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A talkative artefact: Germany and the development of a European launcher in the 1960s

Artefacts as talkative things

When was Europe 'invented', what constitutes European identities, and what is Europe as a political and cultural entity? These questions have occupied the minds of numerous historians and political scientists, in particular since the end of the Cold War and the fall of the Berlin Wall, when the physical barrier that for several decades had symbolised the division of Europe into two opposing blocks was dismantled. The answers to these questions are manifold and controversial – and often revisionist in that they challenge the master narrative of European integration as a linear process leading to the constantly-expanding Europe of the European Union as an integrated political, economic and societal body.[1]

In contrast to the rapidly-growing stock of literature on European integration as a political, economic and cultural process, surprisingly little attention has been paid to Europe as an entity shaped by material networks, scientific knowledge and technical artefacts. Only recently has a research network of European and American scholars started to study the linking and de-linking of (transnational) infrastructures and the circulation and appropriation of knowledge, artefacts and systems in order to make visible the 'hidden integration' as well as the 'hidden fragmentation' in modern Europe.[2] From this perspective, the history of Europe in the twentieth century must include big scientific and technological projects, within and beyond the nation state. Such projects have often surpassed their obvious function as scientific artefacts or technical systems, and have generated a variety of symbolic meanings, economic and cultural impacts, and political consequences.[3]

Big science and big technology are close cousins. Big science means modern science carried out in an almost industrial manner. Big science requires elaborate technological systems which often include large and expensive instruments. Big science is based on substantial financial and human resources, on industrial organisation, and often on strong state support. Big science manifests in military contexts such as the Peenemünde project to build the V-2 rocket and the Manhattan project to construct the first atomic bomb, or in civilian contexts such as the CERN facilities for nuclear and high-energy physics near Geneva and the Human Genome Project.[4] As with big science, big technologies are usually government-sponsored, and traditional commercial considerations are of secondary importance. In most cases, they protect national industries. This protection 'is enhanced, at least in Europe, by international programmes where governments together make long term engagements which are extremely difficult to break. They can thus find themselves locked into major programmes whose costs often spiral dramatically and whose benefits become increasingly difficult to see.'[5] In historiography, the boundaries between big science and big technology are rather ill defined, and often purposefully so as a consequence of the amalgamation of science and technology into techno-science in (post)modern societies.

The project to build a European launcher carried out by a number of leading western European countries in the 1960s fits largely within this characterisation of big technology (and big science), as we will see. In 1962, six European nations signed the agreement to form the European Space Vehicle Launcher Development Organisation (ELDO). This big technological project resulted from the will of European scientists and political decision-makers to contest the two superpowers' dominance in space. The political rationale was to keep Europe independent from the superpowers in general and from the United States in particular. The project, which has been described as an example of 'Euro-Gaullism', extended national interests into the European arena.[6]

From a slightly different angle, the project can be seen as an example of technological failure and failed innovation.[7] In high-performance technological systems such as astronautics, technical failures can be seen as the norm, and the history of American space activities in fact points to the ubiquity of failures.[8] But in the case of ELDO, technical failures led to the final demise of the overall institution. Technical problems combined with poor project management caused a series of misfortunes. Between 1964 and 1970, when the participating nations began to disband ELDO, the patient European public witnessed a full dozen test flights intended to launch the European flag into space, which in a few cases resulted in very limited operational successes but in most cases were technical failures. The German third stage, Astris, was particularly troublesome. Test flights that aimed at demonstrating its operability ended in disastrous explosions.

This case study of the launcher ELDO A or Europa I in general, and its German contribution Astris in particular, shows the importance of big technologies in the formation of Western Europe as a political entity in the age of the superpowers. It also demonstrates the complex effects of technological failures in (post)modern societies. Furthermore, and more importantly in the context of this book, it exemplifies the talkativeness of specific objects. Objects can be described as 'nodes at which matter and meaning intersect'.[9] Material objects, more than ideas alone, can embody multiple and often contradictory cultural viewpoints. It is this multiplicity that gives specific objects their talkativeness, their complex narratives. Objects in museums, artefacts, are often talkative objects per se. In the semi-public space of a museum, artefacts generate dialogue with visitors. The character of this dialogue depends on a variety of constituting factors: the place of a given artefact within an exhibition, its conceptual contextualisation, its materiality, its authenticity and its historic uniqueness, the intensity of the cultural charge, and so on.

This introductory section is followed by a brief technical portrait of Astris. The third section shows the talkativeness of our artefact by outlining a number of stories that are embedded in it. The fourth section explains the fate of Astris as a technological failure resulting from its character as a political artefact, and a brief conclusion discusses the role of talkative artefacts in museums of science and technology.

Astris: a technical portrait

The Deutsches Museum displays Astris, the third stage of the European launcher ELDO A or Europa I, in two different settings: firstly in the space gallery of the main museum in central Munich, where it is shown primarily in a technical context as part of a historical narrative leading from the rocket projects of the interwar period to the most recent spacecraft technology, expressed in artefacts such as the gigantic motor of the latest European launcher, Ariane V; secondly in the branch museum Flugwerft Schleissheim, some 16 km outside the city of Munich, as an integral part of the complete four-stage Europa I launcher. Here it tells the story of the ultimate failure of ELDO as a first attempt by Europe to join forces in order to challenge the monopoly of the two superpowers in space. One might go so far as to say that the museum has fallen in love with this artefact, as its repositories hold two more copies of Astris (Colour plates 1 and 2).

Astris was named after the first liquid-propellant rocket in Europe. In March 1931, at the culmination of the Weimar enthusiasm for space, Johannes Winkler, a former engineer of the Junkers company, had successfully launched Astris from the *Raketenflugplatz* (rocket launch pad) in Berlin.[10] Referring to this climax of seemingly-apolitical rocket research in the Weimar era should demonstrate that German rocket history had developed a second, civil tradition of generating sophisticated hi-tech artefacts, alongside the development of the devastating V-2 rocket in Peenemünde under the Nazi regime. Even in the 1960s, German scientists and policy-makers still acted in the long shadow of Peenemünde, which forced them to be mindful of a sensitive national and international public. After the total ban on rocket technology imposed by the Allied Powers from 1945/46 to 1955, rocketry and space flight in West Germany had to be cautiously reinterpreted as a peaceful and therefore positive goal of human endeavour.

