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Working on Mars

An Immersive Encounter through the Screen

Lost in the kaleidoscopic colours captured by the Hubble Space Telescope, lured in by the deathly blackness of Comet 67P as represented by Rosetta, and straining to make out Pluto through the first images taken by New Horizons, we are awed by such vastness and intangibility captured within the confines of our screens. Society seems to have a fascination with things beyond the realm of perceptual understanding; presenting us with scenes that we empirically know nothing about, the image of a faraway planet on the NASA website is a mysterious one, far more fascinating than our immediate setting. As viewers of such images we are reliant on space agencies like NASA and ESA to provide us with pictures and information so that we may explore these other worlds from the safety and security of our computer screens, smartphones or tablets. Satisfying the public need for images they reflect humanity's ancient impulse to explore, to discover places with their own eyes, and if not our own, then those of our machines.

This essay is drawn to one particular planet: Mars. More spacecraft, landers and rovers have been sent to Mars than any other planet and as such it is the most imaged (and arguably imagined) otherworldly landscape. The landscape is ostensibly familiar; comparable to the deserts of the American West, the plains of Chile, and the rugged landscapes of Iceland, we have an intuitive understanding as to how it might feel to walk across its surface. The *eyes* of NASA's rovers provide viewpoints through which we regard this alien terrain – windows upon unknown worlds, these images bridge a gap between what is known and unknown, between what is visible and invisible.

This is a planet being explored remotely; data is sent back to Earth, examined and reconstructed into different visualisations, allowing for new commands to be sequenced and uploaded, transforming image into action. Through images, scientists and engineers make daily decisions on how to operate the rovers remotely; data gathered from images is key to constructing visualisations of the terrain. Scientific experiments and rover drive paths are simulated before being acted out by the real rovers on Mars. This is done in a number of ways, and the focus of this essay is one of the most current means scientists are using to explore three-dimensional visualisations of Mars: NASA and Microsoft's OnSight project. Using an augmented reality headset to enable a more immersive encounter with an alien landscape, OnSight is an example of how screens are transmuting from the stationary to the mobile, from the two-dimensional to the spatial and temporal.

A Window onto Mars

NASA's Curiosity is the most recent rover sent to explore Mars (landed in 2012), and there are a whole host of other spacecraft orbiting the planet, with a number of missions planned for the near future. For many of the scientists working on Mars exploration, rovers are the next best thing to being there ourselves; stereo-vision, arms carrying instruments and wheels that enable movement over long distances, the rovers facilitate what computer scientist William J. Clancey has termed "virtual presence".[1] Whilst satellite imagery captures a sense of Mars as a whole, depicting the planet as distant and remote, the rovers, being on the ground, offer visions analogous with perception: *windows* onto a world. As Anne Friedberg points out: "We imagine *perception* to be a kind of photographic view of things, taken from a fixed point by that special apparatus which is called an organ of perception."[2] Although of course we do not see as the camera sees (from a fixed point, through one lens, with a particular focal length, etc.) the notion that a picture is a kind of window dates back to Alberti's first modern treatise on painting, *Della Pittura* (1435). The camera, like Alberti's gridded veil, is a mechanical means of translating subject into image. Discussing the camera, art historian Martin Kemp argues that imaging machines and the way data is presented is always linked to the eye because "it is the human visual system that initiates any kind of photographic activity, [...] the end product is rigged to work within the parameters of our sight, and [...] images are irredeemably subject to our ways and habits of seeing in all their variability."[3] The cameras on Curiosity's mast (the right and left black and white navigation cameras and the right and left colour mast cameras) are located roughly 1.97m from the ground, just above human eye height. The cameras then are the eyes of the rover, and in turn an extension of our vision. Clancey argues that it is through the image that scientists can experience Mars in the *first person*. When looking at a photograph of Spirit's tracks in the sand, scientists liken the marks to the scuffing of their boots: "we have been there and we did this. These are our marks – our boots on the ground of another planet."[4] As "surrogate explorers" these scientists become the rovers, referring to aspects of the landscape as if they had stood there themselves.[5] By looking upon an image that places the human at the centre of the mediated experience, the image makes way for the possibility of a virtual experience.

