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The BepiColombo ‘model’: looking beyond the ‘original’

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The BepiColombo ‘model’: looking beyond the ‘original’
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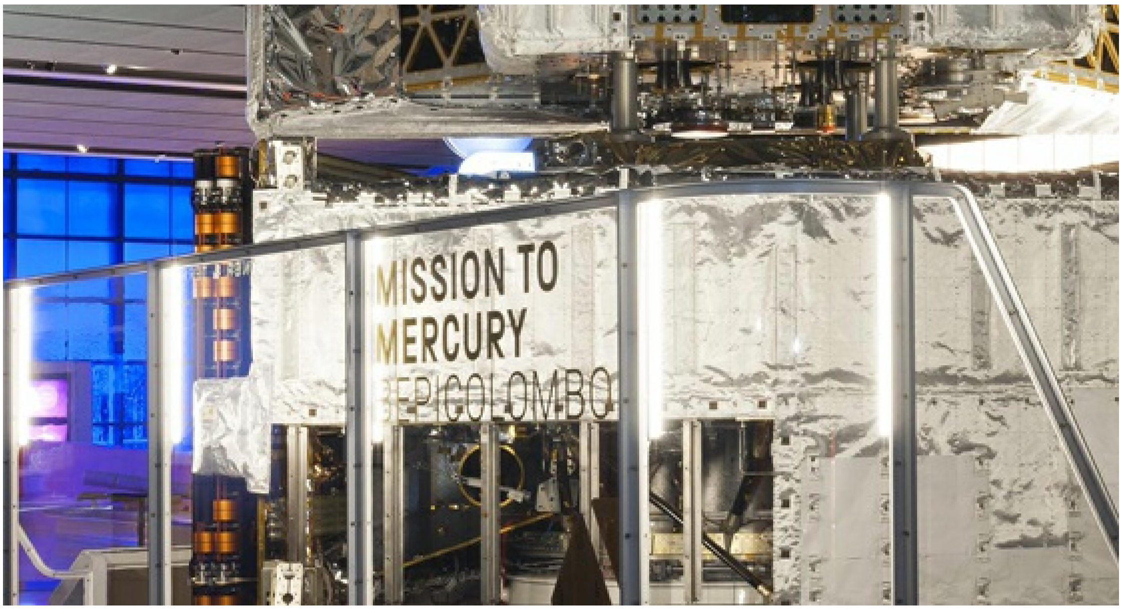

Abstract

This paper examines the role that models and replicas typically play in aerospace museums, which is to use them as references for the original or final product. Using the BepiColombo Structural Thermal Model currently on display at the Science Museum as well as other models in the *Exploring Space* gallery as examples, this paper argues that looking at models as objects in their own right offers more diverse and inspiring narratives for visitors. It presents opportunities to showcase the complex development process for space technology, uncovers surprising stories, and helps to debunk the traditional narrative of progress and advancement that science and technology museums often adopt. BepiColombo is a joint mission to Mercury developed by the European Space Agency (ESA) and the Japan Aerospace and Exploration Agency (JAXA).

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Keywords

models, replicas, aerospace museums, museum interpretation, museum display, Science Museum, BepiColombo, Soyuz, object biography