Astris was conceptualised as a research-intensive innovation in rocketry. The project aimed at cutting-edge technologies. By mastering this scientific and technical challenge, West German space industry hoped to prove its international competitiveness. Part of this challenge was the move from medium-energy to high-energy fuels. From the beginning of the project, the German experts had specified cryogenic fuels, but their partners in Great Britain and France had opted against this leapfrog in rocket technology.[11] Increasingly, the Germans were forced to search for every opportunity to save weight. The pursuit of weight-saving solutions led the Astris team to a number of technical innovations, which were most visible in two components: the corrugated sheet-metal structure of the skin and the fuel tanks.

On their way to the space gallery, visitors to the Deutsches Museum cross the aviation gallery. Two iconic artefacts in this gallery are the Junkers F-11 and Ju-52 aircraft, both characterised by bodies and wings consisting of corrugated sheet metal. On reaching the space gallery, visitors may perceive Astris to be a result of the same material and production technology, which was developed by Hugo Junkers during the First World War and widely used by aircraft designers in the interwar period. A closer inspection of the artefact shows a very different technical concept. The cylindrical main bulkhead of Astris consists of a corrugated sheet-metal structure made from titanium sheet 0.1 mm thick. The industrial contractors had to develop novel technologies to produce such sophisticated materials, and their search for innovation led to manufacturing techniques that were completely novel in German industry.

The overall design of Astris was based on the concept of a single spherical titanium container with a diameter of 2 metres (Figure 1). The tank was separated by an intermediate bulkhead to store Aerozin 50 as fuel in the upper part and nitrogen tetroxide as oxidiser in the lower part. The container was suspended by means of diagonal titanium ribs which were glued to the container and whose ends were spot-welded to the main bulkhead. The tubular framework with a satellite platform was attached to the upper end of the main bulkhead. The high-performance low-thrust main engine and the two vernier engines, as well as the two ultra-light high-pressure containers, were mounted at the lower end of the main bulkhead. The two oval tanks of 135 litres each were constructed of spun-fibreglass-reinforced plastic to store helium at an operating pressure of about 300 atmospheres and a bursting pressure of 580 atmospheres.[12]

The engineers in charge thought that the most critical part of Astris would be its spherical titanium container. In its final design, the tank was specified as having a wall thickness of 0.8 mm. In order to

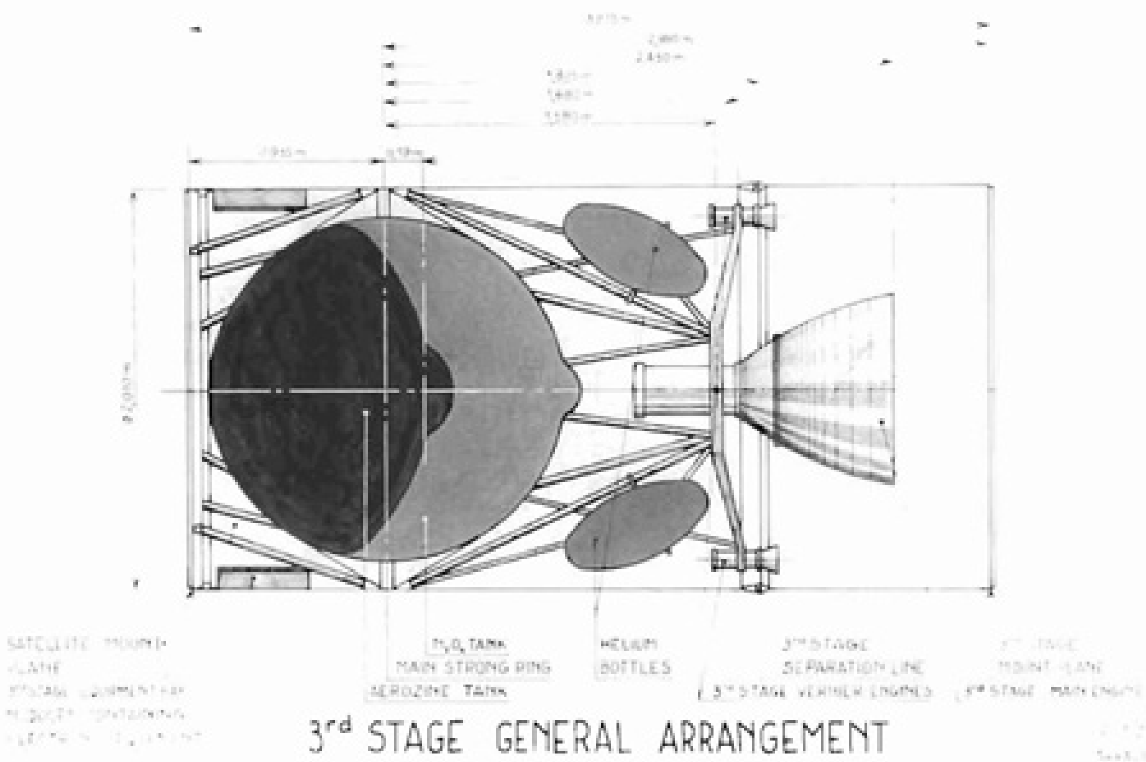


Figure 1 Schematic diagram of Astris. (Archives of the Deutsches Museum)

reach his goal, the engineers had to combine two highly-sophisticated manufacturing modes: the techniques of explosive forming and of electronic-beam welding in a vacuum (Figure 2). Explosive forming as a novel production technique had been developed in the United States to solve the problem of fabricating the gigantic boosters of the Saturn rockets for the Apollo programme.[13] In a final step, the wall thickness was reduced by chemical milling.