But we are not there behind the viewfinder to compose the image before releasing the shutter, nor are we able to compare the image with reality once we've tapped the capture button on our smartphone. We are not, therefore, able to verify first-hand the referent these images signify. Jim Bell, the Panoramic Camera's lead investigator for NASA's Spirit and Opportunity rovers, states that "the relation to reality is a particularly strange one" for Mars exploration; the images captured by the rovers are not "abstract" but they do not represent "a reality that any human has quite witnessed yet, either".[6] For Roland Barthes, writing about analogue photography in 1980, the image always contains the referent; the reflected light physically alters the surface

1 William J. Clancey, *Working on Mars. Voyages of Scientific Discovery with the Mars Exploration Rovers,* Cambridge, MA: The MIT Press, 2012, pp. 59–60.
2 Anne Friedberg, *The Virtual Window. From Alberti to Microsoft*, Cambridge, MA: The MIT Press, 2006, p. 142 [original emphasis].
3 Martin Kemp, *Seen Unseen. Art, Science and Intuition from Leonardo to the Hubble Telescope*, Oxford: Oxford University Press, 2006, pp. 268–269.
4 Clancey 2012 (as fn. 1), p. 103.
5 William J. Clancey, Becoming a Rover, in: Sherry Turkle (ed.), *Simulation and its Discontents,* Cambridge, MA: The MIT Press, 2009, pp. 107–127, p. 114. Clancey also explores the use of such phrases as "where are *we* going to go" or "are *we* going to stay here?" to explore how each scientist projects themselves onto and into the body of the rover. Ibid., p. 115.
6 Jim Bell, *Postcards from Mars. The First Photographer on the Red Planet,* New York: Penguin Publishing Group, 2006, p. 3.

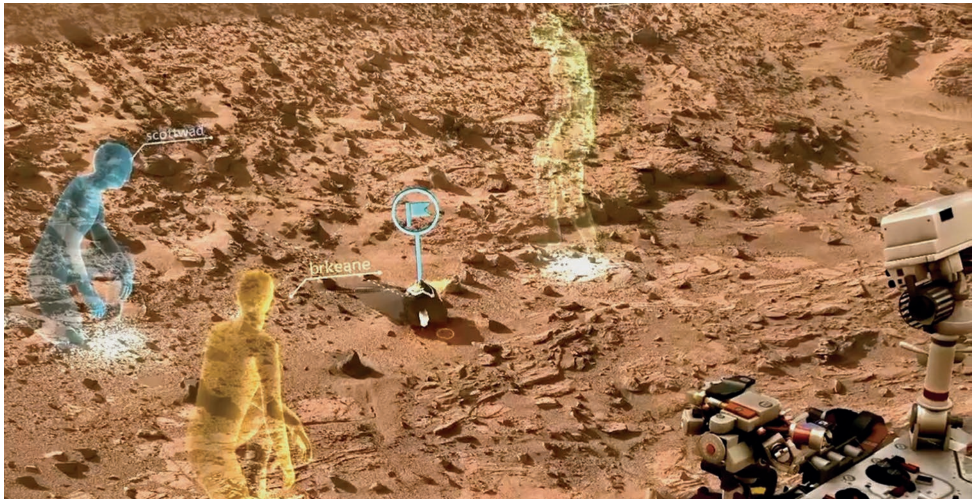
of the negative and the image becomes indexically linked to the object it represents, signifying its presence in some past moment.[7] Mars is just over 225 million kilometres away and data – captured digitally – can take between 4 and 24 minutes to reach Earth.[8] Barthes' referent then is completely invisible to the naked eye. The distance between Earth and Mars reduces our experience of the planet to two dimensions, and the screen becomes an impenetrable boundary – both physically and metaphorically – that more immersive visualisation technologies are trying to break. We experience Mars through multiple forms of images; black and white and colour composites standing in for an impossible experience. These images are viewed principally on computer screens, but the image also becomes another kind of screen, a mediator that is imbued with calibration procedures, technological limitations and the science-driven demands of NASA. And yet images are a vital part of the process when it comes to gaining a more immersive understanding of the rover's surroundings, enabling scientists and engineers to make discoveries or decisions on where the rover should drive next. Panoramic visualisations for instance give a 360° view of the terrain, whereby the rover (and thus the human viewer) is placed at the centre of the image. Red/blue anaglyphs are used to get a sense of the topography, and 3D terrain models are constructed from stereoscopic data to simulate drives and build command sequences. The colour of images is manipulated by scientists to draw out geological features and chemical compositions in a practice of working with images to actively reveal what would otherwise remain unseen.[9] Each virtual manifestation of Mars becomes a screen through which a form of invisible vision is enabled. But this is a landscape humans have yet to witness first-hand. Distance, the unknown and the impenetrable lie at the very heart of these images. These predominantly two-dimensional *windows* often fail to offer their viewers a more intuitive grasp of scale, distances and the rover's overall context on the surface. And this is where recent developments in the field of virtual reality are triumphing.

