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Hubble, trouble, toil and space rubble: The management history of an object in space

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Abstract

This article tells the saga of the Hubble Space Telescope, and how the attempt to overcome the restrictions Earths atmosphere imposes upon astronomy, came to dominate the existence of NASA in the later part of the 20th century. This biography of an object is told over four stages fundamental to the order of management; development, failure, recovery and completion. With a failed mirror, what became hidden and forgotten, was once more revealed. With the wild and uncertain dimension of Hubble's assemblage disclosing itself through malfunction, management was able to rescue through repair its prior unavailability. Eventually management has contended with Hubble's demise as it fades out of view during the process of completion. Running in counterpart to the four stages of Hubble's life will be an explication of the events using the work of Martin Heidegger, particularly his work and concepts of *Being and Time* (Heidegger, 1962).

Key Words • conceal • decay • failure • Heidegger • Hubble Space Telescope • mirror • repair • reveal

Introduction

The aim of this article is to examine some of the key events in the life of the Hubble Space Telescope; to show the pathway towards its failure but more notably, its recovery and eventual success. The Space Telescope was to be NASA's most sublime object in space, having the potential to secure quasi-religious significance through its mission to unlock the secrets of the universe. During the course of Hubble's working life such grand ambitions were thrown into doubt when the inability of the telescope to function properly turned it into the most ridiculed object on Earth, with one Senator anointing it with the derogatory tag of a 'techno turkey'. In particular the article wishes to look at the relationship between Hubble and its management by NASA who along with people from astronomers to astronauts, endured an oscillating relationship between failure and success as the telescope struggled to fulfil its purpose and the achievement of its scientific goals.

What is to be managed has first to come into existence, and the opening historical account will trace Hubble's development stage. Under NASA as the programme architect, a remarkable array of disparate strands were composed between political patrons, private contractors, and worldwide astronomers, making the Hubble Telescope's Earth-bound stages of development an exemplar of how the becoming of an object is managed into existence. The scientific mega-project of Hubble captured a complexity of organizational life where management constantly endured the spectre of failure with the abandonment of the Hubble Telescope often on the projects horizon.

Approximately two months after launch, the Hubble Space Telescope Project Manager declared there was a critical flaw in one or both of the mirrors in the Optical Telescope Assembly, and this incident becomes the second part of the objects management history. Historical biographies can suddenly reappear, as previously forgotten pieces of equipment return to the concern of management. Objects are often implements taken for granted, existing in a vast subterranean backdrop supporting the surface layer of practice and place of explicit management activity. Therefore things often only come into the sight of management as technology comes into view through malfunction. The broken mirror escaped the telescope's assemblage, erupting into the management landscape, and compelling the organization of NASA to take stock of this new contingent realm. History is often made by failure, breakage or fiasco. A mirror's pathway into the totality of the technological system was disturbed and made visible by its fault; creating a new ontological depth and enrolment of management attention. However, the chance of redemption for NASA came in the guise of Hubble's breakdown not being aberrant but as a normal condition of the object's existence (Petroski 1985). Here the third stage in the life of the object is the credit NASA gained through recovery, which was not just a reactionary derivative of failure, but an intended part of the objects biography; service was built into design. The repair illustrated the importance of human space labour and ingenuity where management learning occurred through maintenance (Orr 1996); but it ostensibly allowed NASA to regain credibility and capture the public imagination with televised record breaking space walks displaying a new level of performance from astronauts. The concluding episode in the biography of the Hubble Telescope examines its recent oscillation between worth and eventual demise. In this period, the value of an object is inseparable from managerial motive. Throughout the lifespan of the telescope management strived to fend off decay through service, and failure through repair; eventually allowing NASA to decide and control the fate of its most sublime technological object in space.

Coupled with this narrative, the article will call upon the work of Martin Heidegger, specifically his most celebrated work *Being and Time* (1962) to help understand the relationship between Hubble and its management. The four themes of Hubble's biography development, failure, recovery and demise will be accompanied by a revision of these events through Heidegger's philosophical concepts; the *becoming* of an entity during its development; the *disclosure* and *malfunction* during the failure of

a key piece of equipment; the recovery of this setback through *coping* with what has been revealed; and finally the demise of Hubble which necessitates its *releasement* and removal from the *care* of management.

Some of Heidegger's richest contributions to philosophy are derived from his fundamental theoretical position of hermeneutic phenomenology; which calls into question the traditional Cartesian belief of a separate process of mental cognition from the subject to the object. Heidegger's concept of phenomenology goes further than 'to let that which shows itself be seen' (Heidegger 1962, 56), because Heidegger also wants to observe that which is concealed, instead 'it is something which is primarily and usually does not show itself at all; it is something that lies *hidden*, in that which primarily and usually does show itself' (Heidegger 1962, 59). This twofold nature of an object, that is both *revealed* and *hidden*, is central for this article and the events in the story of Hubble.

