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FCJ-205 Life and Labour of Rovers on Mars: Toward Post-Terrestrial Futures of Creative Robotics

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Abstract: Four Earth-born, human-made robotic rovers have successfully landed on Mars. Equipped with a range of sophisticated technical instruments for imaging, sensing, measuring, data processing, communication and navigation, these semi-autonomous devices follow the directives of their human "drivers", performing exploratory observations, assessments and evaluations and reporting the findings back to their command centres on Earth. In this paper I explore the ways in which robotic exploration of Mars facilitates productive exchanges within the ontological nexus of the human–technological, forging new configurations between the ambits of life and labour which may determine the prospects of post-terrestrial robotic futures.

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Curiosity rises early; it is bitterly cold on Mars at around 5am when NASA's Jet Propulsion Laboratory (JPL) wakes up the rover with a different popular tune each day (from *Hit the Road Jack* and *Walking on Sunshine* to the Beastie Boys' *Intergalactic* and the *Star Wars* theme), and delivers it a list of its daily tasks. Curiosity then sets out through the dust haze enfolding the rusty terrain scorched by solar winds and galactic cosmic rays on its busy schedule to explore the red planet. Rolling on its six wheels across the uneven floor of the Gale Crater, the 2.2 metre tall, 2.3 metre wide and 2.9 metre long rover searches for clues about Mars' habitability. It uses instruments such as hazard avoidance cameras, an Alpha particle X-ray spectrometer and a radiation detector to navigate its Martian environment, sense it, measure its various properties and evaluate its capacity for hosting carbon-based forms of life. The rover pauses at times and uses its 2 metre long arm to take samples of soil and investigate their composition. Coming to a chunk of rock in its path, it engages a vaporising laser to turn it into a fine powder in order to scrutinise it more closely. It slowly but steadily roams a desolate landscape, taking images to document its progress and using its high-gain antennas to report back to Earth. It finishes its day at about 4pm Martian time, and turns off into a sleep mode until the next morning. Since its landing Curiosity has repeated this routine, and it will continue to do so until its instruments stop working, its body parts deteriorate and its battery is irreparably exhausted. And then, when its power source dries up, its vital functions collapse and its links with Earth are severed, Curiosity will halt to rest in the environs of Mars.

Crossing the gulf of millions of kilometres of space, rovers have been toiling on Mars since the late 1990s. Sojourner arrived in the Ares Vallis in 1997. In 2004, two rovers descended onto Earth's planetary neighbour – Spirit landed in the Gusev Crater, and the still-active Opportunity at Meridiani Planum. The most recent arrival, Curiosity has resided at the Gale Crater since 2012. They are neither the first robotic devices nor the first rovers beyond the globe – remotely operated probes with varying degrees of autonomy have been flybying and orbiting, landing and roving on celestial bodies for decades. Yet, with highly refined sensory processing capacities that hone their vision, heighten their analytic perception and enhance their mobility, navigation and communication, the rovers represent a new generation of space explorers. We are evolving the bodies of these robotic agents to adapt to an alien environment on our behalf, and in doing so, we are enhancing their potential to mediate our presence and practices in outer space. Behind the design of a Mars rover stands the financial and logistic potency of military-industrial complexes and their investments into technological advances. A rover is a historical outcome of developments in materials engineering, autonomous processes, remote sensing, teleoperations and informatics, and is an experimental laboratory for future techno-scientific innovation. Cursors of the human exploration of outer space, Mars rovers are at once the results and resources of its technological origins and destiny.

While marking an extraterrestrial trajectory of robotic progress, rovers' presence and activities on Mars sculpt novel exchanges between humans and technology, necessitating new ways of framing the material-social context of their fundamentally experimental, necessarily performative and innately playful and inventive interplanetary ties. This relationship will continue to unfold as these early gestures towards technologically mediated forms of exploration become inseparable from the embodied practices of human creativity. In this sense, the unfolding of our relationship with rovers aligns the exploratory imperatives of their scientific agenda with the purview of practices and research centred upon embodied forms of creative performance and agency. While offering a lens for considering the increasing complexities generated by human–robot relations, Mars rovers not only present questions which can inform critical inquiry into the arena of creative robotics, but also invite us to consider the possibilities of its extension into outer space. Human robotic exploration of Mars is ongoing and evolving and the paths of Sojourner, Spirit and Curiosity will soon be followed by an array of new rovers. NASA's Mars 2020 and ESA's ExoMars operations are already scheduled to increase the population of rovers exploring our neighbouring planet. With longer lifespans and evermore sophisticated abilities and sensitivities, they are set to advance the creative agency of the robotic, becoming vehicles via which the posthuman could be inscribed beyond the terrestrial confines of the globe.