But the problems didn't arise where they were expected. The critical part of Astris proved to be its electronics, the less visible component of the artefact. Fixed at the upper end of the inner side of the main bulkhead, some small black units carried the devices for guidance, control and telemetry. For the German scientists and engineers, these black units were literally 'black boxes'. They also contained the computers to guide and control the first stage of the launcher. As the contractor responsible for the electronics of the whole launcher, the British company Hawker Siddeley had built an impenetrable information barrier around these modules. The German engineers were willing to accept this boundary. Furthermore, they showed 'a refusal to attend acceptance or bench integration tests, a lack of cooperation in defining strict working procedures, a total refusal of responsibilities'.[14]

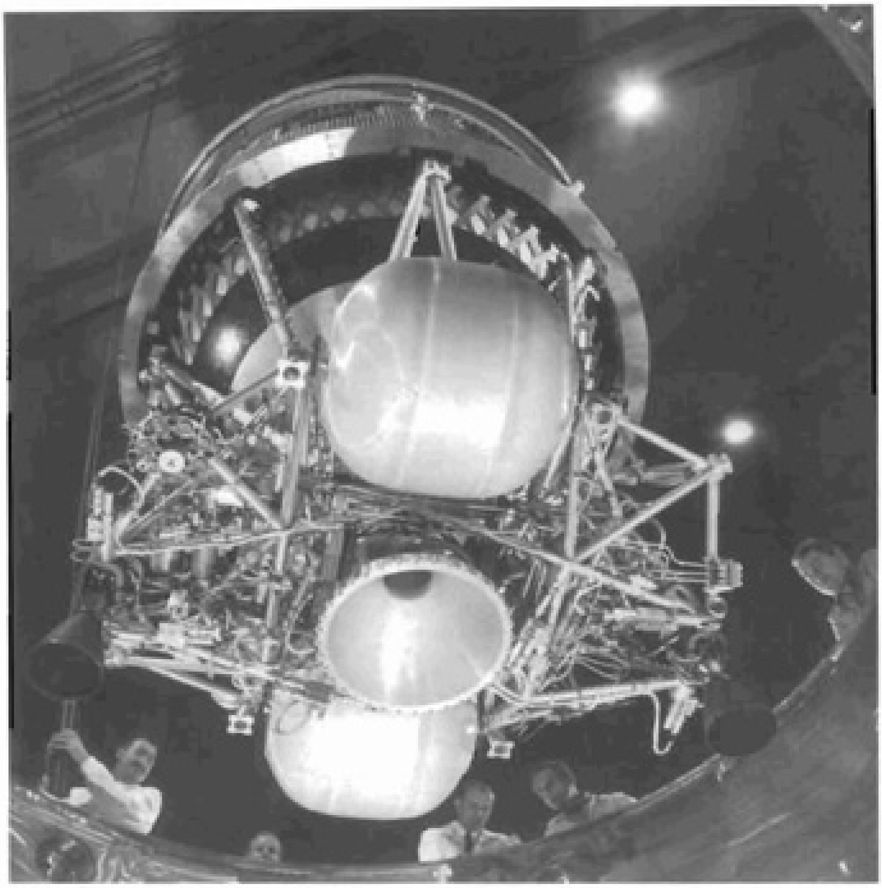


Figure 2 Participating in the ELDO launcher project meant a big technological challenge for German industry: here, engineers of Bölkow AG place a test model of Astris into the vacuum chambers of the corporate testing facilities at Ottobrunn, near Munich. (Archives of the Deutsches Museum)

Not surprisingly, Astris performed poorly. In flights F7 (December 1968) and F8 (July 1969), which aimed to test the operability of the third stage, Astris exploded shortly after separation. In contrast to their expectations, the investigators found that the explosions resulted not from the propulsion system of Astris but rather from an electrical failure between the third stage and the test satellite under Italian responsibility. Fixing the electrical problems did not prevent Astris from malfunctioning on the next test flight, the final flight of Europa I in June 1970. Firstly, an electrical connector disconnected prematurely and prevented the separation of Astris from the satellite test vehicle; and, secondly, the propulsion feed system of Astris failed. This latest disaster convinced the ELDO Council of the necessity to create a Quality Assurance Association, 'but due to a lack of staff, it could not cover all sites and processes'.[15]

ELDO planned to give Astris its major public launch on 5 November 1971. On this seminal day in European space history, the modified Europa II started from the new European launching area, Kourou in French Guiana (Figure 3). The launcher included all three stages plus a new 'perigee–apogee' stage. For a short while, flight F11 seemed to be

Figure 3 Europa II, ready for test flight F11, mounted on its launch base in Kourou, French Guiana. (Archives of the Deutsches Museum)

successful (Figure 4). But after 104 seconds the computer of the British inertia navigation system, which was fixed to the German third stage, failed. After a further 46 seconds the vehicle began to break up and was destroyed by the range officer.[16]

At the next meeting of the ELDO Council some weeks later, the participants were fully aware that the demise of ELDO was imminent. The Council set up an investigation committee of senior engineers and executives from government and industry in Europe and the United States, led by Robert Aubinière, the French Secretary-General of ELDO. The committee report, dating from 30 May 1972, was a devastating proof of ELDO's poor organisation and its massive management and communication problems. In December 1972, after having successfully mastered two 'package deals', the ELDO member states finally agreed to close down the ELDO launcher programme and found a new, much more integrated and powerful joint space organisation: the European Space Agency (ESA). ELDO was finally dissolved in May 1975.[17]