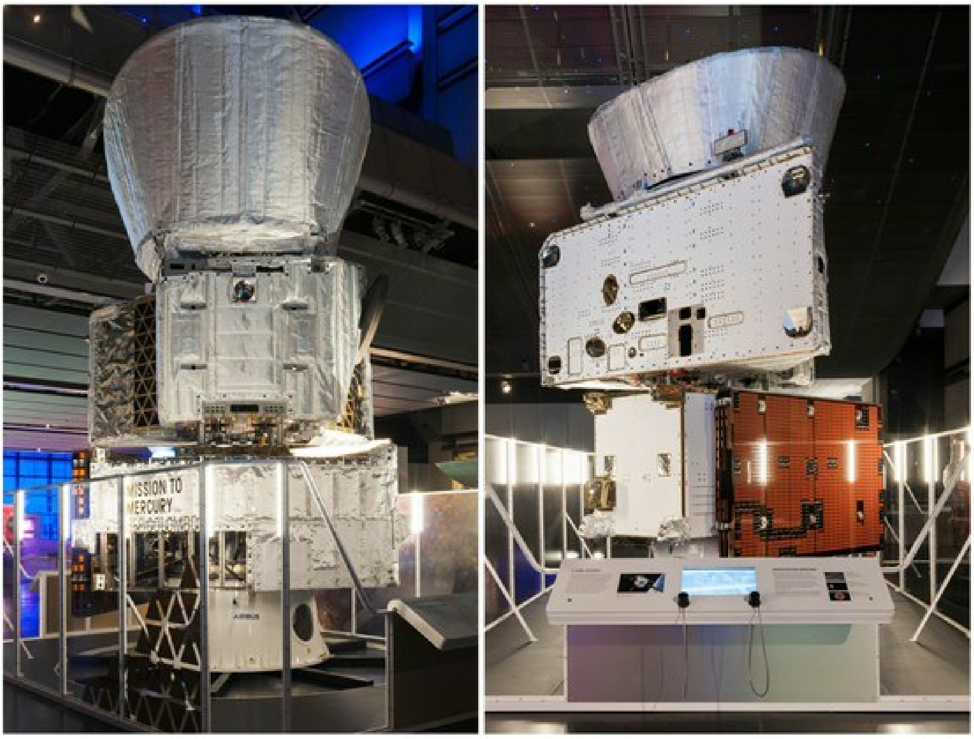
Introduction

The BepiColombo spacecraft is currently on a journey to explore Mercury, a planet named after the Roman god of travellers and luck. The mission gets its name from Italian mathematician and engineer Professor Guiseppe ‘Bepi’ Colombo, who contributed influential work on planetary orbits and gravity assist manoeuvres which were particularly relevant to reaching Mercury. BepiColombo launched on 20 October 2018 and is now nearly four years into its seven-year journey through outer space. It will then spend at least two years observing Mercury. In May 2018, the Science Museum put the BepiColombo Structural Thermal

Model (STM) (see Figure 1) on display in its Wellcome Wing, which is dedicated to contemporary science. This is one of many different types of models currently on display in the Museum.

This paper will examine the important role that models play in space galleries, through a recent case study as well as scholarship on the use and display of models and replicas in science and technology museums.[1] The main case study is the current display of the BepiColombo STM, on loan to the Science Museum from the European Space Agency (ESA). I will also compare the interpretation of BepiColombo to other space gallery objects and exhibits, both current and past. I argue that models in space galleries are often overlooked as significant objects in their own right. Models are compelling artefacts, which elicit fascinating narratives but are too often ignored in traditional space galleries. In fact, at the European Space Agency, each version of the spacecraft is referred to as a model. For example, a typical series of models built for a mission would be a Structural Thermal Model, Engineering Model, Qualification Model, and Flight Model. Each is designed to serve a specific purpose in a space mission, and one is not given a more authentic status over another. Aerospace museums can learn from this approach. Models are viewed as inauthentic only if museums interpret them as such.

Figure 1



BepiColombo Structural Thermal Model on display at the Science Museum, London

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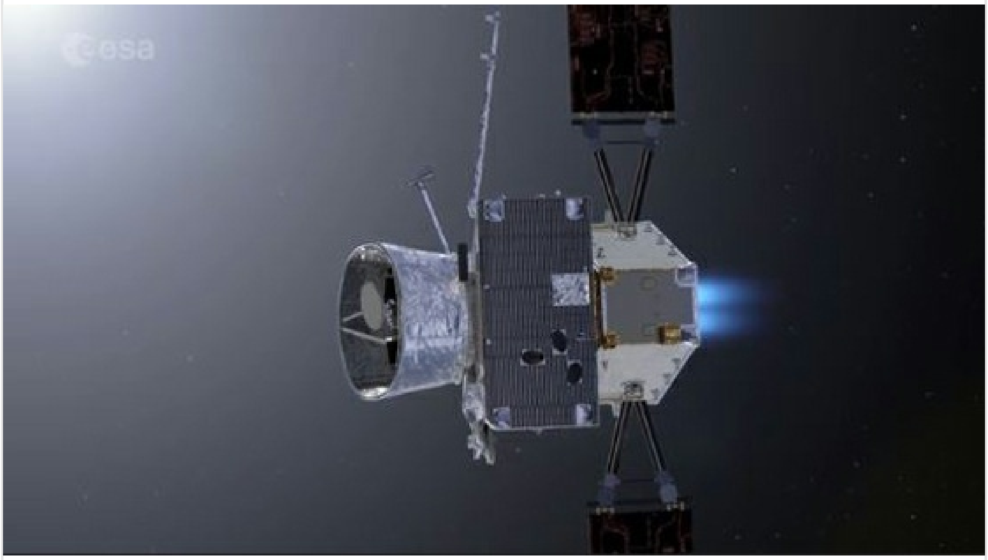
The BepiColombo STM