Yet Gilbert Simondon declared 'there is no such thing as a robot' (1980: 12), discarding the image of the robot as a menacing substitute for the human. The robot, as the soulless machinic replacement of our body and labour, does not exist because this figure – that disturbingly lacks 'interior', a social memory – is only a figment of our prolonged reaction to a shock instigated by the invention of industrial automation (Simondon, 1980). The rise of automation produced a conceptual rupture that left an aporia in language, affecting the ways in which we conceive of technologies, of labour and, consequently, of life. Hannah Arendt (1998) wrote that technological development has fundamentally changed the human condition; beginning with the industrial revolution and culminating with the space age, our techno-scientific creation of artifice has confused the centrality of labour within human ontology and incapacitated language as a performative prerequisite for individual and collective action – its momentum outpacing our ability to think and speak about it. This crisis in enunciation caused by technological progress has been articulated and in

a sense remedied through Simondon's work *On the Mode of Existence of Technical Objects* (1980) and Bernard Stiegler's work *Technics and Time* (1998). These studies vivisected the corpus of the technological as both a material result of human creative expression and a vital co-evolutionary constituent of the human itself. They disposed of the concept of the machine as a mere servile tool or the uncanny entity taking our labour from us to enslave us, introducing instead the idea of the technical as a prosthetic auxiliary in which the 'interiors' of its human makers are exteriorised and embodied, and whose performance consequently changes the morphology of the human.

Our ability to define the idea of the robot and express the nature of our mutable relationship with robotic technologies is still indefinite; this is particularly so in the case of those robots in outer space. The breakdown in the ability to cultivate an adequate language that keeps pace with technological development is exacerbated in outer space; the arrival of the space age caught us unprepared, leaving us, as Harold Leland Goodwin pointed out, 'with an inadequate vocabulary' (1962: 9). The deployment of rovers to Mars not only suggested a new historical stage in the unsayable relations between humans and technologies, the robotic exploration of our neighbouring planet also had a profound impact upon the transformation of our ideas about the ontological link between labour and life. With these conceptual trajectories in mind, this paper endeavours to contribute to the development of ways of thinking that fill ruptures in language, ways of expressing uneasy entanglements between humans and technologies and contribute to development of the extraterrestrial perspective on the study of the creative scope of robotics. It explores Mars rovers as the penumbra of a problem concerning the performative agency of embodied robotic extensions of the human, offering an approach that phrases relations between humans and technologies in terms of the ontological uncertainties that potentially spring from their interplanetary bonds. I probe into the life and labour of rovers on Mars, attempting to enliven these multifaceted bundles of technical apparatus – devices sent to perform an autopsy on a "dead" planet – not just as a substitute for the human in outer space, but as a catalyst of a robotic future enmeshing novel configurations between the ambits of life and labour, the inanimate and the living, and agency and control.

The extraterrestrial evolution of robotics is inevitably inscribed by the high-tech momentum of our biopolitical condition; Mars rovers are material imprints of ever-increasing obsessions with the strategic implementation of technologies to advance what Michel Foucault (2004, 2007, 2008) framed as biopolitics – a politico-economic order grounded in the exploitative control of productive and reproductive forces of "life itself". The dawning of space technologies has enabled the extension of the biopolitical rationale into outer space, giving birth to a cosmobiopolitics and to the idea of humans who will, through the technological conquest of space, exceed their natural limitations as species and advance outward from the terrestrial boundaries of Earth to become more than human (Damjanov, 2015). The Earth-like Mars is an obvious target of cosmobiopolitical aspirations and its exploration exclusively by rovers rather than humans is, at the moment, a necessity rather than a choice. Currently, the (terrestrially conditioned, "wet") bodies of humans are not able to occupy Mars, a profoundly "inhuman" space where they would be alien organisms. But the bodies of human-made rovers can, and their presence on Mars endows humans with the agency of an extraterrestrial species-being, altering them into a force with the potential to make a material impact upon a planetary world that is not their own. While all space technologies are essentially robotic, they are also fundamentally mediatic. The primary function of Mars rovers is to perform as media devices which pump fresh influxes of data into the terrestrial circuits of the biopolitical accumulation of power, knowledge and wealth. Yet the rovers are not simply high-tech mediatic tools in the cosmic age of biopolitics: Stiegler's (1998) work on technical objects as entities inseparable from what we know as human life invites us to

