated operations of modern oil fields. Ironically, in a period where the field operators as well as the

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[55] "Fiberoptisk nett i særklasse", *Elektronikk*, nr. 5, 2000.
[56] *Aftenposten*, March 23rd, 2000.
[57] The bankruptcy petition was presented to the probate and bankruptcy court as of 25th of September 2001. Statements and reports of the insolvency are available at the webpage of the lawyers Ro Sommernes, http://www.rosom.no
[58] On WorldCom and Global Crossing, see Fransman, *Telecoms in the Internet Age: From Boom to Bust To...?*
[59] Harald Nordstrand, Nor Sea Communictaions, at OLF's workshop on digital infrastructure offshore, september 2nd, 2004.
[60] On TampNett, see Olav Harald Nordgard, "Executive Forum", Submarine telecoms Forum, vol. 16, september 2004, p. 12 – 14.
[61] Interview, Gaute Hadland, 10th Decemeber 2004.

Norwegian government were talking more and more about integrated operations, the ownership structure of the infrastructures were seen as less than ideal.[62] As a consequence, The Norwegian Oil Industry Association (OLF) formed a working group consisting of oil companies such as ConocoPhillips, ExxonMobil, Hydro, Petoro and Statoil and the Norwegian Petroleum Directorate in 2003. One of the main issues discussed was the disintegrated networks and future governance models.[63] Nor Sea Com's Harald Nordstrand expressed that "ideally, backbone optical cable networks offshore should have one common ownership."[64] A similar position has been voiced by Stanley Wirak of TampNett: "The best way of meeting these requirements would be to have one company responsible for the planning, development and operation of the whole network."[65] While OLF's working group recommended the creation of a common network operation management unit, which would be responsible for all technical and commercial operations of the infrastructures, they also argued that ownership should be regained.[66] A similar cooperation was important as wireless technology such as WiMax was applied offshore in the same period.

What about the incumbent, Telenor? They were not interested in participating when Statoil laid down the cable for Troll A in 1995. They were not interested when Enitel's bankruptcy created a possibility to enter the market. As satellite communications was less important to the field operating companies, Telenor lost its ties to the petroleum industry almost all together. By selling their stake in the satellite company Intelsat in 2004, Telenor also cut off their previous lucrative part in the international satellite communication market.[67] In the same period, Telenor has expanded their mobile business to new markets, as Eastern Europe and East Asia. As other incumbents, Telenor also moved further up in the telecommunication value chain, focusing on services.[68] This transformation was mirrored in their dealings with

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[62] St. meld. 38 (2003/2004), p. 34.
[63] The OLF Work Group on Digital Infrastructure Offshore, "Digital Infrastructure Offshore: Common Network Operation Management for Digital Infrastructure Offshore on the Norwegian Continental Shelf," (Stavanger: OLF The Norwegian Oil Industry Association, 2005).
[64] Nordstrand, Nor Sea Communications, at OLF's workshop on digital infrastructure offshore, September 2nd, 2004.
[65] Stanley Wirak, TampNett, at OLF's workshop on digital infrastructure offshore, September 2nd, 2004.
[66] "Digital Infrastructure Offshore: Common Netwrok Operation Management for Digital Infrastructure Offshore on The Norwegian Continental shelf", Work Group on Digital Infrastructure Offshore, OLF report, 2005.
[67] Press release available at http://www.intelsat.com, August 16th, 2004.
[68] Thue, *Nye Forbindelser: 1970-2005*.

the petroleum industry, as illustrated in Telenor's share in the company OilCamp, a network services provider, and Telenor's monitoring responsibilities on TampNett.[69]

It is still an early period of optical fiber technology offshore, but two distinct patterns are possible two discern: First, the encroachment of fiber over satellite technology, but also of fiber over radio links. This is intimately related to the increased importance of information technology also in core operations, such as pumping, drilling and production. Second, a diversification of governance models and the subsequent drive for reunification of operations has altered the old model of a dominant telecommunication operator.

Some conclusions

This paper has accounted for how three communication infrastructures have been established on the Norwegian continental shelf from the early 1970s and until the present. Radio, satellite and fiber optic lines has in different historical periods been the dominant technology facilitating the flows of information from the offshore installations to the shore, technologies associated with different governance models and degrees of integration in the oil companies' own operations. Today, these flows of information are becoming an important part in the the production of oil.

