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David Baneke

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presented by David BANEKE
Assistant Professor of History of Science
Utrecht University
Descartes Centre for the History and Philosophy of Science

In November 1973, Piet van Otterloo of the Dutch electronics company Philips issued an evaluation of the company's first large space project entitled *Management Aspecten van het ANS Project*[1]. Van Otterloo was the project manager of the ANS project at Philips' legendary Natuurkundig Laboratorium, the company's central research laboratory, commonly known as Nat.Lab. Together with the Dutch aircraft manufacturer Fokker, Philips had developed and built the Astronomical Netherlands Satellite (ANS), a satellite for astronomical observations. Apparently, it had been a very educational experience, as defined by Douglas Adams (of *Hitchhikers Guide to the Galaxy* fame): "A learning experience is one of those things that says: 'You know that thing you just did? Don't do that'"[2]. The space industry, it turned out, was an extremely difficult industry to enter, even for a major electronics multinational at the peak of its power.

The evaluation van Otterloo gives is an interesting document because it shows in detail *why* space was such a difficult field. Van Otterloo comments on technical difficulties, but he emphasizes that the main problems were in management. He also analyzes the uncertain commercial prospects. Finally, the document highlights the importance of corporate culture and the organizational structure. The satellite project required close collaboration of several of Philips' relatively independent divisions, as well as the Nat.Lab. This proved to be harder than expected. The importance of corporate structure is especially clear when we compare Philips' experience with Fokker's.

DUTCH AMBITIONS IN SPACE AND THE ANS PROJECT

The Dutch ambitions in space started after the launch of Sputnik in 1957, or, rather, after the international reactions to it. In a dramatic diplomatic gesture, intended to regain the initiative after the humiliation of not being the first to launch a satellite, the U.S.A. offered to launch foreign scientific satellites. This made it possible for scientists and industries from smaller countries to enter the exciting new field of space research. Around the same time, several European countries started talking about creating a joint European Space

[1] P. van Otterloo, *Management Aspecten van het ANS Project*, 19 November 1973. I would like to thank the Philips Company Archives, and especially Marianka Louwers, for their help and their kind permission to use this document. I also thank Hermione Giffard for her helpful comments.

[2] D. Adams, Interview with B. Buhler, *The Daily Nexus*, 5 April 2000, reprinted in *The Salmon of Doubt: Hitchhiking the Galaxy One Last Time*, London, Heinemann, 2002.

Research Organization (ESRO, a predecessor of ESA)[3].

The Dutch government was interested in joining international space activities. Foreign minister (and future Secretary General of NATO) Joseph Luns expected that the high quality of Dutch science and the technological prowess of the country's flagship companies such as Philips and Fokker would make entering this new field relatively easy. He supported the creation of a "modest but sophisticated" (*bescheiden maar weloverwogen*) national space program to help the companies[4].

Both Fokker and Philips were eager to become active in space technology. For Fokker, creating satellites appeared to be a logical extension of aircraft production. For Philips, the move was appealing because of the company's desire to be involved in every new technological field. A sprawling electronics company, Philips' products included lighting but also domestic appliances, medical systems and scientific instruments like electron microscopes. Scientific and engineering capability featured prominently in Philips' self-image.

In this period, Philips aimed to be involved in all major new fields of technology, regardless of short-term expectations of profit or practical use. The company invested heavily in research, spending up to 6 % of the turnover on research and development in the 1950s[5]. Board members Frits Philips and Theo Tromp considered cultivating a broad in-house scientific and technological capability to be crucial for the future of the company.

Since the Second World War, Philips had contributed to national research projects in nuclear science, computing, and radio astronomy. In the case of nuclear physics, Philips pulled out when it became clear that the commercial prospects were too uncertain and foreign competition too strong, but the company tended to join every new field as soon as possible and evaluate the business case later. That is also what happened in the case of space technology.

Both Philips and Fokker wanted to enter the space industry for a mixture of commercial, strategic, and political reasons. But how could they start work? Contracts from large international space agencies proved hard to come by and there were few domestic customers. Dutch scientists (especially astronomers) developed some scientific instruments for space research, but those were too small to interest large companies. In 1965, Philips and Fokker jointly lobbied the Dutch government for an expansion of the national space program. They wanted to build a complete satellite. This would provide them with experience and know-how and would demonstrate their capabilities to potential customers. The government agreed to act as a guaranteed "first buyer", thereby funding the investments needed to enter the new market[6]. The result was ANS, to be launched by NASA, which also provided technical and management advice[7].

[3] J. Krige and A. Russo, *A history of the European Space Agency 1958–1987*, vol. I, Noordwijk, ESA, 2000; J. Krige, A. Long Callahan and A. Maharaj, *NASA in the World: Fifty Years of International Collaboration in Space*, New York, Palgrave Macmillan, 2013.

