Heteromatic Robots on Mars: Ethics of going Outer Space

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Heteromatic Robots on Mars: Ethics of going Outer Space *

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Abstract— **The exploration of space has gained pace. It is urgent to face this emerging and deeply transforming technological process with research that deals with societal, political, technical, legal, and ethical dimensions of the trans-planetary developments. This is part of a broader research program that draws attention to the manifold human and ethical implications of these endeavors, particularly those related to the exploration of Mars. The specific goal, in this case, is to open a space of critical discussion that shows the need of such research program: the relevance and opportunity to investigate the features of responsibility and their links to the governance of the space race. This program asks about the ethical implications of going and being in outer space, and lifts the question towards a broader transdisciplinary discussion.**

Challenging the fundamental notion of automatism as an essential feature of the outer-space technology, this research shows that multiple interstices of responsibility open as critical spaces that require ethical and political questioning. The concepts of heteromation -as a challenge to automation- and of heterogeneity -as a challenge to homogeneity- serve this critical purpose and shed light to a chain of processes usually blinded to critical enquiry. This is done here with three (and half) specific Martian missions that serve as examples: 1) NASA's helicopter drone Ingenuity, 2) SpaceX Starship program and 3) the former Mars One mission, or 4) the Tianwen China National Space Administration (CNSA) mission. These cases illustrate the potential of this approach and suggest further research possibilities. These cases help trace and draw together sets of connections that allow the identification of specific ethical issues, the investigation of the values and norms upon which the current actions and future plans, the aims, motifs and goals of these initiatives are built and reproduce.

This paper ends by suggesting an interdisciplinary research approach that combines a technoscientific Actor-Network Theory (ANT) and a fluid Grounded Theory. Such frames suggest a mix of quantitative, qualitative digital and network methods of research, that expand from the collection and analysis of online and social media activity, to expert interviews, content and document analysis. These tools serve to follow and connect the manifold of actors, systems, and processes that make up a heterogeneous heteromatic network of engineering, managerial and organizational activities that involve the multiple ethical implications of going outer space.

This decade and the decades ahead will see many new challenges and changes regarding all things space; and the gaze of this project critically enquiries about their ethical awareness.

I. INTRODUCTION

Planet Mars, partly similar to and mainly as complex as earth. The reasons for exploring the red planet are manifold: from the scientific insights regarding the origins of planets, to the option of potential past or present Martian life, and further to "the capabilities of the Mars surface environment to sustain a permanent human-robotic colonized presence" [43], p. 103. The exploration of space, and of Mars too, is done by robotic agents designed to endure the rather hostile dry, cold and stormy environments of Mars climate, with temperatures of as low as minus 90 degrees Celsius during nights [38]. Robots and lately increasingly so called autonomous systems are sent to research outer space. Recent technological developments and rapidly expanding innovations, like Artificial Intelligence (AI), machine-learning and sensor technologies will make autonomously operating groups of collaborative agents (orbiters, rovers and aerial vehicles) possible in future space missions: "Today's AI innovations are paving the way to make this kind of autonomy a reality" [13], p. 2.

However, new sets of possibilities come with new forms of responsibilities. Whilst space explorations provide high amounts of data and information, the question of past or present life on Mars still remains unanswered [35], p. 1. Besides curiosity and the human drive for knowledge, the witness of presence of life on Mars is a response to a current terrestrial crisis. From climate change and global warming to the recent pandemic that has challenged infrastructures, societies and human race itself, earthlings sooner or later will have to face human-induced problems, or terrestrial threats, like asteroid hits or sudden changes in the earth magnetism. Mars then also appears as plan(et) B for the continuation of mankind, as multi-billionaire Elon Musk proposed [14], p. 194. Space, in those projections, is not any more the outer edge of humankind, marking its limits and its condition; but another interstitial territory between humans, just as once were the oceans, instead.

Such adventures, that now have become closer realities carry with them extensive and very urgent ethical questions: not only the governing decision-making processes that consider the value of life on earth and its futures, but also their potential extension beyond the planet. Furthermore, the data sensed by internationally built machines scouting the surface of Mars are limited, and their ownership very protected. The human mediated programming of the landed devices can only be autonomous to an extent, and a lot is engineered, monitored and steered on and from earth, also and even if one of their purposes is to gather factors to probabilistically project the indeterminacies of life. It would be of a high concern to leave the questions involving the interplanetary expansion of humanity to cumulative fragmental and random automated conditions. As it would be to leave it to programmed sensors, mainly built by a world-wide network of top brains and researchers collaborating as distributed pro-

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cesses of hybridized decisions involving models of artificial intelligence and humans with conflicting interests, and with partial perspectives. The threat of extensive ethical reflection, once again, after the damage has been already done.