A Structural Thermal Model (STM) is designed to test the structural strength and thermal resistance of a spacecraft. During launch, spacecraft are put under immense strain with intense horizontal and vertical vibrations. Each structural element must be tested to ensure that the flight model will survive these launch forces. The STM is attached to a vibrating table and is shaken at different intensities. These vibrations are 25 per cent stronger than those expected at launch (European Space Agency, 2018). The STM is also used to verify the thermal efficiency of insulation blankets, heat resistant coatings and solar reflectors. The model is tested in the Large Space Simulator, which mimics the extreme temperatures in space.

The BepiColombo 'stack' is made up of four main modules.[2] The bottom module is the Mercury Transfer Module (MTM), which houses four solar electric ion thrusters used to power the journey to Mercury. The second module is the Mercury Planetary Orbiter (MPO), which is the satellite developed by ESA that will orbit Mercury, examining the interior and exterior of the planet. The other two modules are the MMO Sunshield and Interface structure (MOSIF) and the Mercury Magnetospheric Orbiter (MMO), which was developed by the Japan Aerospace Exploration Agency (JAXA) and will examine Mercury's magnetic field. The sunshield is designed to protect the MMO from solar radiation and high temperatures during the journey to Mercury.

Video 1



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BepiColombo launch to Mercury

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The BepiColombo STM began its life as a testing model in 2010 when JAXA's Mercury Magnetospheric Orbiter and its sunshield underwent thermal testing in ESA's Large Space Simulator in Noordwijk, The Netherlands. The Mercury Planetary Orbiter was then tested in September 2011, followed by the Mercury Transfer Module in 2013 (Wilson and Schelkle, 2015, p 11). The Multi-layer Insulation (MLI) blanket was particularly critical in these testing stages. Mercury is the closest planet to the Sun so any spacecraft travelling there will face temperatures up to 400°C as well as radiation levels ten times those found in Earth's orbit. Prior to the development of this insulation blanket, there was no existing technology sufficient to withstand the thermal environment that BepiColombo will face. These tests revealed that the MLI was not performing well enough. One problem was too much heat leakage around the sewing lines used to attach the blanket to the system of rails, which secure it to the spacecraft (Ferrero et al, 2016, p 6). The team undertook extensive brainstorming and testing to try and solve the problem. One experiment included attaching a few titanium panels to the outside of the MLI at the bottom of the Transfer Module. Though this was not ultimately successful, the titanium sections used for testing are still visible on the STM in the Museum. In the search for a solution the rail attachments were removed and further layers were added to the blanket. This was then re-tested in the Large Space Simulator to verify that the solution worked. In discovering this thermal failure, the STM functioned exactly as it was designed to. The uniqueness of elements like the visible titanium panels on the STM demonstrate the significance of this object and set it apart from the Flight Model.

Engineers are clear on the importance of discovering this thermal design failure: 'The system verification program, based on an STM and followed by a PFM [Flight Model] was the right option for a program with so many technological challenges. In fact, it allowed [us] to discover several shortcomings in the thermal design of the MPO that were successfully corrected on the final PFM design' (Ferrero et al, 2016, p 8). The thermal design of BepiColombo is complicated and completely unique, and the extensive testing on the STM is integral to the success of the mission. It is on this object that mistakes are made, lessons are learned, and solutions are tested and confirmed.

BepiColombo STM is almost fully representative of the flight model in terms of its structure.[3] They are the same size and approximate weight. Their appearance is also similar – four modules connected in a stack formation. Just about everything on the STM is done to flight specification. From the screws to the heat pipes, to the protective coatings on the antenna. Of course, there is value in their similarities. However, there is also significance in their differences. It is these differences that we wanted to celebrate in the display and interpretation of this object.

The traditional Museum narrative around the object would be to discuss Mercury, the mission, and what scientists hope to discover about the planet. But the STM allows the museum to tell a different narrative surrounding planetary exploration. The exhibit gives a fuller picture of the methods engineers use to ensure the success of a planetary mission. It reveals the challenges engineers face and what it takes to overcome them. It shows the complexities of spacecraft development and the importance of vigorous testing to ensure mission success.