understand them as a material agency moulding our techno-logic drive to be more. In the Stieglerian sense, not only is each atom of the rovers' biologically inanimate and geographically displaced bodies inscribed by the essentially human trace of the "living", but their performance as technical media also advances them into matter vital for the human search for life outside the globe. Rovers on Mars become an instance of biopolitical capital, a part of "life as we know it" and a platform upon which to animate the prospect of "life as it could be".

The Earth-born, human-made, Mars-situated rovers challenge the traditional idea of geographical exploration as a quest for knowledge about unknown regions conducted by an adventurous human who directly experiences and records the environment. They substitute the body of the human explorer and arrive in an already remotely charted territory to enact an array of converged exploratory roles – they are simultaneously geologists, geochemists, biologists, climatologists, meteorologists, data analysts, navigators, photographers and reporters. Their presence and labour on Mars prompts questions about the need for human explorers of space. The allure of outsourcing dull, dirty and dangerous errands to a robot has lain at the crux of its techno-cultural genesis and the advantage of reduced costs and risks have been an important argument in favour of "unmanned" space missions. However, within the debate over the human versus the robotic exploration of space, the need for the actual presence of human explorers is still considered an imperative, while rovers are still considered only envoys of a human mission to Mars. In 1994, NASA historian Steven Pyne wrote that

> [r]obots, cameras, and high-tech instruments can get to the critical environments, record the sights, and take the necessary measurements … the revelations can be broadcast instantaneously and equally for all to witness … What such spacecrafts cannot do is record the experience of actually being there. But what does that mean, when such hostile environments deny one the chance to touch, smell, taste, or communicate directly with one’s surroundings, when an explorer can survive only within a completely artificial environment? (1994: 35)

This ontological divide between human and machinic space explorers has been blurred in the last twenty years. Yes, we humans still depend on the support of technological artifice when residing in outer space (except if we arrive at a natural Earth-twin or a terraformed planet), but our robots have evolved. Each successive Mars rover has been empowered by progressed cognitive, sensory and motoric capacities, and each of them has been more sophisticated than its predecessor in terms of the embodied and contextual modes of its "being there". Destined to live and die on Mars, the bodies of rovers are essentially Martian; they are made to be on Mars, and if the question of the ontology of technical objects is tied to their embodiment in a site-specific, geographically localised milieu (Stiegler, 1998), then a Mars rover is not merely a marker of human technical exteriorisation. The rover could itself enter the vagaries of the ontological through the labour it performs. As a technology able to assess and understand its physical environment, dig holes, collect samples, brush the dust, pulverise rocks and evaluate its own performance, it denies the simple instrumentalisation of its own robotic labour. With a language that validates the experience of the rover – that replaces the idea that only an embodied human presence validates exploration and conquest – the need for the presence of "wet" human bodies on Mars is perhaps obliterated. However, what is put most sharply into relief each morning, when a human driver spurs a rover into life with spirited music, is the need for new ways of describing life as it becomes entangled with technology and ventures into the unknowns of outer space. The evolution of these lively explorers and their embodied claims to life on Mars is paced by the intertwined evolution of ideas about the robotic

mediation of experience and the extraterrestrial potentialities of cosmobiopolitics. There are thus no robots in outer space, there are instead receptacles for human "interiors" that we send forth to gather knowledge – new information through which these interiors can be again enriched and extended.