Although scientists at NASA Ames have been working on head-mounted displays (HMDs) since the mid-1980s, the tech world has recently witnessed a surge in developments in this field, particularly in the consumer market. Based on knowledge of stereoscopic vision, the left and right eye views of a virtual environment are projected into either eye to give the illusion that the user is experiencing the image space in real life. Virtual environments may be fully immer-

7 Barthes was referring to un-manipulated analogue photography: "It is often said that it was painters who invented Photography (by bequeathing it their framing, the Albertian perspective, and the optic of the *camera obscura*). I say; no, it was the chemists. For the *noeme* 'That-has-been' was possible only on the day when a scientific circumstance (the discovery that silver halogens were sensitive to light) made it possible to recover and print directly the luminous rays emitted by a variously lighted object. The photograph is literally an emanation of the referent. From a real body, which was there, proceed radiations which ultimately touch me, who am here." Roland Barthes, *Camera Lucida. Reflections on Photography,* London: Vintage, 2000, pp. 80–81.

8 The time it takes signals to reach Mars depends largely on the position of Mars in relation to Earth with the minimum time delay being 4 minutes, the maximum being 24 minutes.

9 These immersive forms of images were explored in my 2017 PhD thesis titled *Mars, Invisible Vision and the Virtual Landscape. Immersive Encounters with Contemporary Rover Images*. The thesis offered a new understanding of human interaction with a landscape only visible through a screen, and explored how contemporary scientific imaging devices aim to collapse the frame and increase a sense of immersion in the image. Arguing that these representations produce inherently virtual experiences, their transportive power was questioned, highlighting the image as reconstructed – through the presence of a glitch, illusion is broken, revealing the image-as-image. The research re-examined scientific forms of images against examples from the history of visual culture (be it art or popular culture) to draw parallels between different ways of seeing, representing and discovering the unknown.



1 Screen view from OnSight, January 21, 2015.

sive (virtual reality) or virtual objects may be overlaid onto real-life surroundings (augmented reality). Head-tracking technologies enable the user to move about in real space and experience environments as if they were really there, placing the viewer at the very centre of the visual experience.

In 2015 NASA and Microsoft launched OnSight, which uses Microsoft's HoloLens (an augmented reality headset) to display a virtual environment constructed from data captured by Curiosity. As a current screen-based medium that synchronises image, action, and space on the spot, OnSight is being used to explore Curiosity's images in more detail, enabling scientists to "work on Mars".[10] As NASA/JPL state: "images, even 3D stereo views, lack a natural sense of depth that human vision employs to understand spatial relationships [...]. [OnSight] provides access to scientists and engineers looking to interact with Mars in a more natural, human way."[11] This technology is being heralded as an immersive means to explore Mars from a scientific perspective, allowing scientists to plan which areas of the landscape they would like to investigate, image and drill, but OnSight is also being used to explore data from previous Martian days (sols) in more detail. In addition, scientists from all over the world can explore the data *together*; each scientist has their own *avatar* within the virtual environment that the other users can see. The avatar's *gaze ray* (a line of coloured light emanating from the avatar's eyes) enables other users to see where they are looking and each user is able to lay flags to pinpoint areas of interest or possible spots for further exploration by the real Curiosity on Mars (fig. 1).

Navigating Mars From the Centre of the Image

The OnSight software constructs a three-dimensional environment from MastCam and NavCam images, together with satellite imagery taken by the HiRISE camera on the Mars Reconnaissance Orbiter.[12] This technology is being used by both NASA scientists and those working with the data at planetary imaging facilities and academic institutions