This work introduces several cases and dimensions of space endeavors, briefly it illustrates questions future research is urged to tackle, and suggests a research toolkit that helps identifying and engaging these questions in more depth. Questions include the overall research interest of how and where systems of responsibility and ethics are at work within the specific context of each case, what kind of networks and flows of responsibilities are performed, by what or by whom; what do the interconnections and gravitations of actors look like and most importantly how can these interconnections help identify responsibilities and assist in the collective creation of connected processes and networks of distributed responsibility and governance. Researching, designing and developing robotic systems to go to space must not only be safe and secure; but it must align with a jointly established ethical framework that considers the complexity of factors involved: environmental, inter-generational, and multi-cultural, at least. The main goal and innovative character of this contribution lies then in the introduction of the concepts of heteromation and heterogeneity into what increasingly calls for a transdisciplinary discussion around the ethical implications inherent in the research, design and implementation of robotic systems (including those eventually going to space). Billionaires, space agencies, engineers, policy makers, laws and territories, add, as we suggest, to the heteromatic labor contributing yet another layer to the network of involved actors with ethical responsibility.

II. Three Cases (and a half) of Heteromatic Robots on Mars

Robotic and autonomous systems are key technologies for exploring space since the early space expeditions in the 1950s; and is still so with the case of the current missions to Mars. The multidisciplinary field of space robotics is transforming rapidly. It has become a competitive and collaborative landscape of national space agencies and commercial corporate entities of multiple countries. Developments in sensing and in perception, mobility and locomotion, high-level autonomy for systems and subsystems, human-robot interaction and system engineering are both challenges as well as needs in the present and future space robotics. These developments change the ways of exploring space by increasing the pace and reducing costs [23].

The question about the ethical procedures that embody such complex networks of design, production and implementation of robotic systems falls directly on the interstices of human activity that taint these processes. It is necessary, therefore, to identify those forms of human decisions that wire and connect humanly the extension of automated activity. The best way to break into this connective tissue made of human decisions is by realizing that the idea of automation is a myth. "Machines, including AI, constantly call for human help, some authors have suggested replacing 'automation' with the more accurate term 'heteromation'. Heteromation means that the familiar narrative of AI as perpetuum mobile is possible only thanks to a reserve army of workers" [40].

This concept has direct implications in terms of labor rights, indeed, the hiding of human activity behind the umbrella idea of automatism conceals the "extraction of economic value from low-cost or free labor in computer-mediated networks" [18].

In this case, the concept of heteromation also helps illuminating and making visible the interstitial moments of human decision, and repair-modify action processes that penetrate the features of machine processing, robot sensing, artificial-intelligently assessing, whatever data that might be collected -for the case- from Mars. The heteromatic activity extends as far as the communicative action spread and co-created through social media, including comments on streams, cognitive labor of free-lance performances of microtasks, creative labor in challenges and design contests, emotional labor of life changing decisions, or the crowdsourced labor of citizen scientists, only to name a few.

It is part of this research program to contribute to the demystification of the myth of automatism, by specifically developing a conceptual repertoire, a methodological toolkit, and enhancing the empirical possibilities of a critical research on the distributed ethical processes taking place by an assemblage of actants involved in the design, building, releasing of robots or of any of the data related processes, sensing, storing, steering, processing, taking part in the Martian exploration, transportation, diffusion, and colonization.

The first three cases proposed here are the NASA's autonomous Martian Ingenuity helicopter taking and communicating flight, the rhizomatic network of SpaceX "making mankind multiplanetary" [6], and the Mars One media spectacle of the narrative of interplanetary colonization. At the time of writing, a fourth case made it to the western news, about China landing on Mars on May 14, 2021. This fourth case will be incorporated in further detail in forthcoming research, too.

On February 18, 2021 National Aeronautics and Space Administration NASA's Perseverance Mars Rover landed on Mars [37]. It had been launched on July 30, 2020. For the first time in the history of space exploration, the rover carries Ingenuity, strapped to its belly. Ingenuity is a 1,8 kg (on earth) helicopter with the sole purpose of working as a technology demonstration. On April 19, 2021 the first powered flight on another planet was successfully completed. It happened in the thin Martian atmosphere (less than 1 percent of the density of the Earth atmosphere [39]). The anatomy of Ingenuity combines components, both off-the-shelf, hereby many components deriving from cell phone technology; and custom-made. The helicopter is designed to fly "on its own, without human control. It must take off, fly and land, within minimal commands form Earth set in advance" [39]. The success in the demonstration of the possibility of operating flights on Mars and the data provided by Ingenuity have a huge impact on all future endeavors concerning the red planet.