[4] National Archives, The Hague, Algemene Zaken records, file 5714, letter from J. Luns, 23 January 1960; see also D. Baneke, "Space for Ambitions: The Dutch Space Program in Changing European and Transatlantic Contexts", *Minerva*, vol. 52, n° 1, March 2014, p. 119-140.

[5] I. J. Blanken, *Een industriële wereldfederatie: Geschiedenis van Koninklijke Philips Electronics N.V.,* vol. V, Zaltbommel, Europese Bibliotheek, 2002, esp. chapter 4; see also M. de Vries, *80 years of research at the Philips Natuurkundig Laboratorium 1914-1994,* Amsterdam, Pallas Publications, 2005, p. 234.

[6] The relation between the government and industry could be described as a "development pair" as described in P. Lundin, N. Stenlås and J. Gribbe, *Science for Welfare and Warfare: Technology and State Initiative in Cold War Sweden*, Sagamore Beach, MA, Science History Publications, 2010, p. 45, 147, 255.

[7] D. Baneke, "Organizing space: Dutch space science between astronomy, industry and the government", in T. Heinze and R. Muench (eds.), *Innovation in Science and Organizational Renewal. Historical and Sociological Perspectives,* London, Palgrave Macmillan, 2016, p. 183-209.

This last point, management advice, was crucial. Space projects were notoriously complicated because of the extreme demands on quality and precision, the high degree of interdependency between all components, and because of the number and variety of institutions that were involved. This required advanced management methods, which had been perfected by the U.S. Air Force and NASA. Their "Systems Management" became a key technology for managing big projects that involved a variety of stakeholders, large uncertainties, complex flows of information, and (especially) changing objectives and design specifications[8].

To legitimate the government spending, the satellite would be an advanced astronomical observatory. This had several advantages: the international prominence of Dutch astronomy justified a large investment; astronomy was easy to popularize, making the project visible; it would provide ample opportunity to exhibit technological skill; and finally it was not so politically charged as communications satellites[9]. Another reason may have been that a scientific satellite was appropriate since the European Space Research Organization was seen as a major potential client.

ANS was launched on 30 August 1974 from Vandenberg Air Force Base in California. Due to a minor malfunction during launch, its orbit was more elliptic than planned. Now Philips' eagerness to show off paid off. It had developed an advanced and – importantly – re-programmable on-board computer. It was a high-risk plan, but it made it possible to rescue most of the scientific observation program[10].

The science results from ANS' observations were respectable, if not spectacular. The technological performance of the satellite was excellent. Both the Dutch astronomers and Fokker – but not Philips – immediately started to lobby for a second satellite, which eventually became the Infrared Astronomical Satellite (IRAS), a joint Dutch-American observatory which was launched in 1983. Philips supported the lobbying effort, but behind the scenes the company's management had already decided to pull out of the space business.

PHILIPS' WITHDRAWAL AND FOKKER'S STAYING IN

The reasons for Philips' withdrawal can be found in Van Otterloo's evaluation. The project had been an interesting challenge, but that did not justify the amount of staff and resources that had been invested. By the end of the project, more than 200 people were working on it in Geldrop, where the Nat.Lab. was located[11]. The company had especially underestimated the management of the project. Space projects were too complex and too unpredictable and they involved too much paperwork. The project also did not fit the company's structure, with relatively independent divisions that each had their own research and development laboratories, apart from the central Nat.Lab. Projects such as ANS, which spanned several divisions, were rare. Besides, Van Otterloo argued that the commercial outlook for space products was too uncertain. The international market was difficult to penetrate, while the national market was simply too small.

The situation for Fokker was different. Space projects matched its corporate structure

[8] S. Johnson, *The Secret of Apollo: systems management in the American and European space programs,* Baltimore, Johns Hopkins University Press, 2002.

[9] Philips Company Archives, *Voorstel van de Nederlandse electronische- en vliegtuigindustrie voor de ontwikkeling van een Nederlandse astronomische satelliet,* 1966.

[10] P. van Otterloo, "Ruimtevaartinnovatie bij Philips", *Ruimtevaart*, n° 4, 2019, p. 11-14; see also M. de Vries, *80 years of research…, op. cit.*, p. 234-37.

[11] P. Van Otterloo, "Ruimtevaartinnovatie bij Philips", *art. cit*.

very well, since aircraft development projects were also large and complex, involving the entire company. For Fokker, systems management was not just an interesting exercise but a crucial skill. Besides, Fokker was less worried about the commercial prospects, since it could rely on long-term government support for its development projects[12]. Its focus on development rather than sales may have contributed to its ongoing financial problems, however, which eventually proved unsolvable: Fokker filed for bankruptcy in 1996. Its space division survived; it is now part of the Airbus Group. Dutch scientists also remained active in space research, contributing to several high-profile space observatories via the Netherlands Institute for Space Research (SRON). As intended, the ANS project was the start of significant Dutch efforts in space, both scientific and industrial. For Philips, however, it remained a one-off experiment.