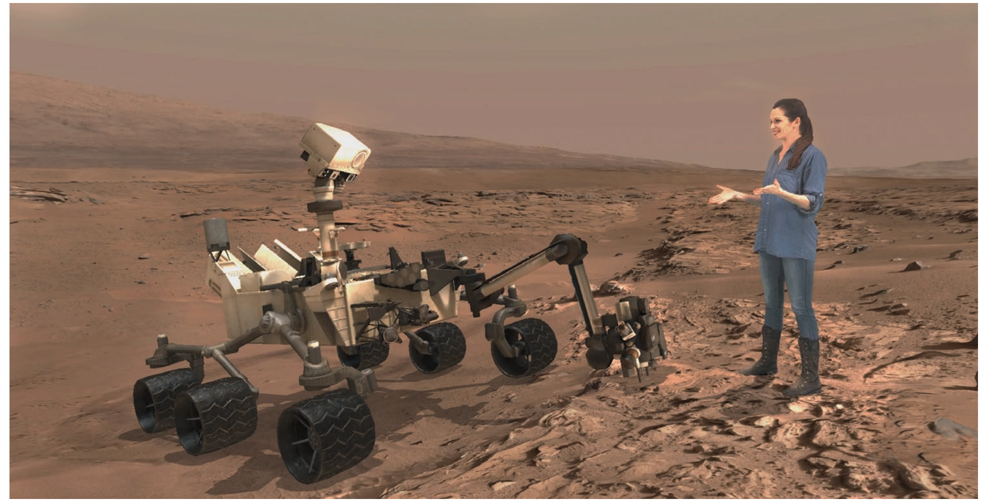
10 NASA/Jet Propulsion Laboratory, NASA, Microsoft Collaboration Will Allow Scientists to 'Work on Mars,' http://jpl.nasa.gov/news/news.php?-feature=4451 (accessed December 14, 2016).

11 Ibid.

12 Project Manager for OnSight Jeff Norris explains: "The 3D reconstruction is created via a terrain processing pipeline developed by my team that takes as input the stereo images acquired by the rover's cameras. The pipeline extracts range information by using a process called stereo correlation, and then uses that range data to build a 3D model of the shape of the terrain called a 'mesh'. The mesh is then coloured using texture maps that are also derived from the images." Jeffrey S. Norris (Founder and Director of JPL Ops Lab, NASA, California), email message to author, March 26, 2015.

around the world. The OnSight units access the data via the internet by connecting to servers at the Jet Propulsion Laboratory (JPL) in Pasadena, California. When the rover moves to a new location, the scientists are emailed notifications about a new scene, which automatically downloads when the headset is switched on.[13]

The kinds of promotional images that accompanied the announcement of OnSight in January 2015 portrayed an immersive experience whereby the user was able to walk across the surface of Mars (fig. 2). However, the actual experience of OnSight is fairly different; as the software combines NavCam and MastCam images, the virtual environment is a patchwork of colour and black and white. Upon donning the headset and clicking through to the Mars dataset what you see is essentially only a kind of *window* onto Mars; the screen has an aspect ratio of 16:9 and it takes up the centre of the user's vision. Unlike virtual reality whereby you are totally immersed in a simulation, augmented reality overlays the virtual and the real: peripheral vision (anything outside of that screen to the right, left, bottom or top) is taken up by real-life surroundings. Although this might at first be seen as a limitation, Research Associate in the Earth Science and Engineering Department at Imperial College London, Dr. Steven Banham, states that an awareness of the user's real surroundings prevents them from tripping up and counteracts the feeling of nausea so often experienced with fully immersive HMDs.[14] As such, the technology can be used for prolonged periods of engagement. As the user moves their head or rotates on the spot, a three-dimensional rendering using photographic data of the Martian landscape



2 Erisa Hines, a driver for the Mars Curiosity rover, based at JPL, talks to participants in Destination: Mars, March 30, 2016.

is revealed behind a window. As the user walks about in real space, so too does the perspective through the window change: through the image-as-screen Mars can be seen from different viewpoints.

Although this tool is not being used by engineers responsible for driving the rovers on Mars, there are similarities between how OnSight constructs a three-dimensional environment and how tools used by JPL engineers model the terrain through stereoscopic data captured by the rover's cameras. Due to the time delay, driving rovers around the surface of Mars in real time is not an option. Instead commands are uploaded on a day-to-day basis. The data from the previous sol is analysed by science and engineering teams and decisions are made on where the rover should drive next and what experiments it should undertake. Commands are written and uploaded at the end of each Earth day and the

13 Dr. Steven Banham (Postdoctoral Research Associate, Earth Science and Engineering Department, Imperial College London), interview by author, London, December 13, 2016.
14 Ibid.

rover carries out these instructions, beaming back its data for the following day, when the whole process starts again. Although scientists return to images taken days, months or even years before, engineering decisions on where to drive the rover are made daily using the most recent data and a different set of tools aid this process.