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Soyuz descent capsule and BepiColombo

The STM arrived at the Museum not long after the purchase and subsequent display of the Soyuz TMA-19M spacecraft (see Figure 2) that transported Tim Peake and his fellow astronauts to and from the International Space Station in 2015/16. The STM went on display in May 2018, in the same space that Soyuz had occupied in 2017, before it went on its UK tour.

Figure 2

Soyuz TMA-19M on display in the Science Museum, London

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When contemplating how best to display and interpret the six-metre tall spacecraft, the content team based the layout of the text, photographs and video on the previous Soyuz display. Their similarities made this a natural comparison object: both were contemporary spacecraft and would occupy the same display space in the Museum. We quickly came to realise, however, that the interpretation of the BepiColombo STM needed to be different from Soyuz in some key ways. Soyuz carried people, one of whom was British astronaut Tim Peake, which meant that many members of the public had heard of the mission (called Principia). The capsule was a flown object; it had been to space and back and had the charred surface to prove it. The purpose of the spacecraft was relatively simple: safely carry the astronauts and cosmonauts to and from the International Space Station.

BepiColombo, however, is a planetary mission, not a human one. Its goals are more complex: no less worthy than Principia, but trickier to communicate to the public. A significant amount of background information is needed to understand the full value of the mission. BepiColombo's name recognition was also limited in comparison to Peake's. Finally, and perhaps most significantly, the STM will not fly. These considerations made the gallery interpretation more challenging than was initially expected and the content team was forced to think about what makes the BepiColombo STM exciting, interesting and unique. Also, we had to ask ourselves, how do we tell an engaging story about a planetary mission with a version of an object that visitors may not consider to be 'the real thing'? The complexity of the object in fact provided a great opportunity. It offered alternative avenues of interpretation that allowed discussion of other facets of the aerospace industry, such as the importance of a working model in spacecraft development. It allowed us to celebrate the STM as both real and significant.

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Models in science and technology museums

Various scholars have examined the use of models and replicas in a variety of disciplines, including archaeology, art, medicine and engineering; but there is little discussion surrounding the display of models in aerospace galleries, despite their prevalent use in exhibitions.[4]

Figure 3

The former *Shipping* gallery at the Science Museum, London

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Museums often display models in their exhibitions and galleries. Using copies of objects can be very advantageous. Some models allow museums to display and interpret objects that would otherwise be too large to have on gallery; for example, a ship model (see Figure 3). Sometimes a model is all that is left of its original; for example, the models of the receiving towers for the early warning radar system during the Second World War, codenamed 'Chain Home' (object no. 1962-365) on display in *Mathematics: The Winton Gallery*. The real towers no longer exist and even if they did, they would be too large to display indoors. Copies are also displayed when the original is difficult to get a hold of; for example, the world's first commercial communications satellite, Telstar (object no. 1983-273), of which there is a replica on display in *Information Age* (the original is still in Earth's orbit). Or a display might include a working copy, designed to show how the original object operated; for example, the Ørsted apparatus (object no. 1983-478) also on display in *Information Age* (see Figure 4) demonstrates the effect of an electric current on a magnetic needle. It is standard for museums to use models as a stand in for the original. However, attention is not always paid to the model itself: who made it? Why? Where was it made? Whose hands has it passed through? The Model Walkway in the Science Museum, an upper level corridor in the *Making the Modern World* gallery, is an exception to this. In this display, the models are given a dual interpretation: they are presented as important original objects, while also referenced in terms of their connection to the final model.

Figure 4

Ørsted's apparatus for showing the effect of an electric current on a magnetic needle. This instrument was likely used at lecture demonstrations in London

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In the book *Models: The Third Dimension of Science*, Hopwood and de Chadarevian argue that three-dimensional models in science, technology and medicine help tell a fuller story of these disciplines. Studying how they were made and used helps give a fuller understanding of both the making process and the final product (Hopwood and de Chadarevian, 2004, p 12). In science, models are not the end product, but often the starting point. They help the maker solve problems as they work. British engineers James Watt and John Smeaton created models to test concepts and fix problems. Ship models were created to prove that a solution would work before carrying out construction on the original (Schaffer, 2004, p 72). Artists have also used mannequins for at least 500 years to help create a composition or for drapery studies (Munro, 2014, p 6).