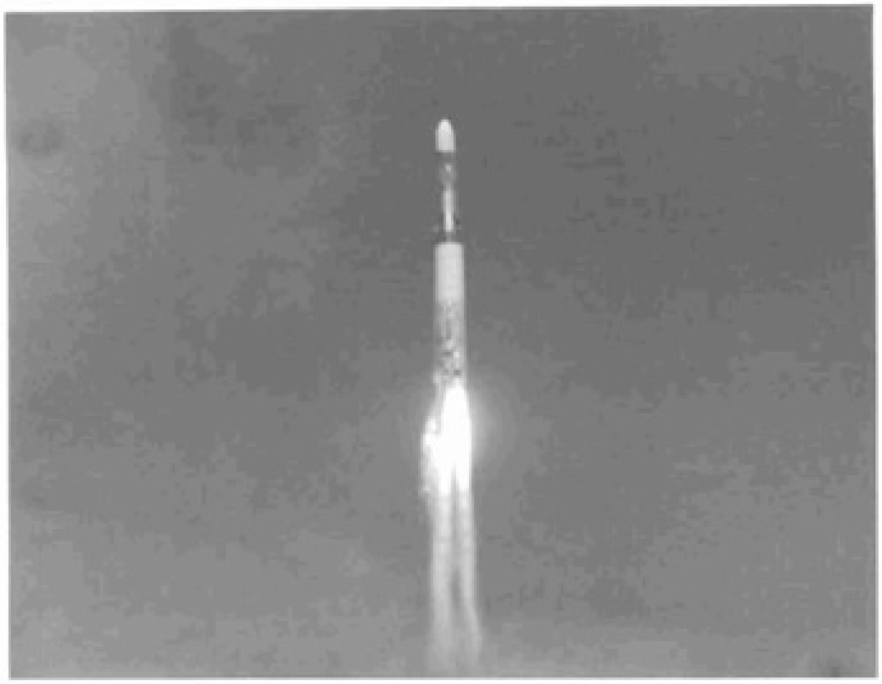


Figure 4 A technical disaster precipitated the end of ELDO: Europa II after its start from Kourou on 5 November 1971. Poorly-designed British, French and German electronic modules caused the break-up of the vehicle. (Archives of the Deutsches Museum)

Astris: a talkative artefact

At the beginning of the twenty-first century, space travel in Europe has become a truly transnational business. Europe as a space-faring actor is even larger than Europe as a political entity: the participation of Switzerland, Austria (before it became an EU member) and even Canada means that ESA involves countries outside the European Union. With Arianespace and EADS as leading enterprises, the space industry has succeeded in developing a refined European structure that is way ahead of the efforts in the fields of politics and society by the European Union. The master narrative of Europe in space is a history of growing transnational integration, initiated by scientists and engineers and based on the strong will to cooperate despite political barriers.[18]

Historians view the history of Europe in space as a history of Europe shaped by tensions, as a dichotomy between integration and disintegration, coupling and decoupling. The long-lasting tensions of Europe in the twentieth century were evident as multinational space programmes developed after the 1950s: individual national rationales often conflicted with the publicly-stated will to cooperate on the basis of mutual understanding and equality of status.

Astris is the perfect artefact to communicate this story, as will be shown. As a talkative artefact, it not only tells the stories of the importance of big technologies as a catalyst of European integration and technological failure, but it also relates to a number of other meaningful historical contexts:

1. Astris points to the importance of the national catch-up effort in science and technology. The history of the relations between the US and Europe throughout the twentieth century is the history of a dense transatlantic discourse and process of mutual orientation.
2. Astris expresses the constituting problem of modern societies in coping with the complexity of big science and big technologies.
3. Astris characterises the dialectics of historical continuities and discontinuities beyond 1945 as a key date in twentieth-century German history, and it points to the limited room for manoeuvre in West German politics resulting from the legacy of the Nazi period.
4. Astris exemplifies the strong persistence of national innovation systems and cultures in transnational innovation processes.
5. Astris highlights the importance of international collaboration for the scientific, political and economic legitimisation of resource-intensive projects in national contexts.

The following section will touch on some of these narrative strands, but focuses first on the ubiquity of politics in European space activities. More than most other fields of science and technology, space is dominated by political interests and state actors. Until very recently government has been not only the sole sponsor of innovation activities in space, but also the only customer for the resulting products, and to a large extent this is still true today. In contrast to most other technologies, in space business market forces and the 'consumption junction' (Ruth Schwartz Cowan) between producers and users of innovations have been less important than actors in the political realm. Whereas modern knowledge societies in general are sought to be characterised by the 'triple helix' of academic research, industry and the state, a collaboration which is driven by economic competition and market forces, in space the 'triple helix' of science, economy and politics has been dominated by the latter.[19]

This is especially true of German space activities, where the ubiquity of politics derived not least from the legacy of history. The historical burden of Peenemünde, the birthplace of rocket technology under the Nazi system, for a long time forced decision-makers to avoid any attempt that could be interpreted as being continuous with this dark period of German history. As a consequence, in German space history, the collaborative network of science, industry and politics shows a clear political bias.[20]

The ubiquity of politics leads to the second focal point: the tension between national and international orientation in German space activities. Again, due to the historical burden of the Third Reich in general and Peenemünde in particular, Germany became the prime advocate for European cooperation. German policy-makers tended to favour international space projects and joint efforts with partners in Europe and the US. In contrast, scientists and industrial actors were keen on upholding a vigorous national programme. They advocated a strong national platform of scientific knowledge and technical expertise, which would act as an essential basis and then allow German science and industry to cooperate in international projects on an equal footing. The tension between national and international orientation affected German space research and space technology on all levels, and this tension is vividly manifested in the artefact Astris.

Early Cold War years and the interlude of the 1950s

In the period immediately after the end of the Second World War in Europe, the Allied countries used the instrument of 'exploitation and plunder' to profit from the progress of German science and technology during the war.[21] This transfer of knowledge from Germany to the United States is part of the long-lasting transatlantic discourse on the problem of how science and technology should be organised to perform at their best. Viewed in this way, the transfer of von Braun's core team from Peenemünde to Fort Bliss in Texas, and later to the 'Redstone Arsenal' near Huntsville, Alabama, can be seen as part of the long history of learning from the excellence of German science. Huntsville was the resurrection of Peenemünde-Ost, the Nazi development centre for the V-2. Americans and Germans quickly began calling the place 'Peenemünde-South'. A significant reason for Huntsville's success was that it followed the organisational principle established at Peenemünde of 'everything under one roof'. This meant that the coordination of the different areas and branches of science, technology and production lay in the 'firm' hand of those in Peenemünde, now working in Huntsville.[22]

During the 1950s the pendulum swung back. The German scientific community was oriented towards and learned from the United States. But at the very beginning of the post-war period the conditions for the rise of a new community of scientists and engineers interested in rocketry were very poor. Rocket technology had been totally banned by the Allied powers. The term 'rocket' was identified with Nazi crimes and devastating warfare; the idea of space flight suffered from the legacy of Peenemünde. Given these unfavourable conditions, it is rather surprising that a number of space activities started in the 1950s, even during the period of Allied restrictions (1945–55). Three events that later allowed West Germany to participate in the European cooperation in ELDO and ESRO (European Space Research Organisation) should be mentioned here.