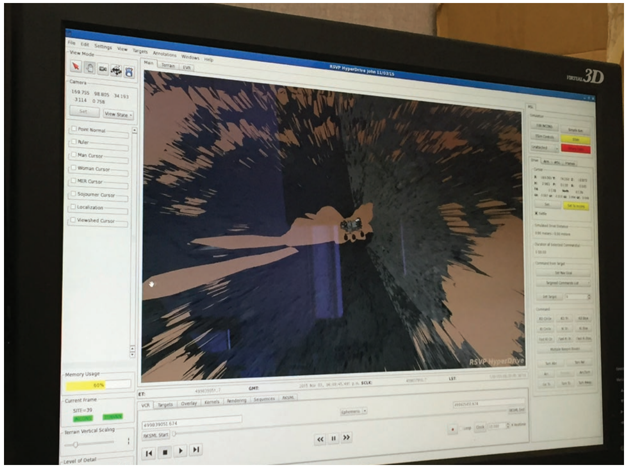
3D visualisation software is used by rover drivers at JPL to assess the traversability of Curiosity's surroundings from stereoscopic data captured by the navigation cameras, the hazard avoidance cameras and the mast cameras. The multiple programmes used to drive the rover are part of a suite of applications called the Rover Sequencing Visualisation Programme, or RSVP. RSVP takes the stereoscopic image data and automatically produces polygon meshes of the terrain. The programme allows drivers to see the rover's positioning in relation to hazards and holes in image data which are seen as potential obstacles (fig. 3–4). The rover drivers study images and analyse the terrain models, simulate drives over them, and when they feel comfortable with the planned traverse, upload the command sequence to the rover along with instructions from the science team.

These models are used alongside the raw images to provide the rover's up-to-date location (fig. 5); they are *interactable* terrain models that display the rover in the context of its *seeable* surroundings. Such modes of visualisation generate what sociologist of science and technology Janet Vertesi terms as an "immersive view of the Rover's environment", "*draw[ing]* Mars *as* [a] tangible, interactable terrain, and allowing engineers to conjure up the sense of 'being there' virtually".[15] In this case, the practice of working

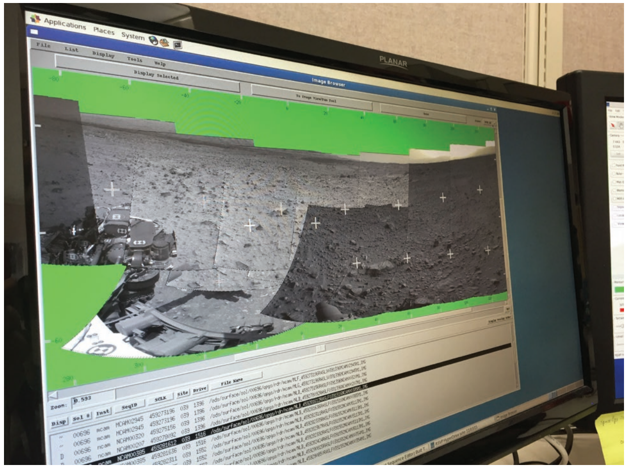
15 Janet Vertesi, 'Seeing Like a Rover'. Images in Interaction on the Mars Exploration Rover Mission, Dissertation, Cornell University, 2009, http://hdl.handle.net/1813/13524 (accessed March 15, 2014), p. 260, p. 262 [original emphasis].

3 Terrain model of Curiosity's surroundings shown in RSVP.

with images and 3D models allows teams at JPL to convert image (simulations of the drive paths) into action (in reality on Mars). In the models, the rover's seeable surroundings are represented by the black and white image data – these images are draped over the underlying polygon mesh, filling in only what can be seen from the rover's central viewpoint. Any holes in image data created by a ridgeline, rocks, or the rover itself are represented in Martian brown – here the polygon mesh is approximated. Rovers are never driven into these spaces because they are unknowns, and for rover drivers these blind spots are as important as the terrain that can be seen. The images then help to define and determine the possibilities and the range of operations. Writing on vision and perception in 1945, Maurice Merleau-Ponty asks how we should experience the existence of absent objects, and how we should experience the nonvisible parts of present objects. "Should we say," he asks "that I *represent* to myself