The primacy that Heidegger affords *Dasein* (Human way of being) in his attempt to unravel human reality – ultimately an attempt to make sense of being-in-the-world – does not reduce the appeal his work holds for examining Hubble during the most notable sequences of its existence. This is because Heidegger also emphasizes the centrality of objects in relation to the nature of being and he suggests 'entities are in every case our preliminary and accompanying theme' (Heidegger 1962, 95). Heidegger places an importance on the constitutive entities that make up our background, what he describes as the *worldhood of the environment* (environment is taken as the world of everyday *Dasein*). Thus an interesting examination of management's engagement with Hubble can be founded upon an ontological interpretation of those entities that are encountered within-the-environment and how they reveal themselves to management. To explore this relationship of management and things that become available, the story shall now begin with the development of Hubble and how it came in to existence, followed by a Heideggerian interpretation of these events.

Development

In a bid to reduce the effects of turbulence in Earth's atmosphere – which distorts the image of celestial objects and causes them to flicker – astronomical observatories have traditionally been built at high altitude. Driven by a desire to forge a closer relationship with the objects of their investigation, a lucidity any enthusiast in their work craves, astronomers began dreaming of ways to escape the confine of this optical spoiler. The ambitions of aspirant astronomers were to be realized through the materialization of a project that covered the span of the 20th century; the construction on earth and deployment in space of a telescope. Three distinct influences will now be examined that allowed a space telescope to come into existence; ideas are context dependant and to be realized have to occur in key junctures when historical events are favourable. First astronomers in the academic community had to believe in the project and be convinced of its merits. Second political patronage was required; as with

most projects, there are always detractors and adversaries who have to be convinced of its worth. Finally the technology had to exist to make science fiction into science fact.

It was the astronomer Lyman Spitzer who first committed the idea of a Space Telescope to paper. In an audacious 1946 publication entitled the 'Astronomical Advantages of an Extra-terrestrial Observation' (Spitzer 1990), he initially offered a proposal for the development of a space telescope claiming 'it would uncover new phenomenon not yet imagined, and perhaps modify profoundly our basic concepts of space time.' (Zimmerman 2008, 11). Others before had shared his desire to transcend Earth's firmaments. Previous enterprising designs to exploit the inert and image friendly environment of space had included the strapping of balloons to a scientific payload and the science fiction fuelled fancy of moon telescopes. Although there were certain bold aspects to the report for the time – the proposed space telescope being three times bigger than anything ground based in existence – his proposal began to forge crucial alliances that gave his idea momentum.

The delineation of Spitzer's proposal into a government funded publication was a significant translation of his vision into a material realm; imbued with the vigour of substance, the idea could now forge a potential trajectory into design where the dreams of astronomers could be realized. However the early stages of a projects life, before prospective support is augmented, can contain its most unsettling moments (Latour 1996) and the mutability of endorsement in the immediate period after the Second World War demonstrated the capricious nature of an object residing in the stages of conception. Spitzer's ambitious thinking was greeted with derision from colleagues who regarded the project 'hazardous and probably undesirable' (Zimmerman 2008, 15). This opposition continued in 1958 when the eminent astronomer Fred Hoyle insisted 'the cart was being put before the horse' his belief centred on the argument any orbiting observatory should be offered as an ancillary to the space programme, and not become the principal figure, complaining further the case for space based observation had been 'promulgated with almost Madison Avenue techniques' (Zimmerman 2008, 20). Such opposition from within one's own community was a difficult obstacle for the project to surmount. Colleagues may have been unconvinced of its merit but their opposition was rendered insignificant against the development of a more serious political concern; an object in space not of America's making.

It took a day in history to finally politically charge the space telescope project – indeed the necessary spur for the entirety of the US space programme – with the impetus for the objects subsequent naissance; the appearance of Sputnik 1 in the night sky. The Soviets foray into space with the first space satellite and surrounding hysteria, administered a vitalizing effect to the US space programme; leading to the formation of NASA in 1958. The earlier tenuous proposal of Spitzer's astro-observatory now not only received support from the scientific community, who were buoyed by the promises coming from America's new space agency and their support for space bound projects, but additionally in the light of a new political epoch ushering in the space race, the added weight of Congressional support.

Scientific discovery played a crucial part in America's war efforts and with huge undertakings such as the Manhattan project the era of 'Big Science' (Weinberg 1961) was marshalled in. Before these fiscal extravaganzas, the practices associated with scientific discovery had generally developed from the solitary pursuits of one man and his laboratory. Science on the scale the world was about to witness would no longer be left to the fortunes of an individual; everything would be massively scaled up. The new projects of 'Big Science', which conducted huge scientific enterprises, required the collaboration of groups derived from the mobilization of immense levels of labour and resources. The postwar rise of the Soviet Union meant the ultimate viability of America's political ideology rested upon the existence of new projects with sufficient scope and endeavour to bestow a sense of awe around their achievement.