Firstly, a number of space societies paved the way for a reinterpretation of space flight as a peaceful human endeavour. Institutionalised as *eingetragene Vereine* (registered associations), these civil, self-organised institutions did not break the Allied restrictions.

Former Peenemünde scientists and engineers successfully created a new space-flight community in the grey area between legal and illegal activities, consisting of a mix of professionals and amateurs. As early as 1947, for example, a group of space-flight enthusiasts emerged at the Technical University Stuttgart, which one year later was officially institutionalised as the Gesellschaft für Weltraumforschung (GfW, Society for Space Research). To comply with the Allied restrictions, the society tried to internationalise. In 1949 it approached a number of sister societies in other countries and proposed the idea of organising joint international conferences and founding an international federation. The internationally highly-respected British Interplanetary Society embraced these ideas and in 1951 the International Astronautical Federation (IAF) was founded.[23]

The main goal of the German society was to establish a space research institute in Germany, and this leads us to the second precondition of the later German participation in European space cooperation: the forming of networks of scientists in space sciences and rocketry. The GfW succeeded in using the international platform of the IAF to develop this aim further. IAF's first president was Eugen Sänger, a well-known expert in rocket and ramjet technology. Sänger had already established, in 1936/37, a research laboratory in the remote village of Trauen in Lüneburger Heide, which in the 1960s was developed into a rocket research centre working for ELDO. With enormous financial support from the Air Force, Sänger had built huge testing facilities for rocket and ramjet engines. In the early 1940s, he and Irene Bredt, who later became his wife, had drafted the concept for a visionary supersonic spacecraft, *Silver Bird*, an early version of the 'shuttle' idea. But more importantly for the Air Force, they also worked on a long-range bomber.[24] In July 1954 the GfW succeeded in officially establishing the Forschungsinstitut für Physik der Strahlantriebe (Research Institute for the Physics of Jet Propulsion) with Sänger as director, who returned from France, where he had worked after 1945. German companies such as Daimler-Benz were involved in the institute, but the bulk of research contracts came from US industry. German government too served as a stakeholder. The Federal Ministry of Transportation provided the basic funding for the institute. Minister Friedrich Seebohm thus tried to gain control over this new and promising field of transport technology.

The GfW also lobbied successfully for the foundation of a chair for rocket and combustion research at the Technical University of Stuttgart, which came into being in 1954. Like Sänger, a considerable number of other German rocket specialists, who had worked for the Allies after 1945, returned to the Federal Republic in the second half of the 1950s, among them Günter Bock and August Wilhelm Quick, who later became key figures in the West German space programme. Both held chairs at technical universities, and both also had leading positions in institutes of the rapidly-multiplying non-academic aeronautical research centres, which in the late 1950s gradually expanded their activities into space research.[25]

Parallel to the formation of a community of scientists interested in rocketry and spacecraft, a community of scholars interested in questions of astronomy, astrophysics and related fields – which later merged into space sciences – was also established. For example there was the Institute of Astrophysics of the Max Planck Society (MPE); its director was the astrophysicist Ludwig Biermann, who became known as the first to find evidence for the solar wind. In the early 1950s Biermann had already tested the 'possibility of creating a comet artificially by injecting suitable material into interplanetary space'.[26]

A third precondition enabling the later West German contribution to ELDO and ESRO was the creation of industrial competence. Recent historiography has shown that West German business had already started rocket development projects during the era of Allied restrictions. After the Korean War the Americans were keen to use West German industrial capacity for joint defence in the framework of NATO. In late 1953 the young company set up by Ludwig Bölkow, who in the Third Reich had done sophisticated design work for Messerschmitt, was awarded the contract for developing an antitank missile. The project was funded by the Dienststelle Blanck, predecessor of the Federal Ministry of Defence, which procured West Germany's armaments. This project gave a head start to the Ludwig Bölkow AG, which became the leading German aerospace and defence company, outflanking the older generation of well-known industrial firms such as Messerschmitt, Junkers and Heinkel. Bölkow's success was due to the constant support of Franz Josef Strauss, the Federal Defence Minister. He developed the concept of a state-supported industrial policy aimed at creating innovative high technologies as a counterbalance to Ludwig Erhard, whose reigning economic doctrine of 'Soziale Marktwirtschaft' favoured the market and kept the state out of business. Strauss's industrial philosophy of state interventionism favoured the aerospace sector especially, which was seen as a key technology stimulating the overall performance of any advanced national innovation system. Not by chance, the closely interlinked aerospace and defence industries became more and more concentrated in Bavaria's capital, Munich, Strauss's political base. And it was again Strauss who in 1961 enabled Bölkow to create a large complex of industrial research laboratories for the aerospace industry, the Industrieanlagen-Betriebsgesellschaft, next to Bölkow's production facilities to the south of Munich.[27]

Thus, when Sputnik was launched, provoking the United States to enter the space race at full speed, and European nations began to reflect on joining forces to further their own participation in the conquest of space, West Germany was at least partly becoming a competent partner. Actors in all parts of the triple helix – science, economy and the state – had resumed their own activities in the business of space. But these activities were not interlinked and coordinated. Space as a well-defined and politically-structured field did not yet exist, and it needed the European challenge to achieve this.