The amount and types of ventures involving outer space are growing enormously. Among them, NASA is increasingly cooperating with other commercial partners. Each entity involved in the projects comes with its own agendas and interests. In the case of Ingenuity, then, its own development has been granted thanks to these corporate-state collaborations, making it into a complex assemblage of interests and of heteromatic activities. Among these activities, there is the creative labor of essay contests to name the helicopter itself [36], or the social media activities that comment and discuss the transmitted data provided by Ingenuity. Linked to the endeavors of NASA, Elon Musk's private company SpaceX is one of its most prominent commercial partners. SpaceX operates in multiple areas, from the Dragon spacecraft to be "sending humans and cargo into space" [7], the Starlink Mission, a satellite network that provides almost global access to the internet [9]; or the Starship program, that is aimed towards succeeding in the development of reusable transportation systems to carry crew and cargo and "help humanity return to the Moon and travel to Mars and beyond" [8]. The interests of SpaceX inevitably transfer and are in tension with the interests of NASA, and it is necessary to consider this as a factor that could shape the ethical procedures wiring the mission.

On his own Twitter profile description Elon Musk introduces himself as "Technoking of Tesla, Imperator of Mars ;)". The CEO and CTO of SpaceX's ultimate goal is to "Make humanity a multiplanet species!" [21]. Musk states that: "If we make life multiplanetary, there may come a day when some plants and animals die out on Earth, but are still alive on Mars" [20] and acknowledges that "Public support for life on Mars is critical to making it happen" [22].

As an example of how these colliding interests might pan out in the future, there is a statement issued by SpaceX and its terms of service for the Starship program. International space law and treaties attribute legal responsibility to the state from where the activity is operated from [4]; however, in the case of SpaceX, the terms of service read as following: "For Services provided to, on, or in orbit around the planet Earth or the Moon, this Agreement and any disputes between us arising out of or related to this Agreement, including disputes regarding arbitrability ("Disputes") will be governed by and construed in accordance with the laws of the State of California in the United States. For Services provided on Mars, or in transit to Mars via Starship or other spacecraft, the parties recognize Mars as a free planet and that no Earth-based government has authority or sovereignty over Martian activities. Accordingly, Disputes will be settled through self-governing principles, established in good faith, at the time of Martian settlement" [9]. This particular statement has a relative validity as far as these activities are not taking place; but it is an early controversial statement that proclaims a form of "independence" for Mars as designed by the terms and conditions of a privately owned company. With this big lot to unpack, the urgency for a legitimate legal frame is clear.

On a question posed on Twitter on June 17, 2018 asking about which documents would Musk recommend to use for the establishment of a governing system on Mars, Musk answered: "Direct democracy by the people. Laws must be short, as there is trickery in length. Automatic expiration of rules to prevent death by bureaucracy. Any rule can be removed by 40 percent of people to overcome inertia. Freedom" [19].

Guenther Golob could benefit from such regulation. Guenther Golob is one of the top hundred of two hundred thousand candidates who initially applied for Mars One, a media spectacle that claimed to colonize Mars [2]. Golob was supposed to be on Mars without the option to return: "Sicherheit, das war mit 40 Stunden Job, Familie, ja, alles gut, recht und schön, aber nur für mich war es zu wenig, ich musste ausbrechen aus meinem Leben (. . .) Das ist ein One-Way-Ticket, und da kann man nicht zurück. Kann man sich vorstellen, keinen Vogel mehr zwitschern (zu) hören? Ich versuche diese Erinnerungen auch unter anderem zu speichern, in meinem Körper, in meinem Gehirn, in meinen Zellen, und auf der anderen Seite versuche ich auch, ohne dem zu leben" [1].

These few examples already illustrate a series of moments that require ethical and regulatory measures. These moments go almost unseen amidst the complexity of the activity that takes place around the Mars missions. They are cases of decision-making that need to be identified, highlighted, and discussed as significant parts in the chain of action. From a standing point that rigorously avoids the automatism in the process, these cases can be made visible. As an heteromatic chain of events, the examples of both SpaceX and Mars One reach from emotional labor of cultivating a lifestyle and leaving everything behind, to the labor of building a flow of comments on social media platforms.