Arguably, aerospace museums rely more heavily on models for galleries and exhibitions than other subjects, in part because collecting from space industries is particularly difficult. The development of the temporary exhibition in 2015, *Cosmonauts: Birth of the Space Age*, is a compelling example of the complexities of collecting space technologies. Ian Blatchford and Natalia Sidlina reflected on the challenges of the exhibition in the *Science Museum Group Journal*:

> Whilst museums were certainly an important part of this project, the really ground-breaking element was persuading commercial and government space bodies – normally with no experience of lending – to engage with and endorse loan requests. Furthermore, in some cases we were to discover that even though key objects were located in these organisations it did not mean that they actually held ownership of them (Blatchford & Sidlina, 2015).

Companies producing space technology tend to be large organisations with a lot of bureaucracy. Work is often subcontracted, making technology ownership difficult to untangle. Materials are often reused: Soyuz, for example, does not have its original main instrument panel because the Russian space agency, Roscosmos, wanted to reuse the hardware. It is also possible they did not want their technology on display outside of Russia as space agency work has historically been secretive and classified – for example, during the Space Race in the latter part of the twentieth century. Space technology objects also tend to be large. Satellites can range drastically in size, and rockets, engines, capsules and solar panels often occupy a large footprint either in a gallery or in storage. The International Traffic in Arms Regulations (ITAR) is a US regulation controlling the manufacture, sale and distribution of defence and space-related articles. This regulation controls the movement of spacecraft from the US, creating further paperwork and delays. The Eurostar 3000 satellite (object no. 2014-103) on display in the *Information Age* gallery, for example, had to be approved for transport to the Science Museum (see Figure 5). It nearly did not arrive in time for the exhibition opening as ITAR approval was delayed due to a US government shutdown.

Figure 5

Eurostar 3000 on display in *Information Age* at the Science Museum, London

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Additionally, these objects were not designed for Earth; they were designed to operate weightless and in a vacuum, meaning that displaying them on Earth can require significant support and extra expense to ensure they are structurally sound and safe for visitors. When planning the BepiColombo STM display, there was a discussion around whether the attached solar array could be shown fully open as it would be during its journey to Mercury, rather than folded up as it would be at launch. This was not feasible for a number of reasons, not least because the length of the array would mean that visitors would have to duck under it. Even if the array was partially deployed, the weight of it meant that it would have to be specially suspended so as not to unbalance the STM stack.

Lastly, when a museum does happen to get its hands on a piece of hardware that has been to space and back, it is usually expensive. Even if the object is gifted, it is still costly to have it shipped and specially installed. It is also important to note that the most exciting objects developed by these industries usually do not come back, but remain in orbit around the Earth, on the Moon or on Mars, or burn up on re-entry into Earth's atmosphere.

Looking particularly at objects used for review and development, like engineering models and STMs, allows museums to discuss the challenges and failures that many space missions face during the lifetime of a project, moving away from the false narrative of progress and advancement that science and technology museums have historically adopted.

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The role of R&D models in 'public sciences'

A look at the scholarship surrounding the use and display of models in museums can help put the BepiColombo STM and other aerospace models into further perspective. Percival Marshall (1902, pp 3–14) argued as early as 1902 for the importance of collecting engineering models for museum display. Of course, the engineering models he referred to were not developed by space agencies, but there are close similarities. As in space technology, Marshall saw the importance of using models to exhibit work that is too big or still in use, such as ships, docks, piers and bridges. He especially believed that the strength of the model lay in its ability to demonstrate the development and features of engineering to non-specialists. Inventors perfected their ideas on working models, ensuring that the final product would work efficiently. These reasons all make engineering models strong display objects, with stories of their own to tell.

Foster and Curtis's article, 'The Thing about Replicas—Why Historic Replicas Matter', also offers an interesting lens with which to examine the BepiColombo STM. Foster and Curtis focus primarily on reproductions of archaeological material, however (as was their intention), much of their argument can be applied to other museum subjects, including space technology.

The object biography of the replica and the original allow historians to study the reach of the 'authentic original': 'We can trace and consider the extended agency of the authentic original thing, including artefacts that might not have moved (far) from where they were first erected (e.g. an Irish high cross), while direct copies might make their way around the world' (Foster and Curtis, 2016, p 131). The reach of the originals and the copies, who comes into contact with them, how they are used or displayed, give a more complete biography of the original object. Applying this approach to BepiColombo, the 'authentic original' (the Flight Model) leaves the Earth, flying past planets and sending images and data back to us. The copies, replicas and models are left behind to be used for education, research, promotion and gifts. BepiColombo therefore does not just exist in space for scientists, but it also resides on Earth for the general population. When engineering models like BepiColombo are no longer needed, they are often discarded, with some parts being reused for other missions. This display of space objects in a museum allows the spacecraft an extended existence, performing the function of engaging public interest and enthusiasm for space travel and exploration. Aerospace museums are therefore a critical element of financing human and planetary space flight, helping to generate new engineers and scientists. Thus, there is a strong argument that models should be actively included in displays and galleries, not just because flown objects are not available, but because the models themselves are significant, unique and inspiring.