The formative period of West German space policy

When in the late 1950s the already well-established research institutes for aeronautics began to actively expand their scientific programmes into space research, state actors agreed that neither new institutional structures nor new scientific paradigms and methods were needed. Space was seen as a continuation of aeronautics at higher altitudes. When Germany's largest centre for aeronautical research, the Deutsche Versuchsanstalt für Luftfahrt (DVL), publicly announced the foundation of a new department for space research in 1959, it was again Defence Minister Strauss who strongly supported the proposal. He asked the DVL to coordinate all German activities in astronautics. Strauss advocated close cooperation with the United States, enabling German science and industry to catch up and gradually draw level with the cutting edge in this field of science and technology. In early 1959 Edoardo Amaldi formulated his famous memo 'Space research in Europe' and quickly gained support from other eminent European scientists such as Pierre Auger and Harrie Massey, but he opted for an alternative to transatlantic cooperation. The European and transatlantic options which were now on the agenda of political decision-making each met the interests of conflicting groups in the German government, categorised as the 'Gaullists' and 'Atlanticists', who constantly competed for dominance in foreign policy.[28]

But to begin with, the German government was not at all prepared to play its part in the emerging European cooperation. This was clearly shown when all countries participating in the Geneva conference of 28 November to 1 December 1960 signed the agreement to set up COPERS, except West Germany. This didn't mean that Germany was reluctant to support the foundation of ESRO, but members of the government had failed to work sufficiently closely to clarify their position. This became even more embarrassing when the British Minister of Defence, Peter Thorneycroft, visited Bonn in January 1961. Speaking with four ministers of Adenauer's cabinet, he was confronted with four different positions. This led to negative comments in the German press and the demand for a clear statement from the chancellor.[29]

In January 1962, when the whole of Europe was looking towards Bonn, Adenauer gave his final word. He added responsibility for space to the remit of the Federal Ministry of Atomic Energy, which consequently was renamed the Federal Ministry of Scientific Research one year later. But this was only a half-hearted decision, because he also installed an inter-ministerial coordination committee, which led to a complex and time-consuming decision-making process. It is not surprising that industry heavily criticised this complicated political construction, especially as German space policy in the following years showed – and continues to show even today – a scientific bias that often disregarded the opportunities for an active industrial policy.

The decision also had a long-lasting effect on how space programmes were managed. In 1962, using the American example of non-profit corporations and trying to adopt the management procedures that had been developed in the US in the meantime, the Federal Research Ministry established the Gesellschaft für Weltraumforschung as an independent administrative body. But the ministerial bureaucracy kept this institution under firm control and never granted it the autonomy it would have needed to manage large-scale space programmes efficiently. This was only the first link in a long chain of mistakes in managing space projects.

During the crucial year of 1961 it was not at all clear whether the Federal Republic would finally join ELDO. When the government asked a group of distinguished experts to comment on the British–French proposal to build a launcher based on the British Blue Streak as first stage and the French Coralie as second stage, the response was negative. The experts criticised the technological backwardness of the projected launcher Europa I in comparison with the American launchers. They came to the conclusion that neither science nor industry in Germany would profit from the project (Figure 5).

It was purely for political reasons that government remained involved. Firstly, the European venture legitimised Germany's re-entry into the field of rocketry, which still suffered from the historical burden of Peenemünde. Secondly, as prime mover of European unification, West Germany was forced to consider seriously any initiative that would strengthen Europe, particularly if the initiative was co-launched by the most reluctant partner, Great Britain.
The German government thus declared it was interested in the Europa I project, but with two conditions attached: firstly, there must be close cooperation between Europe and NASA and, secondly, there must be a careful re-examination of the scientific, technical and financial conception of the project by teams of experts from Britain, France and Germany. When the teams met in late April 1961, the British and French delegates presented well-prepared papers with a much more transparent breakdown of costs than had been seen before and a long list of benefits resulting from the joint effort. Günter Bock, the head of the German delegation, was so impressed that he and his colleagues changed their minds – and so did the formerly more sceptical politicians. Even the Federal Defence Ministry was now in favour of a joint European effort, particularly as in the meantime the US government had shown its unwillingness for open bilateral cooperation on an equal footing.