There are more examples of space ventures that derive from the uncertain implications of corporate and state-based initiatives. The Trans Astronautica Corporation's (TransAstra) vision of "building the 'transcontinental railroad of space' aims to open the solar system to humanity" [10] by yielding manufacturing and propellant materials to "unlock" thousands of asteroids potential for a cultivation of self-sustaining operations of humans for "science, off-world commerce, and deep space exploration" [10]. This initiative plans to be in service for empowering industries like "space solar power, space tourism, space data processing, in-orbit manufacturing, and untold others" [10]. And untold others. Via asteroid mining, that is mining materials and resources directly from in-orbit asteroids and selling these to "private companies and NASA alike" TransAstra plans to change the current economic model governing the space industry, revolving around high launch costs, the inability of servicing satellites leading to these systems and satellites being "over-engineered to ensure everything works 100 percent of the time" to "reusable spacecraft production, asteroid mining, and in-orbit refueling" [10].

At the other end of these initiatives, interplanetary missions by the China National Space Administration (CNSA) such as Tianwen-1 that recently landed a rover on Mars, is entirely owned and managed by the Chinese state. The absence of collaborative networks outside of China, and the non-transparent management process makes the whole process uncertain from an ethical point of view; and controversial from a planetary perspective considering the case of the Long March 5B rocket debris that returned to earth without a proper landing plan, threatening the health of many [25].

III. The Governance of Robot and Space Endeavors: Initial Implications and Future Explorations

These cases mentioned earlier are just a form of example involving Ingenuity, Mars One, and SpaceX. Checked in detail, these cases revealed the presence of an intertwined system of scientific and popular narratives combined with a drive for spectacle that illustrated the activities, the breakthrough, the discoveries around Mars. Among them, there was some prominence given to the exhibition of networks of humans and of technological capabilities, of images and data-vizualisations explaining and describing the robotic systems engineering. Many of those complex processes, actually, have generated mind-blowing outputs but they did not share the features of their governance, as much as the features of the technical capabilities. The fascination for the technological achievement should not conceal the ethical conditions behind its development: and ask whether such technology was developed in adequate and fair conditions. In the realms of power, not only the what is decided but also the who is taking these decisions is an element that needs to be considered with particular care; and all sorts of ethical procedures must be taken into account. This is particularly true when power lies in the hands of visionary individuals leading huge multimillion corporations [14], p. 144.

A. The Space in Between: Activities and Awareness

The recent years have seen ever growing corporate and institutional initiatives dealing with the practical and ethical issues related to robotic and autonomous systems, and even more so with AI rapidly becoming integral parts of all areas of life [14], p. 148.

This paper is part of a broader research program designed -among others- to grow awareness on the complex processes including practicalities and interests that coincide and collide in the collaborative development, building and implementation of robotic systems. The ethical responsibility in the case of complex robotic systems extends from engineering to implementation, and they are are to be governed through complex mechanisms that take into consideration the full extension of networks of interactions and of interconnected values, not always explicitly mentioned; and inevitably never completely solved, once and for all.

Indeed, the level of indeterminacy of such titanic complex adventures makes any effort to anticipate all answers untenable. The discussion therefore must be organized along three spheres regarding the question of distributed ethics. The three spheres are a) artifacts and technology as integral parts of performing society, b) engineering, robot and space ethics and c) a short outlook on potential future ethical implications of current space endeavors. The forthcoming sections critically discuss the main features of these three approaches, to suggest, as a conclusion, a line of work that will explore these issues from a conceptual, methodological and empirical perspective.

IV. From Robotic Systems to Processes of Hybrid Heterogeneous Networks

Artifacts and technology are integral parts of a performing society; and this can be exemplified with a comment on the report of the nuclear disaster in Fukushima (2011): "For all the extensive detail it provides, what this report cannot fully convey – especially to a global audience – is the mindset that supported the negligence behind this disaster. What must be admitted – very painfully – is that this was a disaster "Made in Japan." Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity" as stated by Kiyoshi Kurokawa [3], p. 9. It is true that this fragment can be considered to fall in the cultural stereotype, but technology and the artifacts produced by humans cannot be isolated from the cultural milieu in which those devices were produced. Therefore, stereotypical or not, the technology wears the imprint of the cultural environment within which it has been designed.