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P. van Otterloo, *Management Aspecten van het ANS Project*, 19 November 1973

In this report, Piet van Otterloo, the project manager of ANS at the Philips Natuurkundig Laboratorium (central laboratory), comments on “Management Aspects of the ANS project”. The report does not state who asked for it; it may well have been Van Otterloo’s own initiative. A colleague described it as “some sort of testament” of Van Otterloo: “It is of course a personal view, but it originates from discussions with so many different people that its objectivity is sufficiently secured”. He added that it would provide a good case study for Philips’ internal study group for talented young staff[13].

In the first part (pages 1-14), Van Otterloo analyses the factors that contributed to the project’s successes, delays and cost overruns. He points especially to the many design changes throughout the project, either by choice (opting for improvements) or by necessity (because components did not meet the standards or subcontractors did not deliver). The project planning procedures struggled to keep up with the frequent changes, especially with processing their consequences for other components.

According to Van Otterloo, Philips’ staff had to learn systems management the hard way. Initially, no time had been planned for all the procedures, and the amount of paperwork was “tremendously underestimated” (p. 6). Nevertheless, it was a very useful experience (p. 11):

> Not only can we now make a reasonably good planning and cost estimates, but the uniquely demanding nature of the ANS and the intense contact with NASA and GE[14] has also taught us a lot about QA[15], product supervision, and those kinds of things, which creates a whole new perspective on the project. Before we would not think of writing specifications at the beginning of a work package, now we regard not just specs but also test plans, reviews, procedures, FMECA[16] etc. as useful tools in development and production […]. There is a clear similarity between our

[12] M. Dierikx, *Uit de lucht gegrepen: Fokker als Nederlandse droom, 1945–1996*, Amsterdam, Boom, 2004.

[13] Philips Company Archives, Letter from F. Valster, 20 February 1974.

[14] DB: General Electric provided technical assistance for the project.

[15] DB: Quality Assessment.

[16] DB: Failure Mode Effect and Criticality Analyses.

way of working and the System Management that is promoted by the Central TEO[17] (we have been in contact with TEO throughout). I think the ANS project has been a very valuable exercise in the application of Systems Management in an R&D project.

The first part ends with a discussion of the question "do we want to do this again?" (p. 13-14):

Before answering this question, we need to clarify a few points:

− the goal of the ANS project was to get enough experience to enable the Dutch industry to make competitive bids for international projects, in order to secure contracts at least equal to the Dutch contribution to those projects.

− it is only interesting to do this if it is profitable, in the future if not directly, and if sufficient continuity can be guaranteed.

Even if one takes all European space projects together, the continuity is not there. This not only means having to train staff again and again, but also that qualified production processes will lose their qualification. Obtaining qualification is a very costly business. Besides, the projects are all very different (different astronomical satellites, communication and navigation satellites, earth resources satellites, etc.) and countries are not always assigned the same part. This means that every project has to be planned as a new project, including costly training and process qualification, even if one has significant skills and knowledge.

All this makes a project so expensive that competitive bids are out of the question and that any room for profit is lost. This effect increases as contracts are further apart in time. The smaller a country, the smaller the sum of all national projects and shares in international projects. Because they are released in batches, and spread over various companies (not only according to technological criteria), it will be clear that the work should not be divided again within the company[18].

Considering the required investments (cleanrooms, measuring and test instruments) and in training the staff, the minimum size of a sustainable space group is quite large. I would estimate it at 10 people with academic qualifications, with 15 to 20 assistants, 5 to 10 design engineers, and as many workshop staff. The cost, including materials, are in the order of Hfl. 5 million[19]. Below this size, the cost rises quickly because of the repeated hiring, training and dismissal of staff. By concentrating all the work in one place it should be possible to keep such a group going within Philips, as long as it is prepared to work on all kinds of problems. Fragmentation over several divisions[20] and the Nat.Lab. would be undesirable. If space work were to be assigned to one division, there would be room for cooperation with the Nat.Lab. in projects with a high degree of innovation. The staff within the space group would have to rotate frequently, according to the changing nature of the project.

Even then, one could never match the prices of American industry, because aerospace contracts are so frequently granted there that it is possible to keep a qualified production line running continuously.

If, despite all these arguments, one would still want to bid for a contract for other reasons, it might be necessary to make a bid that almost certainly will make a loss. To keep a correct perspective, one should still make a realistic cost estimate, submit a part of that as total cost to the client, and create a budget for the rest from our own resources. This would give a better idea of the situation within the company, everybody would know what to expect, it would provide a more realistic goal for the project leadership, and the extra money would have to be found sooner or later anyway.