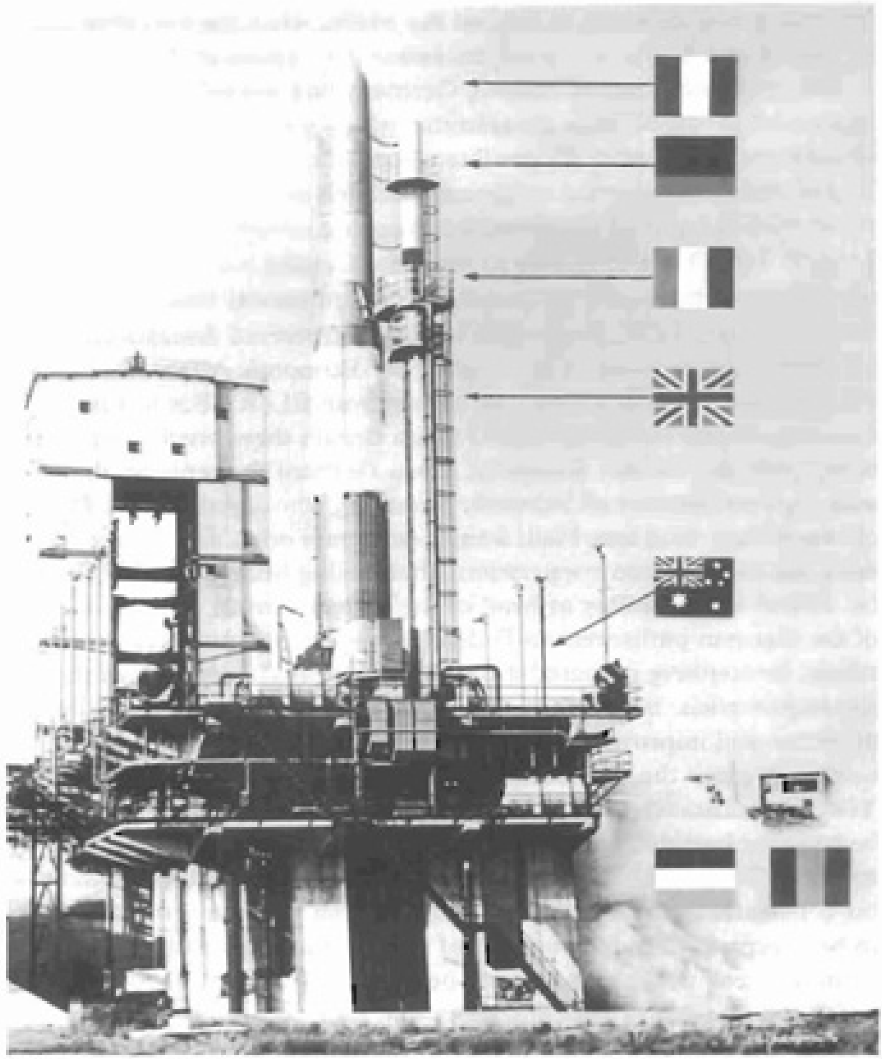


Figure 5 The share of work in European space activities: the flags and arrows show the responsibilities of the various nations participating in Europa I, which originally was planned to have its first launch in 1966 from the Australian launch site at Woomera. (Archives of the Deutsches Museum)

The German scientific experts had accompanied their vote for the Europa I project with the warning that only a forceful national programme would allow the German space community to be an equal partner of France and Great Britain. The aerospace industry gave the national programme even more priority. When in July 1961 science and industry joined forces to found the Kommission für Raumfahrttechnik (Commission for Space Technology), they were driven by the fear that the resources provided by the German government would only go to international institutions and have little effect on the home country. Ludwig Bölkow demanded that the national programme should be 'at least twice as large as the expected German contribution to the Blue-Streak-project'.[30] Here, Bölkow formulated a relationship between nationalism and internationalism which developed into a set of guidelines for the aerospace industry for the following decades.

But reality was different, at least in the 1960s, when the contributions to ELDO and ESRO exceeded the national programme.[31]

From the early days of ELDO, Germany had strongly favoured a more sophisticated future programme, which would meet the needs of the emerging market for satellite communications. During the ELDO intergovernmental conference in Paris on 19–21 January 1965, the French delegation suggested leapfrogging straight to ELDO B, because ELDO A was unable to meet the Gaullist aim of breaking the American monopoly of launchers for commercial satellites. In Germany, the ELDO crisis again led to controversial discussions on the French proposal. The Ministry for Economic Affairs, for example, voted for an immediate retreat from ELDO. But it was Germany which stabilised ELDO when Britain threatened to withdraw completely in 1965/66. Ironically, it was Gerhard Stoltenberg, the new Federal Minister of Scientific Research, who saved ELDO. He changed from Saul into Paul, from a deliberate critic to a strong advocate of European cooperation, after having been promoted from his former responsibility as head of the budget control committee of the German parliament to Federal Minister responsible for space affairs. Stoltenberg prepared a compromise to find a way out of the immediate crisis. Based on the ongoing programme, a substantially modified and improved rocket, ELDO B/Europa II, which would be able to place the ESRO and CETS (Conférence Européenne des Télécommunications par Satellites) satellites into high orbits, should be built for launch from Kourou. One week in advance of the decisive meeting of the ELDO Council, Stoltenberg succeeded in convincing his colleagues in the German government that this compromise had to be accepted, despite a number of good arguments against it from scientific, technical and economic perspectives.

On the first day of the conference that took place in Paris on 26–28 April 1966, the ELDO Council agreed on Stoltenberg's compromise. Germany had to pay a considerable price for this political success: the German share of the ELDO budget rose from 22.01 per cent to 27 per cent, whereas the British financial load was reduced from 38.79 per cent to 27 per cent. The German intervention came nowhere near to ending the almost constant crisis of ELDO, as Great Britain's reluctance to engage further in European launcher development showed.[32] But Germany had again convincingly demonstrated its role as a motor of European space cooperation.

Astris: a political artefact

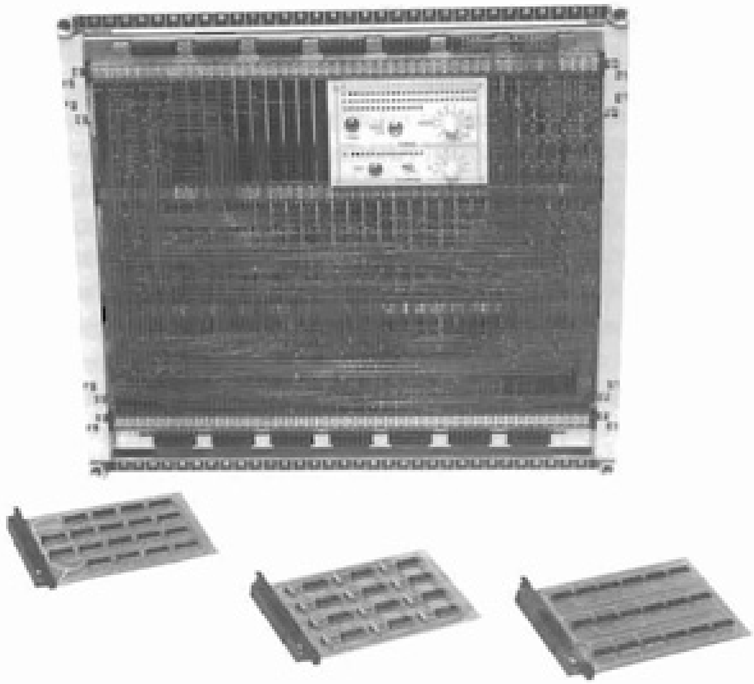
During the 1960s, the Federal Republic of Germany convincingly demonstrated its role as motor and catalyst of European unification in general and as an actor in space in particular. This role was reliant on German taxpayers and the neglect of other fields of science and technology policy, but in the long run it kept open the door to a

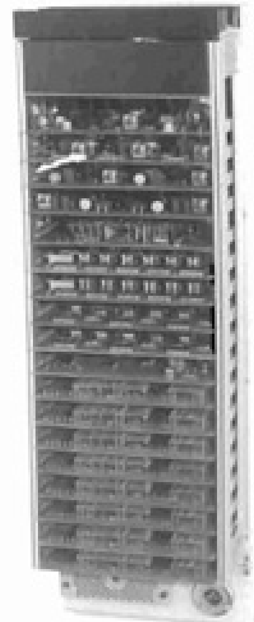
Europe in which scientific knowledge and technology capabilities served as cognitive and material bases for growing societal integration.