The BepiColombo STM has had its life extended at the Science Museum. In its original existence, it was designed and built to test the thermal and structural strength of the spacecraft. It was a tool used exclusively by engineers and scientists with the sole purpose of ensuring the success of the mission. With the model's transfer to the Museum, its meaning and interpretation have changed.[5] For visitors, this is the only BepiColombo they will ever see. While the Flight Model is making its way through the Solar System towards Mercury, the STM remains bound to Earth and provides another avenue for visitors to engage with the mission, engineering and science. Its audience has changed from a small group of engineers to hundreds of thousands of museum visitors over its lifetime on display. Now, it is a tool for inspiration and education. Its presence in the museum enables us to tell the story of BepiColombo – from the many engineers and scientists that worked on the project, to the kind of testing that spacecraft undergo before launch. We can also tell the traditional story of the Flight Model – when it launched, where it is going, why it is going and how difficult it is to get there.

As the Flight Model travels to Mercury, further interpretation avenues open for the STM on display in the gallery. As Foster and Curtis (2016, p 133) wrote: 'These stories illuminate the networks of people, places, and things, enfolding the contributions of many people and materials, to inform our appreciation of their legacies. In this sense, the difference from the original becomes a biographical aid and virtue rather than an aspect that diminishes the value of the replica, in a materialist sense.' As BepiColombo travels to Mercury, we can tell the story of its journey including where it is and what it is doing. We can overlay interpretation of the model to relay problems, successes and milestones to members of the public. When it arrives at Mercury, we can discuss the scientific instruments, what data they are collecting and how scientists might use it to discover more about the planet. We may get some images from the instruments that we can show the public. All the while, BepiColombo's identity changes within the museum, including the way visitors see it and how the museum continues to interpret it.

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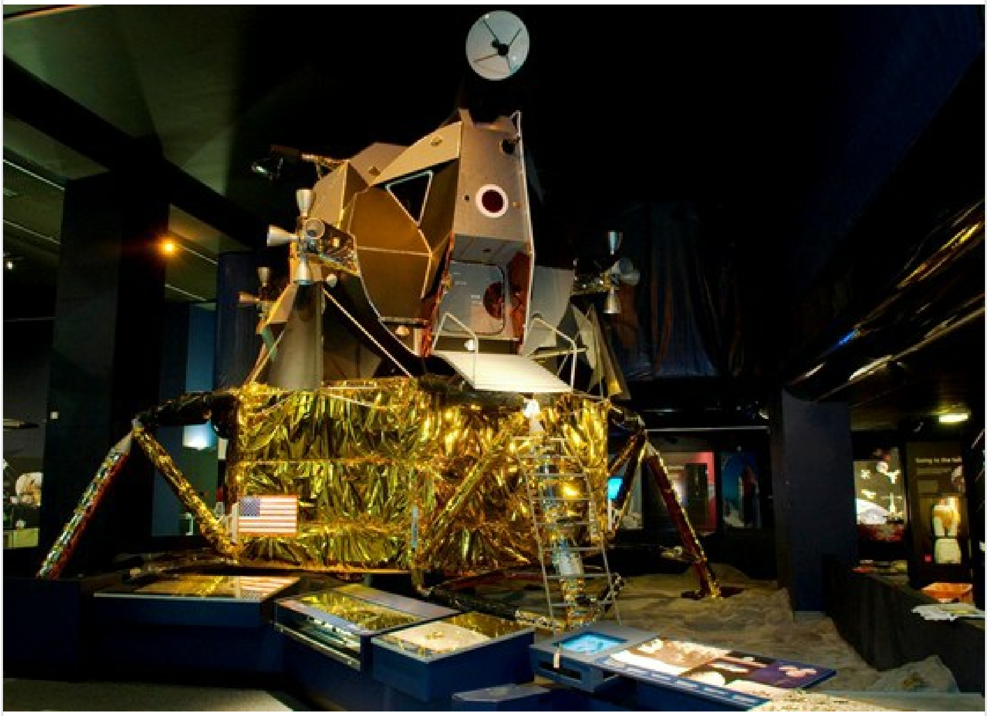
A future space gallery