4 Elevated terrain model of Curiosity's surroundings shown in RSVP.



5 Photograph of Curiosity image mosaic shown on-screen in RSVP.

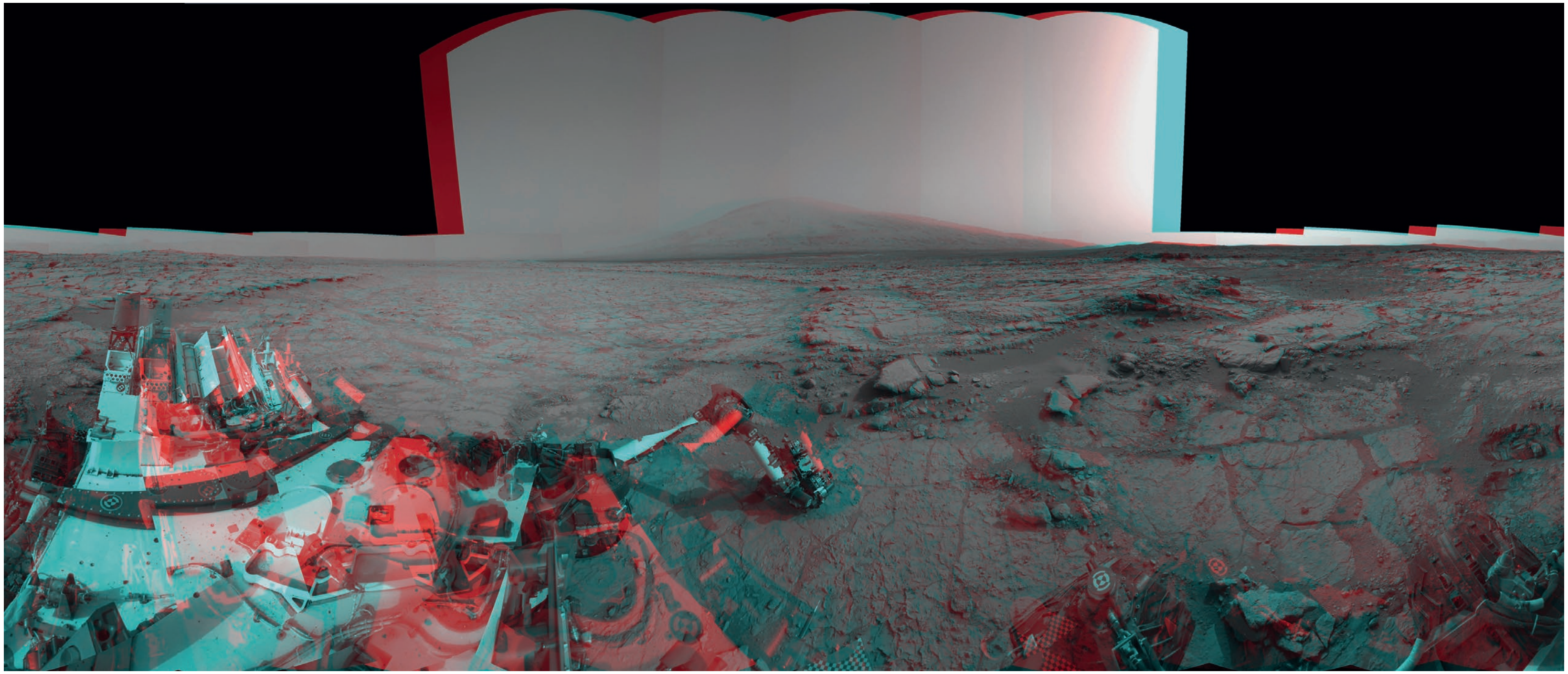
the sides of this lamp which are not seen?" The unseen sides of the lamp are anticipated, according to Merleau-Ponty, "as perceptions which would be produced" upon movement.[16] The terrain model in RSVP highlights the gaps in image data, what cannot be seen by the camera's lens. Unlike Merleau-Ponty's lamp, the Martian landscape is not a space we can reach into or around to touch: we cannot physically move through the landscape to reveal the invisible. The visible landscape is framed by the flat colour of the polygon model, showing the "limit of visibility".[17]