> Sputnik posed a great challenge … As a foreign threat with military overtones, it was clearly the government's business. As a blow to U.S. credibility, it seemed to demand a response in kind. As a technocratic accomplishment, involving the integration of science and engineering under the aegis of the state, it called into question the assumptions behind U.S. military, economic, and educational policy – every means by which the mobilization of brainpower is achieved. (McDougall 1997, 139)

Once the project received NASA's official stamp of approval and roused by the necessary groups on board, one final obstacle lay in wait – money from Congress. The budgetary demands of the Apollo mission, which cast a shadow over the telescopes project, meant competing space programmes vied for a diminished amount of funding. In 1974, using the fiscal logic provided by a renewed focus on 'earthy problems' (Zimmerman 2008, 57) Congress voted to deny the necessary funding, thus threatening the very existence of the telescope, long before any mirror had been polished, and consigning its existence to the passages of history.

An emphatic riposte from astronomers was required and what followed was the coordination of a lobbying effort to reassign the telescope its rightful path. Eventually the Senate rescinded its efforts to dull the hopes of astronomers and eventually approved funding of US$36m as an initial sum to allow work to begin in earnest with 1983 as the provisional year of launch (Smith 1989). With this funding commitment, the growing status and complexity of the project also brought increased fragmentation, detracting from its chances of existence. A *dramatis personae* gradually coalesced around the Space Telescope Project; but this coming together was not always harmonious. Although NASA was the overall programme architect its organizational structure encouraged rivalry between different groups. Competition between the Space Centres of Marshall and Goddard for power and resources lacked any of the necessary coalition building between institutions to make the project a success. In the end Marshall succeeded in the award to construct the Space Telescope, while Goddard had to settle for the lesser role of constructing the necessary scientific instrumentation (Dunar and Waring 1999, 56). Among a host of contractors the Perkin-Elmer

Corporation undertook the precision work of constructing the telescopes mirrors; a decision that in the fullness of time would have untold consequences.

Finally in 1983 the telescope was given its name, the now familiar Hubble, after the astronomer Edwin Hubble. The naming of an object plays an important role in its obduracy, where it acquires a certain anthropomorphic character and at this point the future of Hubble appeared secure. However, its eventual launch would now suffer further setback. Due to the Challenger disaster, work on Hubble entered a period of cessation during which engineers were able to perform additional work on the existing design. Management was forced to provide a specially adapted Earth bound home where it was kept in storage for a number of years at a cost of US$6m per month (Zimmerman 2008). If NASA had not endured the Challenger disaster the Hubble Mission would have certainly been plagued by further problems. In any project additional time is often a gift where further upgrade and work is undertaken. The elapse of time in this instance allowed further improvements to occur, making Hubble more robust and ready for launch.

Becoming

This first episode in the life of Hubble concerns its becoming, not only how it came to be, but also how it continually fluctuated into a state of (*non*)existence. Examining this in the wider philosophical sense of Heidegger's work, it is possible to understand the development of Hubble as a process that is intrinsically temporal. Hubble in these early stages was always becoming; its existence is one of movement, not in the sense of shifting locations but changes in the security of its status and appearance as an entity.

The *what it is* and *how it is* of Hubble was defined by its very being as an entity with a trajectory for 'Heidegger's topic is not at all some hypostasized 'being' but rather movement'(Sheehan 1981, 536). Hubble had a role to perform for management in becoming a working space telescope and its development was an odyssey to achieving this goal. The awareness of purpose is what Heidegger terms *absent-but-anticipated*. In the case of *Dasein* it is the interplay between the presence of its *being-as-existence* and the *absence-as-death*. At this stage in Hubble's history, its being as an entity in the presence, where it awaits its launch, is defined by the absent but anticipated goal of its mission in space. So in this sense, even at the beginning of Hubble's existence, its trajectory is laid through its objectives, making the project always *towards-its-end*.

To understand the relationship between Hubble and management it is important to look at the twofold nature of movement, that of hiddeness and disclosure. For Heidegger the essence of any entity lies in the pathways of an *autodisclosive* process, which is understood as its inexorable movement into appearance. What is important for an interpretation of Hubble's becoming is this disclosure only occurs in the presence of human existence – *Dasein*. Therefore what renders Hubble as an intelligible entity and discovers its disclosive nature is management itself. The process of becoming for Hubble is therefore a movement of disclosure to management.