Labouring Life

A Mars rover goes through two transformational stages of life and labour and these phases occur in two very different physical environments. The first starts here on Earth with a gestation of ideas in which the rover's design is conceived and the minutiae of its component mechanical and electrical parts are assembled into a bodily form. It learns a language and its perceptive senses mature to work in sync with its data processing facilities. It then takes its first tottering steps during a terrestrial test drive in laboratory conditions. After this formative period, a rover departs to where it really belongs, where it is made to be, and where it can utilise the skills it has been taught, leaving the incubator of Earth to come fully to life on Mars and commence its labour. An ontological trajectory of labour, according to Arendt (1998), originates in an event of 'natality' and is something that is bestowed upon a body at birth. It holds the potential to alleviate the restraints of life as a way of forging paths in the prospective pursuit of freedom. In Arendt's view, this potentiality of labour is profoundly affected by the techno-scientific push toward automation, which makes human labour redundant as a constitutive feature of our existence, and this fundamental alteration of the human condition has been additionally fuelled with the coming of the space age, which has provided the means for human alienation from the cradle of the Earth. If we transpose Arendt's idea – that from its beginning human life is marked by labour – onto Mars rovers, we stretch our understanding of the ontologies produced in the performance of human–robot assemblages. When rovers begin, or "are born", they too are inscribed with the potential to perform labour (perhaps even more than humans, whose social organisation diverts its productive potential). And while Marxist thought determined that 'labour made man', and while human labour created a Mars rover, the rover's realm of being is in part defined by the action of taking up its labour on another planet. Its embodiment as laborious explorer is the becoming of a life that heralds changes in our ontological thinking about the nature of robotic ways of being.

When considered from the perspective of Bruno Latour's (1999, 2005) work on human and non-human assemblages, a rover's performance on Mars, rather than robbing humans of labour and alienating them from Mars, returns the fecundity of labour back into the supposedly empty, labour-less hands of humanity. I suggest that if, as Simondon proposed, there is no robot as we imagine it, then there is also no such thing as a rover's "labour" as we traditionally conceive it. Rovers do not labour on Mars; their embodied performance, orchestrated and conducted by humans, is something which keeps rehearsing the event of their birth, continuously bringing forth life beyond Earth. This performance is directed and managed by humans with political and economic agendas, but it also has an aesthetic which suggests a shift in the conceptual apparatus we use to understand the ideas of life and labour. The work which defines the life of machines on Mars is nothing without the labour of humans. Rovers might perform their own natality, but this reveals the dependence inherent in the fact of their 'createdness' (Arendt, 1996: 51). Yet the potential for labour inscribed in the event of their "birth" also implies the possibility of agency amidst the life of an assemblage that merges human and machine. If Arendt's thinking about the idea of natality and the interconnectedness of labour and life is used as a lens through which to consider the embodied potential of rovers, we can dispense with the illusory idea of independent posthuman machinic life, and instead articulate the ontological questions produced by the labour of a living assemblage of the human and the

technic.

Although they are set apart from Earth, the bodies of Mars rovers are intimately integrated into contexts of the terrestrial and the human from which they arise. Assembled from materials and compounds found or made on Earth such as aluminium, titanium, silicon, copper, bronze, lead, stainless steel, tin and zinc, rovers sent to Mars carry specimens from Earth in and as their own bodies. The rovers are also interconnected with Earth though the communication signals that they exchange with their ground control, signals whose very materiality connects the bodies of rovers on Mars to those of humans on Earth. Signals that rovers such as Opportunity and Curiosity emit in order to report on their activities are picked up by the Mars Odyssey Orbiter which relays them to NASA's Deep Space Network, a system comprised of antenna complexes located in the USA, Australia and Spain which then distributes them to the JPL, where their content determines the next human action; signals dispatched from Earth to Mars follow the reverse direction of this interlinked course. By bridging the gap of space separating two planets, communication infrastructure such as the Mars Odyssey Orbiter and the Deep Space Network facilitates and accelerates the human relationship with Mars, as it is refracted through the embodied labour of rovers. These transactions draw the physically separated bodies of humans and rovers into one operational unit, within which their productive agencies interact and mutually affect each other. While only rovers have a bodily experience of Mars, the work of these bodies is merely one part of an interplanetary network of robotic labour. The exploration of Mars, within which humans and non-human agents are incorporated into a robotic network, is erasing the strict ontological boundaries that divide the bodies of living humans and inanimate rovers. As Félix Guattari reasoned, 'it is impossible to deny the participation of human thought in the essence of machinism', yet 'up to what point can this thought still be described as human?' (1995: 36). Integrated into the complex of a robotic mission on Mars in which their materialities and vitalities intermingle, machines that are no longer inanimate and humans who are not exclusively or only human anymore fuse into a productive participatory force, giving form to such pregnant questions.