[17] DB: Philips' central Technical Efficiency and Organization department.

[18] DB: this is a reference to the participation of several of Philips' divisions in the ANS project, which, according to Van Otterloo, made it inefficient.

[19] DB: Dutch guilders; about 1.87 million dollars at the time.

[20] DB: In Philips the divisions were called *Hoofdindustriegroep* or HIG.

Without a realistic cost estimate in advance, one cannot assess the desirability of the contract in comparison to the losses it will cause. There is a great chance that the losses will prove to be unacceptably large. A report from an independent research group which investigated the cause of the bankruptcy of Rolls Royce (ref. VIII[21]) describes and seriously criticizes exactly this process.

In the second part (p. 15-25), Van Otterloo presents some more general reflections on the organization and management of large complex projects. I quote the first two pages (p. 15-16):

Managing Large Complex Projects illustrated with Some Examples from the ANS Project

Introduction

Some characteristics of a project as meant here are:

− large and complex

− innovative, either designing new things or a new combination of existing things

− limited in time, capacity and financial means

Considering the large efforts in many different fields that such a project demands, it is to be expected that:

− much interdisciplinary collaboration will be needed

− the project will be too large for one company

It will be clear that such a complex thing requires special care, both in terms of organization and of direction. See below for a definition of these terms (from ref. IX):[22]

PROJECT APPROACH

PROJECT MANAGEMENT: *coordinated planning, management* [besturing] *and control of projects*

PROJECT ORGANIZATION: *systematization of the collaboration between the specialists from different functional departments who work on various projects.*

Organization

As mentioned above, usually multiple firms and institutions will be involved in a single project. They will have their own functional organization, which the project organization will cut through. Such an organization is called a matrix organization (see for example the organization chart of ANS Nat.Lab. Geldrop fig. 1[23]). One of the problems of such an organization is that one man can have multiple bosses. We can distinguish:

− hierarchical boss, responsible for hiring, assessment, and policy [*beleid*] of the department

− functional boss, who takes care of professional specialization and requirements

− operational boss, who issues assignments and defines priorities

As the hierarchical/functional boss is usually already present historically, the operational boss needs special support from the board in order to enable a balanced interplay. If this is not provided, one cannot expect good policy from the project leaders.

[21] PvO: *Aviation Week and Space Technology*, 20 August 1973, p. 60 ff.

[22] PvO: *Productie en Onderhoud*, 8, n° 5, 1973, p. 102 ff.

[23] DB: This probably refers to another document, since the illustration is not included in this report.

Creating a project

Management:

An important condition for a smooth running project is that the end goal is clear. This concerns both the idealistic goal and the technical one. The idealistic goal could be: we do this to learn from it, or we produce a trial series to get production started. The technical goal should define exactly what the ambitions are. These are written down in the design specifications.

Specifications:

The specifications have to meet two contradicting requirements:

– strict definitions, because so many people, far apart from each other and coming from different disciplines, have to be able to work with them

– flexibility, because things always have to change in an innovative project.

Both requirements can be met by creating a "system group". Apart from configuration control, including specs and interface control, another important task of this group is arbitration in case of disagreements surrounding changing specs. Other important tasks are coordinating and standardizing things that are not covered by the specs. The system groups should of course only make the system specifications. These are used to determine the subsystem requirements, which can only be defined on the level of the subsystems, although they have to be monitored at system level.

The ANS project did not have a system group. The original idea was that its tasks would be taken over by coordination between the subsystems. The result was, however, that the person who was most worried or felt most responsible for the success of the entire program, would take on more work than could reasonably be expected. It also made it possible for the man who did not feel like, or did not have the opportunity, to participate in this supposedly joint activity, to not do any work because sooner or later someone else would do it anyway. This created so much frustration that in the end, no one did it any more. It was also not possible to agree in advance who would take care of which part of the system activities, since these activities were not completely predictable. For all these reasons there should be a system group which performs all the tasks which are needed to keep all subsystems informed, and to mediate in case of disagreements. This group can also play a large role in later integration and testing at the system level. The system group should be flexible and able to react quickly, in order to be able to recognize and solve problems on time.

Later, Van Otterloo describes how this issue was eventually solved in ANS (p. 23):

During the critical phase of the ANS project, we instigated a daily meeting of the project manager with subsystem managers and sometimes planning and the quality control department. In this meeting, which started at 17.00 hours, all problems of the day were discussed and actions for the next days were agreed on. This proved to be a quick and efficient way to deal with problems, in which each of the participants contributed to the execution of the chosen solution.

The reports ends with annexes about the development of the project's staff numbers, about the problems with the computerized planning system, and suggestions for an improved system to keep track of cost and time overruns during the project.