Heidegger interpreted this disclosure as grounded in movement that he terms 'temporality'. 'Whoever builds a house or a ship or forges a sacrificial chalice reveals what is to be brought forth. It is as revealing, and not as manufacturing, that techne is a bringing forth' (Heidegger 1993, 319). The essence of management is to reveal, to bring forth what had previously been hidden or awaiting discovery, and to imbue a potential project with the necessary kinetic force to reveal its *availableness*. To describe this force Heidegger uses a term *Ereignis* to denote movement as a process that compels an entity into its final state of being. The initial account of Hubble's development has charted some of the relations that seem to draw the project forward into the eventual entity of a telescope. The management of any enterprise is faced with its own pull towards its eventual conclusion, a process of trying to become what it set out to achieve in its successful completion. However the wants of management to succeed in a project are not guaranteed. The Space Telescope could have taken an alternate course to the one management rendered, but paths which are not the interests of management often lack the necessary impetus as they are never actualized into a process of becoming. Significance in this story of Hubble can encapsulate the paths where the potential failures have contributed to the objects history in parity with its actual success; demonstrating the need to examine 'the forces that could have seized the thing but did not' (Massumi 2003, 42). The story of the Space Telescope this article is beginning to tell will hopefully show the history of an object is not just a tale of its successful route to becoming, but also a documenting of the uncertain and process nature of its existence where it 'Resides in a condition of possible histories' (Koselleck 1985, 271). The telling of this erraticism in the life of Hubble will now continue and show how objects can become resistant to the chosen pathways of management. Parts of an assembled whole can become obscured from management view, laying dormant until things go wrong when the addition of the user puts the telescope to work. Hubble's ability to bite back is then revealed as it asserts control over the destiny of NASA's management.

Failure

When it was launched in April 1990 the total cost of Hubble had reached a staggering US$2.5bn making it the most expensive scientific instrument ever assembled (Smith 1989). There was inexorable quality to Hubble's eventual take off for a number of reasons. The project was undoubtedly besieged by a catalogue of disruptive incidents, but these problems must be situated within the complexity of the telescope and surrounding work practices where disruptive variables are a normal condition (Perrow 1999). The mutual support of its allies and organizational imperatives of NASA gave it an unyielding momentum that compelled the object into space. Its potential worth to humanity was too beguiling to tolerate any threat of abandonment; Hubble simply had to be. However the hitherto ill-fated history of construction did notaugment confidence about its deployment and no amount of testing could pacify worries on

the ground. Scientists and engineers awaited the spectre of failure; something was bound to go wrong. Setback is the inevitable part of space projects, the people involved just hope faults are minor, not considerable. Once it was set free in space, a watchful world was heavy with anticipation as its two solar arrays unfolded to capture the energy source of the sun for power up; and as they unfolded so did the start of its orbital tribulations.

Hubble juddered into action and then stopped, entering a safe mode of essential operations only, and vicariously sending jitters across the emptiness of space back to Earth. However, its working order could only be assessed with the attestation a token image of a star could provide. An expectant media needed to be abated and NASA was eager to vindicate its might; the fortunes of object and organization were sealed together by a star light years away. When the telescope captured its initial image – what astronomers call 'first light' – there was not the expected sharpness, but a star with a peculiar circular haze. Immediately some astronomers recognized the cause of such distortion. Among a host of malfunctions that occurred in the first few days of orbit, NASA became a hostage of fortune to the flaws of this one particular disruptive object. Hidden within the assemblage of the telescope, was the spherical aberration of its mirror. Disillusion was confirmed approximately two months after launch, when the Hubble Space Telescope Project Manager declared there was a critical flaw in one or both of the mirrors in the Optical Telescope Assembly (Chaisson 1994). Such technical glitches are normal episodes in the life of space instrumentation. Echoing this assertion a NASA test support manager claimed about the project 'no matter how much testing and research you do on a piece of hardware on the ground, there are some things you just can't do and so you have to make adjustments' (Dunar and Waring 1999, 509). Until the technological object is switched on, management is forced to invest it with trust, placing its faith in the objects resilience and crossing their fingers to ward off disappointment. Management allowed pieces of equipment to become forgotten parts of labour, entering into a waiting game with the onus on the object to make the first move, and ensnare the organization within the nightmare of its dramatic reappearance. Let us now trace the instance of the mirrors opening gambit where a slender anomaly during its manufacture pierced the legitimacy of NASA's entire organizational existence.

The committee which was established to investigate the technical failure was able to trace the history of the spherical aberration and reveal its error strewn production. Technicians at Perkin-Elmer, the contractor who made the primary mirror had mismeasured the precise position of a lens in the device and over polished its surface by 1/50th the width of a human hair (Allen 1990). What was so lamentable about this blunder is the fact technicians had been aware of the mirrors flaw during testing and instead of interpreting the erroneous test data as an indication of a potential fault, they proceeded to discount this evidence preferring to account for any discrepancies by pointing the finger at the data itself and calling into question its reliability. As with the Challenger disaster of the same period the derivation of fault in the mirrors production lay in the 'normalization of deviance' at NASA (Vaughn 1996). Management

failed to account for things that went against the imperative of cost reduction, laying the ground for malfunctioning things returning to make their presence felt and remind management of past misdemeanours. Objects seem to have a dual quality of being hidden from view when all is well, until they cause mischief for management to rule over through malfunction. The article will now once more return to Heidegger's work to illuminate this episode of failure and twofold existence of things which become the concern of management from a hidden realm.

Malfunction and disclosure

As the account of the faulty mirror has just demonstrated the qualities of an entity are revealed during our concern or manipulation of it. In the case of Heidegger's example – that of a hammer – qualities are revealed when we take hold of it and put it to use. *Equipment* can therefore have qualities that are ready to be put to use and become available to us, Heidegger terms this a *readiness-to-hand* (Zuhandenheit) 'This kind of being which equipment possesses – in which it manifests itself in its own right – we call "*readiness-to-hand*"' (Heidegger 1962, 98).