Robotic probes on Mars pose difficulties of distinguishing where human agency ends and the robots' begins, but they still preserve a clear division of the scope of the activities conducted by each: humans compose and send a command to a rover; the rover receives it, decodes it, executes it and reports back; humans receive the report, analyse it and issue another command. However these cyclic actions are not performed without interruption. Communication between a rover and its ground control does not occur instantaneously – it takes between five to twenty minutes for a signal sent from Earth to reach Mars and vice versa. The current deep space communication facilities are not capable of conquering the spatial distance between two planets to enable real-time interactions. During the delay in communication, the rover's performance occurs in a blind mode – in this gap humans can never see what the rover is doing, they can only wait to receive its report about what it did. This lag in communication regularly leaves the rover unsupervised and so communication within the human–robotic network is based on a trust in the embodied presence of the rover, which offers only its own report as confirmation of its actions. While our blindness is not total, these gaps in the communication between parts of the assemblage are pauses in human control. We should be wary, however, of overdetermining the potentialities of the independent, uncontrolled agency of these technologies. Although it is possible to anthropomorphise the rovers, to imbue their labour with a false blush of "life", and to animate discourses about their presence on Mars by proposing that they are "emissaries" with the potential to themselves become living, what is perhaps more pertinent is to suggest that their agency within a living network is reinforced by these blindspots of communication. So while there are no robots – only the machinic extension of the human and the tools

(technical, social, linguistic and political apparatus) we use to define and manage life – rovers themselves contribute to how the life of this network is conceived by perplexing the coordinates of what dictates robotic labour.

Rovers' exploration of Mars complicates a previously straightforward ontological calculation of labour by shifting it back from the robot to the human body. While there are only a few rovers on Mars, their operations are sustained by a significant number of humans; in the case of Curiosity, the rover's direct support comprises a pyramid of highly qualified scientific labour – sixteen rover drivers and around four hundred analysts and controllers are engaged in its performance. The labour contributed by these human elements of the rover network reflects a historical swing from labour that is sustained by the physical capacities of the human body employed in material production, toward a labour which has been described as 'immaterial', 'affective' or 'cognitive' (Lazzarato, 1996, 2012; Hardt and Negri, 2001, 2004; Terranova, 2004). And yet, even labour such as remotely driving a Mars rover requires certain bodily provisions, such as the capacity to use a mouse and keyboard. The performance of a rover involves a similar combination of the material and immaterial dimensions of labour. While moving its body and extending its "arm" to dig and collect samples, it is also performing calculations, navigating and mediating communications. Yet within the rover–human network – what Latour (2005) would identify as a collective composed of human and technological actants – it is the human element that is reduced to its own labour power. While rovers journey, sense, explore and experience, it is human bodies which are reduced to their bare labour, while working to design, build, launch and eventually drive their creations. Such a configuration of the rover–human network modifies the ambits of labour within "life as we know it", bringing it closer to the definition of life which Christopher Langton derives from his work on artificial life – as not merely the fabric of matter in itself but the 'result of the organisation of matter' (1996: 53). The idea of life that appears in the rover–human assemblage is defined by this interplay and inversion of labour forms, a process of relational positioning between the human and rover within the arena of the robotic. In this sense, while conducting its "labour" on Mars, a rover both performs and transforms life itself, absorbing the biopolitical capacities of labour – what Tizianna Terranova terms the 'power of labour … in the making and remaking of the world' (2004: 129) – and embodying them in a robotic cosmobiopower.