Technologies are artificial products of societies with many beings involved in their design and development as inventors, explorers, engineers, corporations, legal, or governmental representatives, consumers, and politically engaged citizens. Each one of all the actants that directly or indirectly participate in the process adds momentum and direction to the cultural production, the technology. Such addition does not mean that they are able to steer the entire development of the device. Society is part of the machine and the structure of technology is part of the economic and social structure [41], p. 291f.

These features operate in both directions: the same way that a technology emerges within a cultural context that taints its features, that technology will likely operate by reproducing the inequalities and unbalances that conform that particular society and cultural environment. This is a fundamental reminder because as much as technology is not neutral, it is necessary to ask to which form of inequalities might its design serve.

A. Collective Machines and Ethical Engineering: To Mars and Back

"Responsible Artificial Intelligence is about human responsibility for the development of intelligent systems along fundamental human principles and values, to ensure human flourishing and well-being in a sustainable world" [16] p. 119 and beyond...

Technology, including robotic and heteromatic robotic systems, AI, and machine learning, is intricated in societal processes through its multiple forms of interaction with humans, or with itself or with political or economic institutions. Technology therefore must be considered as an agent in the network of activity that forms a society. Failing to do so, only disguises an important side of its societal importance by attributing technology a false form of autonomy and of neutrality.

Science and Technology Studies (STS) is a branch of social sciences that studies innovation and technology as a connective perspective. This branch considers that the extensions of the complex network of science, technology, society and nature and industry melt [41] [30]. From this perspective, humans and non-humans must be considered as agents alike interacting within the network.

ANT is one strand within STS that reveals networks of mediations [31], p. 236, made up by collectives of associations of human and non-human actors [32], p. 11. These heterogenous networks are made of things, artifacts, humans, norms, signs, texts, organizations and more to form hybrid actors which are inscribed into programs of action [11], p. 15. The task then is to follow and describe these networks of hybrid collectives [30]. Description, connection and interpretation are a form of unfolding network analyses that highlight the network norms of "connectivity, flow, communication, participation, transparency, authenticity, and flexibility" [29] p. 10.

From this perspective, the social is always inherent in technology [41], p. 191 and in the practices of research, design, production and innovation. Engineering and specifically robot engineering or participating in the engineering of an autonomous robotic system are processes that require the knowledge and cooperation of many fields; electrical, mechanical, software engineering, mathematics, physics, AI, and robotics [28], p. 430 and more. Engineering in that sense can be considered a layered practice that involves several key features. This understanding of technology development as a network of connections, actors and actions, helps mapping the ethics of engineering a little further. For instance, the goal of engineering, the internal and external goods, the principles, and virtues as well as the identification of the silent institutional pressures within which the engineering process might be embedded [12].

Robot and AI ethics offer the chance to reflect about the principles of fairness and goodness upon which a society is allegedly based on. Robots and AI ethics also offer considerations about the meaning of human life, and about the role of technology in all of this [14] p. 142. Robot ethics, as form of applied ethics engages with the ethical aspect of the design, manufacturing, implementation and usage of robots [44]. The common discussions in this field turn around issues like safety and risk assessment in planetary protection, the protection of the astronaut health, private and commercial space activities, and the moral argument of using robots instead of humans for the exploration of space, except for the one purpose of colonization [5]. Most of these questions fall within the realms of safety and errors. Yet, the debates on law and ethics, and on the social impact of robots, as well as the impact of robots exploring new planets, have to be confronted, too [33]. After all "technological development cannot be left to the contingencies of private interests and unregulated market forces" [15]. Real-time technology assessment [26] and strategies of anticipatory governance could be relevant key features for the ethical engineering of machines, as hybrid heterogeneous socially connected assemblages.

B. Future Space Oddity: Interplanetary Trolley Problems and Ecological Challenges

Exploring the potential future impact of current space endeavors helps to understand their ethical implications: For example, the trolley problems and new ecological challenges that come with heteromatic robotic systems inhabiting space.

The continuous integration of autonomous cars into traditional traffic, carrying the promises of mobility, increased security, and optimized flows of traffic asks for complex technological, societal, and legal innovation [17], p. 92. Autonomous cars, however, also raise questions in the realms of ethics; i.e. in situations of conflict with potential hazardous, or even harmful up to fatal outcome: Who is to decide, and how is legal responsibility distributed, and shared amongst the multiple actors involved (algorithm, engineers, operator, manufacturer, and many more)? This case can be easily scaled to understand the magnitude of such uncertainties in space exploration, or in the case of expected commercial space tourism.