Heidegger wants to highlight incidents that allow us to glimpse at the world 'What is it that makes this world light up' (Heidegger 1962, 75). An important aspect for understanding the narrative of Hubble's malfunctioning mirror is that our acquaintance with an entity is born from its failure; it is when they become unusable that we gain knowledge of their existence. Heidegger develops three different modes in which equipment becomes unusable; *conspicuousness* – when something is damaged; *obtrusiveness* – something is missing; *obstinacy* – something stands in the way. For Heidegger 'we discover its unusability, however not by looking at it and establishing its properties, but rather by the circumspection of the dealings in which we use it. When its unusability is thus discovered, equipment becomes conspicuous' (Heidegger 1962, 102). In Heidegger's vocabulary the equipment that is the mirror becomes *presence-at-hand* (Vorhandenheit). The mode of *conspiciousness* has the function of bringing to the fore the characteristic of *presence-at-hand*. The mirror was once part of the *referential whole* amongst a totality where it was 'constantly sighted beforehand in circumspection' (Heidegger 1962, 105), but when there is malfunction we are forced to recognize the mirror for what it is 'the assignment has been disturbed – when something is unusable for some purpose – then the assignment becomes explicit' (Heidegger 1962, 105). Once breakdown has occurred 'Pure *presence-at-hand* announces itself in such *equipmen*t' (Heidegger 1962, 103). The customary action is now for repair where the *equipment* becomes available to us once more and reverts 'to the *ready-to-hand* of something with which one concerns oneself' (Heidegger 1962, 103). The broken mirror becomes *presence-at-hand* but the relation to the mirror once more becomes *ready-to–hand* once it is under repair.

With the incident of the faulty mirror, 'the drama of things themselves' (Harman 2005) erupted into the view of management. With malfunction acquaintance was

renewed with the forgotten mirror, which had become concealed as part of the *referential whole* of the telescope, compelling management to engage with the consequences of past mishandlings, averting attention to back to the crucial time frames of Hubble's construction; what had become hidden in the totality of Hubble's *equipmentality* now ruptured into view. The world of management is often peripheral to the actual workings of *equipment*. It is only through failure that what was once a tangential piece of *equipment* becomes the focus of an organizations full consideration. The fully assembled Hubble takes on an essence of its own, becoming an autonomous object, sharing the goals of management. When the blurred images are revealed for the first time, the relationship between organization and object is disturbed; different circumstances are thrust into the awareness of management, asking to be dealt with, a different management goal is now revealed, that of repair.

The mirror came into view through management's *concernful dealings* 'entities become accessible when we put ourselves into the position of concerning ourselves with them in some such way' (Heidegger 1962, 96). It was not until the telescope was pointed towards a constellation of stars and required to take an image that its fault came into view. 'We discover its unusability, however not by looking at it and establishing its properties, but rather by the circumspection of the dealings in which we use it' (Heidegger 1962, 85). It is therefore difficult for management to be fully expectant and therefore prepared for malfunction. Our primary interaction with equipment comes from use, and in this sense it is not until the telescope is fully operational that things burst into management praxis and arrest the attention of NASA's organization. Heidegger suggests there are ready ways of coping with the disturbance, and the next section will discuss NASA's ways of coping with the faulty mirror; through the serviceable nature of Hubble's design and human endeavour in space.

Recovery

Hubble was the most astronaut friendly space craft ever flown. In its design engineers inscribed a level of endurance into the object that provided an ability to cope with any threats to disrupt its purpose and obviate potential failure. With an expected lifespan of 15 years and possibly beyond, incorporating a serviceable nature into its design would give the Hubble Telescope the opportunity to periodically adopt the incremental advances in the technology of space instrumentation made back on Earth. In a paper on the nature of repair Graham and Thrift (2007) sum up the need to design things with a serviceable quality 'To make something serviceable is to understand the world is involved in a continuous dying that can only be fended off by constant repair and maintenance' (Graham and Thrift 2007, 6). This process of dying is also important when considering our relation to objects. The continuous nature of dying is not just human phenomena but one also shared by the material realm. The issue for management is how to plan in anticipation of what is to be expected and avoid the pitfalls of ignorance. NASA went to extraordinary lengths to accommodate the possibility of

failures and malfunctions. More than 16,000 photographs were taken of every square inch of the spacecraft to ensure astronauts would not be taken aback during work. A berthing dock was developed to keep the telescope steady during repair. Hand rails and footholds were strategically placed around Hubble and every bolt was made the same size to make the work of astronauts as effortless as possible (Chaisson 1994).

The unavoidable decline of Hubble's operational capabilities made it a mandatory requirement of management to anticipate malfunctions and plan for repair and maintenance; an expectant belief in breakdown gives management the chance to be familiar with failure before it arrives. The management of space projects must comprehend that failure and decline are omnipresent in complex systems. It is only through such awareness that management can be ready and implement a recovery strategy of which preparation and training are all important.