In the Milieu of Mars

The "second life" of a rover, the event whereby its machinic body arrives at its intended destination and becomes an explorer proper, marks the beginning of the realisation of its full robotic potential. The rovers' presence on Mars, their site-specific performance, is conditioned by the extraterrestrial geographies of the physical locations in which they are situated. They rove across a landscape that is marked by volcanos, canyons, valleys, impact craters and sand dunes and covered in a dust rich in iron oxide, which tones the surface of the planet red and whose reflections colour the pink skies above. Enclosed by a thin atmosphere almost entirely comprised of carbon dioxide which provides no barrier to the harmful impact of radiation, held to the soil by a gravity whose pull has only one-third of the strength as that on Earth, the rovers' missions take place in an inimitably non-terrestrial world. The sols of Mars are of slightly longer duration than days on Earth and a Martian year lasts twice as long as a terrestrial one. The passage of the sun and the two moons mark alterations of surface temperatures on the red planet from around +50°C in the equatorial areas in the daytime to about -150°C at the poles during the night. Such spatio-temporal conditions demarcate the distinctive environment in which rovers reside, making Mars not merely a background against which the rovers operate, but a milieu that both produces and is produced by the

performance of these technologies.

The notion of milieu is useful for considering the ontologies of the human–machinic assemblages involved in the robotic exploration of Mars. The concept of milieu features prominently within works which have explored life's malleability and vital fabrics, such as Georges Canguilhem's on its epistemological conceptualisations (1991, 2008), Foucault's on genealogies of its governance (2004, 2007, 2008), Simondon's on its interlinked 'organic' and 'technical' trajectories (1980) and Stiegler's on its technical synchronisation with its environs (1998). Although these works use the term "milieu" with various emphases, they all suggest that it defines a locus of life: it is a material context which both frames and is framed by life's productive forces. Having arrived on Mars and commenced their missions, rovers initiate Mars as a milieu. The life of the assemblage – embodied in rovers – transforms Mars from a "lifeless" space to an environment in complex discourse with living things. The interaction between rovers and this milieu opens the "dead planet" as a setting whose distinct characteristics encourage the transformative unfolding of the human–technological as a creative force. Designed to frame Mars for humanity, rovers themselves must be framed by their milieu; their labour both mediates and is mediated by the milieu of Mars and this is what makes them a corpus *par excellence* through which to extend ideas and lexes about what constitutes embodied life beyond Earth.

Rovers' exploratory capacities develop in response to their environment. Held by its indifferent gravity, a rover surveys the planet, measuring the temperature and radiation to which its body is exposed. Its experiences of the Martian environment hone its reception and responsiveness to it. Through such experiential learning, a rover advances, correcting errors, extending the utility of its functions and refining its sensory and navigational skills. Information about each rover's experience of Mars is also passed onto its successors; they are embedded as a "memory of experience" into the design of the next rover. At one level, this transfer is directed toward the enhancement of a rover's physical aptitude to explore: it feeds into the development of more advanced scientific instruments and mechanical parts which will improve its ability to act in, and interact with, its milieu. At another level, Mars fundamentally shapes the performance of the robotic life extended onto it. Humans might exteriorise themselves via rovers into the Martian milieu, but rovers are also informed by the memories of their precursors' time on Mars. That said, the evolutionary potential of the rovers and access to their shared history is still managed by human controllers. What appears as genealogical progress arises as a biopolitical strategy aimed at the selective refinement of rovers' "genetic heritage", as an endeavour to "bioengineer" their bodies and make them more apt to be on Mars. Yet what the rover-human assemblage also suggests are potential gestures toward a rovers' gradual acquisition of a collective memory, the procurement of their own interior that can itself be exteriorised in the milieu of Mars.

The milieu of Mars demands the evolution of rover autonomy; their performance is increasingly guided by their internal onboard processes, with the data they collect through laser rangefinders and stereoscopic cameras being used to compute a detailed local topographical map that they then utilise to safely traverse the terrain in question, once it is approved on Earth. The issue of a robot's autonomy – the degree to which its actions are independent from human command – lies at the crux of evolutionary robotics, and the progress of the robotic exploration of Mars has increasingly improved rovers' ability to self-navigate and plot courses of exploration. Each consecutive rover arrived on Mars with an upgraded navigational system. On 27 August 2013, Curiosity used its "autonav" cameras for the first time to traverse terrain which was neither visible nor known to the JPL, and the safety of which was not sanctioned by ground control. Human