Thus, the domination of space research activities by political factors was an important prerequisite in establishing Europe as a powerful force in space. With its family of Ariane rockets, ESA, the institutional successor of ELDO, developed a highly-competitive and technically-reliable system of launchers that succeeded in the rapidly-expanding market for research and communication satellites. Ariane became a political icon of successful cooperation and integration in Europe.[33]

But the learning curve Europe had to climb was steep, and achieving this success was painful and costly. As we have seen, ELDO is a classic example of the failure of a big technological project. When in May 1972 the Aubinière commission published its report on the disastrous explosion of Europa II on test flight F11, it became evident that ELDO had failed because of its political character. The report vividly criticised the inadequate organisation of ELDO and its poor management structure. It emphasised the weak position of the ELDO secretariat, which had no say in the central task of contracting. How contracts were awarded for their respective parts of the joint launcher was the *arcanum imperii*, the prerogative of politics. The national governments jealously controlled their financial investments in ELDO so that these were returned as contracts for their national research laboratories and industries. This policy of *juste retour* (fair return) was identified early on as a key misconception of European 'cooperation' in space.[34] Rather than fostering transnational collaboration from the bottom up, the member states sought to acquire as much knowledge and resources produced in the joint undertakings as possible, in order to strengthen their economic positions in the international markets.

The supranational body of ELDO continued to organise its institutional structure in a way that reflected the concept of the nation state which had dominated European history for many centuries. This orientation resulted in a fatal technical problem that manifested most significantly in Astris. The disastrous performance of Astris on test flights F7 to F11 resulted from the poor communication between the British contractor Marconi and its German corporate counterparts. But it also resulted from communication barriers within the German industrial partnership. Lack of coordination led to a technical design which obeyed 'none of the elementary rules concerning separation of high and low level signals, separation of signals and electrical power supply, screening, earthing, bonding, etc.'[35] Eventually, none of the participating firms was willing to bear responsibility for these failures, not even the Arbeitsgemeinschaft Satellitenträger (ASAT), which was created by the German government specifically for the task of coordinating the work of Messerschmitt-Bölkow-Blohm (MBB) and Entwicklungsring Nord (ERNO) on Astris. Eventually, the small company ASAT could not bridge the traditional tensions between





Figures 6 and 7 Large-scale technological projects often fail at the level of small-scale artefacts. A rubber ring that began to leak at low temperatures led to the Challenger *Space Shuttle catastrophe, and malfunctioning electronic devices, such as the ones here, caused the disastrous test flights of Europa I and II. But eventually the demise of ELDO resulted from its inadequate transnational organisation and its poor management structure. (Archives of the Deutsches Museum)*

MBB und ERNO and so become freed from government control (Figures 6 and 7).[36]

The strong coupling of science and politics which marked German project management found its continuation at the next level of space administration. In August 1962, the Federal Research Ministry's Gesellschaft für Weltraumforschung, which had been deliberately established that year as an independent body to be in charge of overall space project management in West Germany, was unable to free itself from political authority and interference. Despite all efforts to reform the institution, in the eyes of industry it remained a body which was controlled by government and worked alongside political actors.[37] In 1972, the German government reacted to the Europa II disaster by integrating the project management authority into the National Laboratory of Aeronautics and Space Research, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt. This proved to be no more appropriate as a way of ensuring efficient project management. In the mid-1980s, the federal government was again forced to reform the institutions to take account of fierce criticisms from industry. In 1987, the government founded the Deutsche Agentur für Raumfahrtangelegenheiten to be in charge of space management, without really decoupling space science and space politics. The political administration's withdrawal from interfering was only half-hearted, which meant that project management for space activities remained a major issue on the national agenda into the 1990s. In 2000, the government returned to the solution of integrating the space management authority into the National Laboratory for Aeronautics and Space, which in the meantime had been renamed the Deutsches Zentrum für Luft- und Raumfahrt.[38]

Astris reflects the strong bond between science and politics which is said to characterise knowledge societies since their early beginnings in the scientific revolution of the early modern period.[39] Moreover, Astris, as a political artefact, reflects the tendency of (post)modern knowledge societies to undermine the status of science as the unique method for gaining truth. For science and politics are said to have acquired equal epistemological standing as preferred sources of truth.[40] Last but not least, Astris reflects a decisive element of innovation processes in advanced innovation systems, as the cost of Germany's participation in ELDO to produce the artefact Astris had to be covered by German taxpayers. In high-risk big technological projects it is the state which is forced to bear political and financial responsibility, while corporations come on board late in the day at comparatively low risk.

Finally, to close the loop, this chapter has to return to the idea of talkativeness as a conceptual tool for analysing material objects in general and museums' artefacts in particular. As shown, the talkativeness of a specific object manifests in the multiple cultural narratives which it offers to its observers. And in fact, a closer look at Astris' material and cultural performance has identified a multiplicity of narrative strands of which only one, if not the most significant one, has been outlined here in depth: its character as an artefact resulting form a big technological project which was shaped by political forces and political actors.

Conclusion

Historians and cultural scientists have begun to acquire the methodological ability to listen to talkative artefacts and to cope with the multiplicity of their narratives. Museum curators have started to develop sophisticated methods of using talkative artefacts, which often are overcharged with myth and cultural meaning, to convey such interpretations of history to visitors.[41] But what do we know about the scientific, technical and cultural literacy of an average museum visitor, what about the ability of various visitor groups to listen to talkative artefacts? Can talkative artefacts generate dialogue and what are the constituting factors to foster such a dialogue between unequal partners: the place of a given artefact, within an exhibition, its conceptual contextualisation, its materiality?

In fact, these are open questions on which museums need to reflect further. Such concerns are all the more important, as museums perceive their material heritage, their artefacts, to be powerful conveyers of not only scientific and technical expertise, but also historical and cultural knowledge.

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