Developing the content for BepiColombo's display in the Museum has highlighted further interpretation opportunities for other models displayed in space galleries. In the Science Museum's *Exploring Space* gallery, for instance, models are almost exclusively described as 'an example of', 'a replica of' or 'a model of'. Only occasionally are these models interpreted as objects in their own right. Though no audience research has been done on the Science Museum's space gallery, there has been research done on *Cosmonauts: Birth of a Space Age*. Results from the audience research suggested that visitors were unsure which objects in the exhibition were real and which ones were models or replicas. Visitors thought that the engineering and illustrative models were interesting, but not as compelling as 'the real thing' (Fisher, 2016, p 25). I suggest that by interpreting objects in their own right, they can become 'the real thing'.[6]

Figure 6



Apollo 11 Lunar Module, 'Eagle' on display in the Science Museum, London

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When considering the display of objects relating to space, using this approach would be novel. Celebrating a collection of models as objects in their own right would, I suggest, be an exciting experience for our visitors and would allow museums to tell a diverse set of stories about the aerospace industry. For example, the Apollo 11 Lunar Module, 'Eagle', (see Figure 6) currently on display in *Exploring Space*, was originally constructed by Pinewood Studios for the Museum in the 1970s. It is unusual to find a film studio as the maker in a space gallery and the circumstances surrounding this acquisition are not explored in the interpretation. It is possible to imagine another interpretive narrative in which this replica could help to illustrate the representation of space travel and exploration in popular culture. Space agencies like NASA are often directly linked with film productions, such as Ridley Scott's 2015 production of *The Martian*. They provide expert advice and at the same time the film provides NASA with a broad platform through which to reach members of the public, generate support and inspire new generations of scientists and engineers. It could be argued that viewing the Lunar Module and understanding more about the link between space technology and film is a more surprising and engaging narrative than just its relationship to the real lander.

By examining the object history of models like the BepiColombo STM, museums can give a fuller picture of technological development in the aerospace industry. They can reveal the process engineers and scientists must undertake to launch a spacecraft. Other, less obvious narratives become clear too, such as the ways in which space agencies communicate their ideas to the public and how they try to generate funding and support. Models allow aerospace museums to give visitors a fuller picture of the entire space industry. Museums could do more to tap that potential.

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Tags

- Exhibitions

- Museology
- Curating
- Science museums
- Space exploration
- Object display
- Scientific models
- Object interpretation

Footnotes

1. 'Replicas' and 'models' have different definitions for different academic disciplines. This paper concentrates primarily on the meanings of models and replicas in the context of space technology.
2. The BepiColombo STM and Flight Model were built and tested by Airbus; the company was also integral to the installation of the STM at the Science Museum in 2018.
3. The BepiColombo STM on display is missing the Mercury Magnetospheric Orbiter (MMO) STM developed by JAXA as they wished for it to be returned to Japan when testing was completed. It would have sat inside the sun shield, hidden from view from visitors so its removal does not compromise the display.
4. For further reading on models in other disciplines, see Hopwood, N and de Chadarevian, S (eds), *Models: The Third Dimension of Science*. For archaeology see Foster, S M and Curtis, N G W, 2016, 'The Thing about Replicas—Why Historic Replicas Matter,' in the *European Journal of Archaeology*; for art see Munro, J, 2014, *Silent Partners: Artist and Mannequin from Function to Fetish*; for medicine see Bailey, M, 2019, 'Modelling life', McEnroe, N (ed), *Medicine: An Imperfect Science*.
5. To read more about the significance of object biographies and how object meanings change over time, see Alberti, S, 2005, 'Objects and the Museum', *Isis.*
6. While this paper touches on how the interpretation of objects impacts on their perceived authenticity to the visitor, there have been other studies looking at the impact on visitors of original and authentic objects vs replicas. This is a large area of study which is beyond the scope of this paper but as an example see an evaluation of visitor perceptions relating to authentic vs replica objects at the Deutsches Museum in Hampp, C and Schwan, S, 2014, 'Perception and evaluation of authentic objects: findings from a visitor study', in *Museum Management and Curatorship*, Vol. 29, No. 4, pp 249–367.

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