I have argued that one explanatory model can not account for the causes for these changes, but that firm decisions on integration or disintegration of infrastructural services and ownership has to be understood within a larger framework of regulatory and technological determinants. I have argued that each of the technologies were shaped by a set of different relations between network operators, production companies and governing agencies of national and international character. Consequently, the connections offshore were shaped by a set of relations onshore. Subsequently, these offshore connections would alter the ties between telecommunication network operators and oil operating companies to such a degree that the oil producing companies would become telecommunication operators in their own right in the early 2000s.

[69] For the former, Jan Harestad, interview with author, December 10th, 2004. Telenor sold their stakes in the company in 2006. For the latter, Åpen Linje, nr. 11, 2002.

What typified these relations and connections? The early period, dominated by radio communication, was characterised by large logistical challenges related to the development of the first fixed installations offshore. Few technological alternatives existed, even though the inadequacy of VHF radio and radio telegraphy was apparent to all parties involved. The large and international oil companies that started operating at the Norwegian continental shelf was also "forced" to comply with a regulatory and technological frame of maritime origins, and the capabilities of the companies were of little importance. The relations between the NTA and the oil companies were, however, characterised by a mutual frailty.

The second period was dominated by satellite communications, and lasted from 1976 and up to the mid 1990s. The initial decisions to use satellite communications over tropscatters was contrary to the oil companies' initial wishes. As described above, it was intimately related to a set of changing relations between the NTA and Intelsat, changes that were caused by delicate balancing act by the NTA: Their effort in ensuring a reliable connection to the archipelago of Svalbard and sufficient bandwidth to the platforms offshore both relied on technological advances as well as regulatory change. However, the relationship between the NTA and the oil companies, which financed parts of the earth station at Eik in Rogaland, was equally important.

At the same time, an expansion of telecommunication networks between installations would prove important to the governance of offshore infrastructures. These networks were operated by the oil companies on license from the NTA, which created capabilities within the oil companies that would later be used to operate their own links to the shore. In the case of Statoil, this facilitated the creation of self-owned and self-operated radio links as well as the first fiber optical cable to the shore at Troll in the mid 1990s. The integration of infrastructures to the shore coincided with a growing interest in remote operations of the oil facilities, which depended on technological advances.

This was also part of a larger transformation of telecommunications, as the incumbent firm Telenor lost its position offshore and new entrants to the liberalised telecommunication market were moving offshore. However, this interest was soon to cool off: Enital went bankrupt and Telia were less than interested in their infrastructure in the North Sea. Consequently, the emergence of fiber created caused disintegration: Different

telecommunication and oil companies were involved, Enitel and Telia was even cooperating, but in time, varying degree of commitments from the fiber owners was apparent. From 2003, various coordination efforts has been introduced, both on industry level, such as the OLF working groups mentioned above, but also by subcontracting parts of the infrastructure operations to other parties, such as the re-emergence of Telenor as an monitoring provider from 2004. This can be understood as co-evolution of transactional coordination and reintegration of infrastructural ownership and operations by the oil companies based on capabilities, in line with what Jacobides and Winter has called the intertwined determinants of vertical scope.[70] The steady encroachment of fiber optics in what was the domain of satellite communications could be understood as in line with Antonelli's view on localised technological change, as it was first deployed internally between platforms.

However, much of the technological choices analysed above was based on perceptions about future use: When Phillips Petroleum dismissed the use of satellite in 1972, the claim was that an substantial increase in the use of "automation remote control and monitoring."[71] Similar claims were made when the oil companies on the southern part of the shelves got interested in fiber in the mid 1990s. The future use of remote operations from the shore would need high bandwidth and reliable connections, something that the present satellite system could not deliver. This was again based on a wide held belief in an substantial productivity increase coming from integrated operations and e-operations, claims backed by the Norwegian government.[72] The actual use of communications infrastructures has been dominated by two broad dynamics: In the early period, administration tasks were moved offshore, requiring servers and connections between platforms as well as between the headquarters onshore and the installations offshore. In the later period, operations have been moved onshore, utilising remote technology. However, a more thorough investigation in actual use could perhaps reveal different patterns and dynamics than those highlighted in this paper.

[70] Jacobides and Winter, "The Co-Evolution of Capabilities and Transaction Costs: Explaining the Institutional Structure of Production."
[71] Letter from J. F. Walker, 30th October 1972 to P. Mortensen, Radio Departement, NTA. Dcm 0311, A, TD, RA.
[72] Olje- og energidepartementet, *Om Petroleumsvirksomheten* ([Oslo]: Departementet, 2004).

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