investment in robotic development is allowing Mars rovers to explore more independently and more inventively and to become progressively creative; the imminent ExoMars mission, for example, uses a rover that can not only find the best way to arrive at the given coordinates by itself but can also revise its chosen course as it encounters obstacles. The independence of movement and spontaneous improvisation that characterises the autonomous labour of these robots endows them with the agency to experience, suggesting a potential freedom of creative action in which they could exteriorise themselves. A rover's contact with the environment is what transforms Mars into a milieu with the potential to accommodate the interiority of technical life. Mars impacts upon both a rover's mediation of its milieu and the rover's remediation of this experience into a message signal that it modulates and sends to humans (and that is further distorted by travelling through interplanetary space and being demodulated on Earth). These effects of milieu – the environmental disturbances of Mars' mediation at the very level of signals and their processing – have the potential to become an intrinsic part of the "robotic experience".

This experience of milieu, which is necessarily incorporated into the composite life of the human–rover assemblage, relies on technics of the rover; as Stiegler describes it, the establishment of 'the relation of the living to its milieu' is possible only through the medium of the technical object, through 'organized inert matter'.

> [T]he singularity of the relation lies in the fact that the inert, although organized, matter *qua* the technical object itself evolves in its organization: it is therefore no longer merely inert matter, but neither is it living matter. *It is organized inorganic matter that transforms itself in time as living matter transforms itself in its interaction with the milieu.* In addition, it becomes the interface through which the human *qua* living matter enters into relation with the milieu. (1998: 49, original emphasis)

Through their productive response to the Martian environment, or through what Stiegler calls 'interaction' with a milieu, the rovers arise on Mars *as if* they were alive. Humans organise inorganic matter into a rover and adjust it to better respond to its location so that humanity can better exteriorise its own living matter into the milieu of Mars, but through the rovers' labours this organisation of inorganic matter starts to transform itself into living matter. The robotic exploration of Mars leaves not only the material imprints stamped by rovers onto the surface of the planet – the tracks that their wheels engraved into its dust, the pulverised rock that they vaporised, a crevice that they carved into its soil. The exploration also deposits material traces of the intertwined agencies of the human and the non-human, which intervene in the milieu of Mars to inscribe it with life – life that is neither organic nor inert, but intrinsically robotic. In this sense, the robotic exploration of Mars is not so much an attempt to search for and find signs of life, but instead a biopolitical extension of life into its milieu via technical apparatus. This, in Stiegler's words, is a 'pursuit of life by means other than life' (1998: 17), an endeavour to harness the creative potentials of robotics and breed life on a barren Mars. While Mars can only function as a milieu through the embodied presence of the rovers, this milieu now potentially influences – and thus in part frames – the direction of both technological progress on Earth and, perhaps more profoundly, our ideas about the nature of living matter.

Rovers Recollected

The robotic pursuit of life is a laborious enterprise, even for rovers – cast to explore, they are destined to experience and to live, but also to die on Mars. Their presence on the red planet gradually takes its toll;

Martian dust eventually enters their sealed joints, their wheels steadily deteriorate, they get caught in sand storms, their scientific instruments degrade, and progressively, their body parts are damaged beyond repair. While all Mars rovers have significantly exceeded their estimated lifespans, their exploration ultimately terminates in its final stage – death. (Mars rovers never retire; they go straight from their labour to their deaths.) Thus far, Mars has been "the final destination" for two rovers, Sojourner and Spirit. On 17 September 1997, in the 83rd sol of its mission, Sojourner contacted NASA for the last time. After being charged and recharged for a three-month period, the battery of the Mars Pathfinder, the lander via which the rover communicated with Earth, permanently gave up. For several months, its ground control had unsuccessfully attempted to repair the connection with the rover, and the mission was aborted on 10 March 1998. What happened to Sojourner after the communication breakdown remains a mystery. A satellite image taken by the Mars Reconnaissance Orbiter in 2007 identified the Mars Pathfinder, but provided insufficient evidence with which to determine Sojourner's position; it was unclear whether it executed the last command it received and crept back toward the lander, or whether it simply wandered off in some unknown direction and was lost. Spirit's life on Mars was marked by a series of unfortunate events. In March 2006 its right front wheel stalled, leaving it to drag, impeding the "primacy" of its movement, and in November 2008 a tremendous dust storm that roared across Mars incapacitated its energy supply and shut it into hibernation for three days. The rover got terminally stuck in a patch of soft soil in May 2009 and JLP's attempts to free it were relentless, but futile. In January 2010 the crippled Spirit was recast to explore in a stationary mode and its immobility began to hinder access to the power supplied by the sun. The rover went *incommunicado* in March 2010, its 2210th sol on Mars. The JPL speculated that Spirit perhaps "temporarily" turned itself off while trying to recharge its batteries, or that its mission clock failed and, having lost its orientation in time, it accidently went into a sleep mode; despite the efforts to re-establish contact with the rover, Spirit never awakened. Since May 2011, when attempts to recuperate it were terminated and the end of its mission was officially announced, the rover has been left to rest in the Troy crater, west of the Home Plate plateau, in the Martian southern hemisphere.