Traditional definitions of training have focused on 'the effort to develop knowledge, skills and attitudes through learning experiences to achieve an effective performance in an activity' (Garavan et al. 1995). One of the main purposes of space mission training is to give astronauts a familiarity with the environment of space, which became the setting for repair activities to Hubble. The workshop of space, its conditions and the appenditures of the crafts astronauts traverse, created a series of challenges to NASA and the astronauts because its conditions are literally not of our world. NASA therefore relied on simulation to mimic the space environment and give astronauts time for preparation and carefully choreograph the Extra Vehicle Activity (EVA), described as 'a ballet of bodies and three hundred tools' (Dunar and Waring 1999, 28). A favoured way of reproducing the weightless effects of space is to conduct training exercises in vacuum chambers or underwater. In preparation for the repair mission, astronaut Storey Musgrove underwent a series of tests in a vacuum chamber to rehearse the procedures that the repairs to Hubble would follow. After working for four hours checking the performance of tools at temperatures of −170 degrees Centigrade, Musgrove suffered the effects of such harsh conditions with severe frost bite and tissue death in eight fingers (Tatarewicz 2001). The training schedule had to continue unabated for the other crew members, and after a rapid recovery Musgrove rejoined his colleagues in a demanding pre-mission schedule of over 738 hours of water tank simulations (Tatarewicz 2001), giving the astronauts time to absorb into the routines necessary for the repair work.

NASA went to enormous lengths to reproduce the environment astronauts would experience while performing their labour in space. A full sized mock up of the telescope was constructed from helium balloons with the express duty of providing astronauts with a familiar sense of the working environment of outer space.

The success of the repair mission would hinge upon reproducing the conditions of space here on Earth, in which the astronauts can practice the repair work until it becomes routine action. The more accustomed the astronauts are with the workshop of space, achieving mastery of their world through effortless action, the greater the chances of accomplishing the goals of the mission. The repetitious actions in the training sessions, using the same tools which will carry out the work but in a simulated

environment, meant when the work was conducted in space it was not for the first time and ridden with new disclosures.

The crew needed to display new ways of coping and situational learning to overcome the problems they were to face. Before the repair mission astronaut Jeff Hoffman spoke of how the crew would cope with any difficulties. 'If we run into trouble, we'll caucus among ourselves and decide what to do next, regardless of the timelines' (Chaisson 1994). Due to the extent of repair work, the mission had an extremely tight schedule of Extra Vehicle Activity over the course of five days, leaving no margin for error. During one period of work on Hubble crew member Jeff Hoffman has since spoken about the situated awareness required when a problem arose because the replacement equipment would not fit. After replacing a camera the latches of an instrument door were refusing to close, this demanded the astronauts to push and pull until eventually a decision was made to improvise a lasso like strap 'Ground didn't quite get it, they were afraid we were going to collapse Hubble like an aluminium beer can' (Hoffman – interview, 2008). After consultation with those at mission control it was decided to trust the astronauts in their work 'as we were up there in real time where the action was happening' (Hoffman – interview 2008). NASA chiefs only had a telepresence of the manoeuvres being orchestrated in space and therefore lacked the situated awareness available to the astronauts. The NASA people on the ground were basing their recommendations through a more detached theoretical reflection. This episode demonstrates the ingenuity needed during human labour in space. When things go wrong in space the business of rectification is an endeavour fraught with danger.

The completed repairs were a phenomenal success in space, however it required the verification through use of the telescope, when crew members would be back home to share the tension of receiving the 'second light'. Hubble then revealed the focused image of a distant star as originally anticipated 'It was as if the human race had been living in a fog, and that fog was suddenly lifted, revealing the heavens in all their glory' (Zimmerman 2008, 180). The process of revivification had begun and the real work of the astronomers could commence, there was immediate excitement about the images Hubble was capturing and over the coming months and years scientists would regale in the astonishing discoveries portrayed by the telescopes forays into space.

Coping

The conceptual framework of Heidegger can present an alternative portrayal of the endeavours carried out by the astronauts. In the following passage Heidegger discusses the certitude of death and the importance of embracing the nature of finitude for understanding *Dasein's* being-in-the-world.

> To expect something possible is always to understand it and 'have' it with regard to whether and when and how it will be actually present at hand. Expecting is not just an occasional looking away from the possible to its

> possible actualization, but is essential, a *waiting for that actualization*. Even in expecting, one leaps away from the possible and gets a foothold in the actual. It is for its actuality that what is expected is expected. By the very nature of expecting, the possible is drawn into the actual, arising out of the actual and returning to it. (Heidegger 1962, 306 emphasis in original)

All things have a finite existence and if we accept and understand the 'continuous dying' of things around us then management is *ready to cope* with its consequences and engineer designs with the provision of serviceability. Hubble has *equipmentality* as an array of *equipments*; nuts, bolts, mirror, solar arrays, computer, all adding up to the total aggregate of the functioning Hubble Telescope. For the astronauts this will consist of the *equipmentality* of the shuttle and Hubble – which was fastened together by a berthing dock – and the platforms, handrails and foot holes that provide a sort of scaffolding for the space walks and allow the highly trained and conditioned astronauts to display new levels of mutual adjustment and enactment with robotics. This enactment only became possible through the hours of gruelling training where astronauts were able to gain insight into what the work would demand.