Similarly, the installation of satellite systems such as SpaceX Starlinks mega-constellation planned to launch up to 42 thousand satellites into lower orbit until 2027 [8]; or the expected accumulation of space debris, that is objects in orbit that no longer have a specific function, or even a cherry-red Tesla roadster, sent to outer space by SpaceX as part of its Falcon heavy rocket promotion launch in 2018 [24]. Given the growing amount of space waste orbiting our outer stratosphere and the eager plans to get more and more things out there, one ethical issue that emerges is the environmental and ecological issues of space waste or the growing light pollution due to some eagerness at conquering space. The issue of governing and polluting the space with traffic and the ethical question of who has the right and the legitimacy to do so, or to regulate on it.

C. No Sacrifice, No Victory: Collective Shared Responsibility

This paper calls for increasingly considering all the existing networks of hybrids and their politics into account, cultivating a more inclusive approach that helps dealing with the pressing ethical concerns. That is the conquest of space does not happen as a neutral or as a clearly automated process. The technology developed for the occasion is prototyped and needs constant human attention and human intervention. The question is then, to what extent is this human intervention considered from its ethical responsibility. To deal with these issues it is necessary to start unveiling the hidden tentacles behind the deployment of Ingenuity; the potential improbability drives that govern SpaceX as well as the, interstitial layers of entertainment lurking, deeply rooted longing visions for questions on the answers of all things humanity, as seen in Mars One.

The distributed agency, that is the agency distributed between various elements of a complex network made of human and of technical actors, must be approached by considering the whole assemblage for instance from the ANT [30], [31], [32], [11], [29], framework. The systematic identification of the elements forming the assemblage will also allow to identify their responsibility in the process and to map the features of its organization and its governance [42]. These are also the networks of responsibility [34] that will enable to track and trace the actors and moments of accountability: technical responsibility in the research and innovation of technology, individual responsibility of engineers and users, consumers and operators, Corporate Social Responsibility (CSR) of companies and collectives, the self-governance of organizations, branches, Non-Governmental Organizations (NGOs), auditors and the media, and the co-regulation of political, legal and public players [42], p. 43.

V. SUMMARY AND OUTLOOK

The outer space and Mars are on top of the agenda for the coming decade; and most of the exploration and sensory activity is in the hands of complex automated systems: robots. Furthermore, over the last few months, the Mars operations have made it to the news and to the trending topics of the social media platforms as orchestrated planetary promotion campaigns.

This paper considers three (and a half) of the recent Mars endeavors, the Mars One mission, SpaceX, and the NASA helicopter Ingenuity together with a brief mention of the recent Mars mission programmed by the China National Space Administration as examples that illustrate the complexity of the factors that intervene in the design, build and implementation of the robotic automated systems in charge of sensing, storing, and processing Mars and the journeys there.

The term heteromation is used then to explode the black box of the automated processes by identifying the need of intervention, repair, and human coordination that hides behind the complexity. With the notion of heteromation it is possible to illuminate the interstices of human presence that populate the mystified automated processes; and this has implications at least at two important levels: one, labor; the idea of automation hides the work of humans that intervene and grant that the automated process works; and two, ethics; the presence of human intervention implies decisions, actions, and assessments that require a critical consideration.

The purpose of this paper is to open these interstitial spaces of human labor and to ask about the ethic procedures informing them. These queries lead directly to the question about the governance and chains of command that articulate the activity at the broadest scale; and this is shown with examples from the several missions considered.

This is the introduction of a broader research program. Its point is to develop a triple toolkit: conceptual, methodological, and empirical, that helps critically quering the ethical and governance features of the Mars missions and extensively of the outer space forthcoming adventures. To do this, the conceptual will build on the developments and extensions of the STS applications of the ANT; the methodological will involve a mixed methods combination of tools building around Grounded Theory and the empirical will innovate with the incorporation of digital methods, social media analytics, and qualitative expert-driven and quantitative and network analysis research.

It is only a start, but it works as a critical tool that searches into the invisibilized human intervention hidden in the enthralled gaze of the technological development, and of the automation myth, to ask finally about the very human and culturally situated values, principles, assumptions and ethics driven safety measures that shape ultimately into an assemblage of power that materializes the human governance of the machinic robotic system.

"The machine is us, our processes, an aspect of our embodiment. We can be responsible for machines; they do not dominate or threaten us. We are responsible for boundaries; we are they" [27].

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