The milieu of Mars gradually tears and wears a rover's body until its death is an imminent event. The human–machinic networks invested in Mars exploration seek to delay the demise of rovers and protect the vitality of the robotic mission by preserving the fragile materiality of their embodiment. When a rover meets with a fatal accident the assemblage that animates it searches for a rescue solution, trying to heal its dysfunctional extremities and revive its performance, but finally communication fails and the appendage is severed. However, the deaths of Mars rovers such as Sojourner and Spirit are part of the progress of robotics; they are evolutionary sequences in its development as a living network of humans and technologies. These deaths are also each a result of an error that takes place within the Martian unfolding of the robotic; they are failures that occur within exchanges with the milieu of Mars. In Canguilhem's vitalist thought, error is intrinsic to life and life evolves through error; summarised by Foucault in his introduction to Canguilhem's *The Normal and the Pathological*, error for Canguilhem 'is the permanent chance around which the history of life and that of men *[sic]* develops' (1991: 22-23). Yet error, aside from being destructive, is 'instructive' (Canguilhem 1991: 61). While Mars rovers might falter and fall, their fatal errors become part of a learning process that forwards not only the scientific capacity for robotic exploration, but also the evolution of the human–rover network, and a language to accompany it. This evolution is twofold. It not only improves the longevity and embodied performance of the rovers in relation to their milieu; it also strives toward enhancing the communicative bonds between the organic and inorganic elements of the assemblage. The most significant step in this direction is the ongoing project of establishing a permanent internet connection between Earth and Mars, which would overcome the interplanetary

distance and erase the present communicative delays and errors. These strategies are oriented toward strengthening both the material aspects of the embodied robotics, and the social relations between the human and the rover. While obstructed by error and death, the entwined agencies of this robotic life continue to grow in response to the Martian milieu.

Opportunity and Curiosity are currently actively exploring Mars, but their sols on the red planet are numbered. When an error incapacitates their bodies and their ties with Earth, they too will die. More robust rovers more firmly knotted into communicative networks are likely to land on Mars; perhaps they will even perform autopsies upon the bodies of their progenitors and dissect their errantry in order to absorb their past experiences. It appears at least possible to speculate that the robot bodies that wander Mars will take on new shapes, evolve new sensitivities, and be incorporated into an ever more sophisticated network of living relations. The kind of life spun from the robotic probes on Mars might progress to such a degree that it blurs its parts into a whole and the idea of human exploration of space becomes an ontological anachronism. It is clearly conceivable that the wet bodies of human explorers will eventually be sent to Mars; it is less clear how they will encounter the dead and dying bodies of their robotic envoys. Will their life and labour on an alien world be enshrined in death, their bodies becoming historical monuments or avoided as garbage piles on the outskirts of human life on Mars, or, perhaps, will we strip them for their parts and harvest their bodies to construct new objects and apparatus? Perhaps the life which encounters the graves of "old" rovers will recognise its former self in these remnants; perhaps they will remind us of life as it used to be and allow us to recognise what we have become. Our arrival on the red planet will represent a defining point in our rapport with rovers. It will demand consideration of new forms of Martian intimacies bred between the nodal, living, human–technological network of robotic agency and its new, entirely extraterrestrial planetary milieu. This event could be the *kairos* of robotics, the moment in which post-terrestrial futures and their cosmobiopolitical organisation are unmistakably determined by the creative potential of human technologies.

Biographical Note

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