The complete sense we have of our work is not just formed from the monotony of repetitive tasks but also develops out of our familiarity with the immediate material world of work; the structures, tools and objects. Familiarity therefore is an environment managers at NASA may benefit from fostering. Training in a Heideggerian sense is to 'create our perceptions of another world which is at first unfamiliar, to create a particular mode of being. The referential whole is grounded precisely in familiarity, and this familiarity implies that the referential relations are well known' (Heidegger 1962, 117). Another way of looking at the familiarity of *being-in-a-world* training can instil, is the feeling of effortlessness when we are so engrossed in the activity as to produce a mutual flow with the object of work. For Heidegger this state of being is termed *unthought* and means 'it is not thematically apprehended for deliberate thinking about things; instead in circumspection we find our bearings in regard to the entity. When we encounter the door, we do not apprehend the seats, and the same holds for the door knob. Nevertheless, they are there in this peculiar way. We go by them circumspectly, avoid them circumspectly … and the like' (Dreyfus 1990, 168). When an astronaut goes about their work in space, the levels of absorption they have endured in simulated environments on Earth makes the repair work second nature and acquits them with 'a sense of how the object will show up' (Heidegger 1962, 233). Such *absorbed coping* gives the astronaut an advantage when the dealings occur in a *background of familiarity*, but this mode of being is insufficient if the background world of equipment is disturbed, bringing to the fore *obtrusiveness* – something is missing or *obstinacy* – something stands in the way. The stubbornness of the latches of an instrument door interrupted crew member Hoffman's course of action. Its *obstinacy* required him to change his mode of being from '*absorbed coping*' to '*deliberate coping*'. The latches '*in-order-to*' had broken down and its assignment in the '*referential whole of equipment*' had been disturbed. For Heidegger the scheme peculiar

to deliberating is the '*if-then*'; 'if this or that, for instance, is to be produced, put to use, or averted, then some ways and means, circumstances, or opportunities will be needed' (Heidegger 1962, 410). Subsequent actions were deliberated and planned. After detached thinking the astronauts were able to implement their course of action, to improvise and fudge the door, or kick it shut if need be.

The demise of Hubble

The hostile conditions of space subjected an unimaginable toll upon Hubble's instrumentation. Towards the periods when service missions were required, the telescope could become completely inoperable. Its materials and parts were tightly coupled in a complex system exposing them to forces and pressures that undo; its aggregate parts gradually separated, altering the form and consistency of the telescope. In his work on ruin and materiality, Edinsor (2005) summarizes the process of ruination with the following passage 'things give up their solidity, their form, yielding to the processes which reveal them as aggregates of matter, erasing their objective boundaries, those edges which could be felt and looked at and suggested that the object was inviolable as a discrete entity' Edinsor (2005, 114). Eventually Hubble was wrestled out of management's grasp through the process of decay. Objects do not exist in perpetuity; there demise is written into their very existence.

With the tragic loss in 2003 of the space shuttle Columbia, and a subsequent suspension of the shuttle programme, Hubble's future significantly changed. The aftermath had dramatic repercussions for the continued service and therefore future use of Hubble. The risk to the lives of astronauts while journeying to Hubble was considered too great. Combined with this setback, Hubble was hit by a parsimonious budgetary cycle and revision in space policy under the Bush administration; the chances of Hubble's continued existence were receding. It therefore came as no surprise when the fifth and final Hubble service mission was removed from the 2005 NASA budget. However the decommissioning of Hubble provoked an emotive response from those who understood the scientific value it could still contribute. Also for NASA as the architect of Hubble it was important to hold the fate of the object, thus emphasizing the ownership and control of its historical trajectory and its power to choose a closing narrative befitting of what had become its bejewelled spectacle in space. In the end NASA could not inflict Hubble with such an indecorous finale. The effort that had already gone into the object meant it had to be a success right until the end and the respect NASA afforded Hubble with a final service mission was a testament worthy of its contributions to science. Hubble's value transcended that of a mere orbiting object, it was not to be discarded and left to become rubble in space due to fiscal constraints. The question for management was to decide when its end should arrive. The value of an object is inseparable from political and managerial motive. Hubble had to constantly compete for funding and justify its scientific value against a host of alternative space based projects. A plan is now underway to launch another space telescope into

orbit. The James Webb Telescope is due to venture into space in 2013. It is not a wholesale replacement of Hubble – it does not have the optical capacity of Hubble – instead it will use infrared imaging to observe deep space.

After the final service mission due in May 2009, Hubble will be left to wither in space and gradually shut down. For a while this iconographic symbol of NASA will be condemned an ignominious resting place among the orbital wasteland of space rubble. A more reverential end to honour and dignify its service to humanity will come with an intended 2015 de-orbiting mission; Hubble will become a fireball in a controlled decent over the oceans of Earth. Maybe this is the poetic ending Hubble deserves; its better to burn out than fade away.

Releasement

This concluding part will now make one final return to the work of Heidegger to interpret these closing moments of Hubble's biography. The planned de-orbiting mission means Hubble will eventually disappear from management's view. However Hubble leaves us something *ready to hand* that was part of its existence, the knowledge it has helped produce. For Heidegger ending in the sense of disappearing can still have its modifications according to the kind of being which an entity may have 'The rain is at an end- that is to say it has disappeared. The bread is at an end – that is to say it has been used up and is no longer available as something ready to hand' (Heidegger 1962, 417). Through its contribution to knowledge the Hubble project possesses a dynamic of incompleteness (Knorr Cetnia 2002), which means the definitive ending of its existence may be difficult to substantiate. Its conclusion is not reached as with a work of art 'as the painting is finished with the last stroke of the brush' (Heidegger 1962, 289). As an '*epistemic thing*' (Rheinberger 1997), it is an object which has been involved in the production of knowledge. In a sense Hubble will live on in the knowledge it has given us and the changes it has made to scientific thinking:

> one cannot get away from history. Here by history we have in view that which is past but that which nevertheless is still having effects. The past has a remarkable double meaning. The past belongs irretrievable to an earlier time, and in spite of that can still be present at hand now. (Heidegger 1962, 430)

However, Hubble cannot be objectively present forever. In the end objects fade and are drawn along an unstoppable trajectory to exhaust their existence. All entities share the same course in their history; their eventual demise 'Manifestly these "Things" have altered. The gear has become fragile or worm-eaten "in the course of time"' (Heidegger 1962, 431). Their assembled connections make the present be felt, joins and seams are forced apart as entities labour against each other. Service and maintenance are the twin combatants to halt this gradual decline of decay. The episodic service missions of Hubble punctuated its timeline and became crucial to the telescopes continuance; demonstrating an organized resistance against the inexorable effects of

time. Any manufactured object creates an illusion of permanence, an assembled whole masks the forces that have gone into its production. A man-made object is exposed to natures efforts to reclaim the state of things, regaining control of their performance and refashion them back into the simpler constitutive elements. It is the nature of care to preserve objects in the structures we have created, bringing to the fore the role of management in staving of the effects of decay.

As a befitting end to Hubble's existence Heidegger points us towards how the power of an entity is founded in the '*letting be*' which would allow Hubble to articulate meaning out of 'the mysteries' (Heidegger 1966, 128) beyond its material existence. Hubble has revealed us beyond our associations with things, and the worlding of our existence. It has disclosed us as an expression of our history in the Universe. As Management has disclosed and revealed the entity of Hubble, then the telescope has also revealed something of the hidden and concealed about our very existence and been able to tell us something about our place in the universe. This is what Introna calls 'things naming us' (Introna 2005). Sometimes humanity is capable of constructing objects that can look back upon us and reveal our nature of being.

> Our projects run down and end, like us. The life of things is not just poetry of growth, vitality and becoming, but also poetry of loss, decay and finitude – like us. Do our great projects not name our ongoing desire for transcendence? Do we not build pyramids, cathedrals, temples and towering office blocks as expressions of the possibility for overcoming our finitude – inscribing into the flesh of things our deepest existential desire for a 'life after death'? (Introna 2005, 7)

With a replacement telescope soon to be launched, in some sense NASA is finally letting go of Hubble 'In awaiting the next new thing, it has already forgotten the old one' (Heidegger 1962, 419) and is in a position to place its resources into the success of other projects. Later in his life when writing on technology Heidegger warns of the dangers of becoming to firmly attached to technological entities 'suddenly and unaware we find ourselves so firmly shackled to these technical devices that we fall into bondage to them' (Heidegger 1966, 53). It is the duty of management to choose the time when it is right for something to fade into the background, to return once more to the backdrop from which it emerged. Management must be unemotional in its decision processes and it is only then it is in a position to make a dispassionate decision and be free to 'let go of them, let go of them at any time' (Heidegger 1966, 54). While acknowledging and paying tribute to what has gone, management is not indebted to the being of Hubble, it must 'deny them the right to dominate us, and so to wrap, confuse, and lay waste our nature' (Heidegger 1966, 54). The final moment of Hubble's history is a difficult decision to make. Heidegger's term of 'releasement' is about detaching ourselves from something. It is not possible for management to remove the entirety of Hubble's disclosed nature for it resides in a historicity of relatedness where its past will always be accessible. However, releasement can represent a way for management to move on and free itself up for a new becoming, another project which is to be revealed. In the final act of *letting go* of Hubble, management performs the duty of

making a decision about what is not to be managed any more. It has been a story about management bringing something into view, but now at the end, management must let go, and turn towards something else.

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