In a similar fashion, Paul Virilio writes on shifting one's gaze, one's vision and one's blindness: "Shifting your gaze, whether thanks to the mobility of your head or the mobility of your eyeball, also means effectively shifting your blindness, your own relative blindness."[18] In the RSVP terrain-mapping tool we see according to blindness, distinctly aware of what is missing. Blindness pushes up from underneath the terrain model, giving material form to that which remains invisible. We cannot fully perceive the surrounding landscape, not through Curiosity's eyes or our own. Rover drivers can simulate Curiosity's traverses through the virtual model, but by doing so they cannot reveal any more than what is already there. Curiosity is at the centre of the image. RSVP allows engineers to see what is on the periphery of vision, to rotate, zoom in and out, and generally gain a more encompassing understanding of the terrain they have to navigate, but this vision is dictated by the rover's capabilities, the limits of

16 Maurice Merleau-Ponty, *The Primacy of Perception,* Illinois: Northwestern University Press, 1964, pp. 13–14.

17 Paul Virilio, *A Landscape of Events,* Cambridge, MA: The MIT Press, 2000, p. 38.

18 Ibid., p. 39.



3 *Mars Stereo View from John Klein to Mount Sharp, Raw.* This 360° anaglyph combines dozens of images taken by Curiosity's right and left Navigation Cameras on January 23, 25 and 26, 2013 (sols 166, 168 and 169). Photojournal image addition date: April 23, 2013.

its vision – in a visualisation that is, to quote one of JPL's rover drivers John R. Wright, only "two and a half D".[19]

3D may be achieved through 3D-enabled screens or red/blue anaglyphs which are used to get a more kinaesthetic sense for the terrain. Yet images like *Mars Stereo View from John Klein to Mount Sharp* appear as *windows* (fig. 6); a viewpoint which has been given artificial depth. Such images are shown on computer screens, and OnSight attempts to bridge the gap between an onscreen image and physical experience, allowing a more intuitive exploration of landscape. Scientists spend prolonged periods of time looking at image data and editing it to produce certain results. Before OnSight, what was lacking was the ability to physically move about within the landscape, to inspect a particular rock, or to walk about and get a *feel* for the terrain surrounding the rover.

19 John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, November 3, 2015.

But there are still limitations, primarily relating to the fact that the environment can only be constructed through data captured by the rover.

Donning the OnSight headset and *airtapping* through the drop down menus to load the scene, the virtual environment appears through a window. This window is overlaid onto real-life surroundings and shifts with the motion of the user's head, always directly in front of their eyes. From its vantage point Curiosity can image its near surroundings in high resolution, but as with RSVP, *seeing* behind objects is not a simple case of walking into the landscape and looking from a different perspective; the virtual environment is dictated by the rover and its cameras' stereoscopic reach. Unlike RSVP, which represents the unseen sides of the landscape in a different colour, OnSight's objective is to increase levels of immersion, so unseen sides of rocks and terrain features are estimated, rather than being left blank. The further away from the rover the user gets, the more the software has to fill in. As a result, these features appear slightly distorted as the photographic data is stretched over the underlying polygon mesh. As long as the user remains close to the rover, the distortion does not impede a great deal on the level of immersion.

Nonetheless, OnSight enables its user to gain greater situational understanding for the terrain around the rover, just as they might if they were *there on Mars*. Project manager for OnSight Jeff Norris elaborates on this:

> *OnSight tries to engage many of the same senses that a geologist would have when exploring a location on Earth. A very important sense that OnSight engages but a traditional computer monitor does not is* proprioception*, the body's sense of its own position and movement. Because we rapidly and accurately track the position of the scientist's head as they move around in their office, we can show them the views of Mars that they would have if they were moving in the same way on Mars. This is what creates [a] 'first-person perspective'.*[20]

The importance of experiencing the world from within, with the body as the locus of perception was set out by Merleau-Ponty: "I do not see [a space] according to its exterior envelope; I live in it from the inside; I am immersed in it. After all, the world is all around me, not in front of me."[21] The image is a space in which the objects do not surround us and immersive technologies attempt to deceive us otherwise by enveloping us in the image. With OnSight the body is quite literally placed at the centre of the experience; the user must move his/her body to reveal more of the landscape. Artist and critic Brian O'Doherty describes a similar experience: "[T]he Eye urges the body around to provide it with information – the body becomes a data-gatherer."[22]

With OnSight, however, our vision and body become oddly detached; reaching our hand out in front of us – as if to point towards something through the window – it disappears, existing behind the screen within physical and not virtual space. Despite our body being integral to *how* the illusion is revealed, the eye is isolated, being the only entity present in the image of Mars. To this end, Merleau-Ponty discusses the idea of the seer and the visible:

> *[...] without even entering into the implications proper to the seer and the visible, we know that, since vision is*

20 Norris 2015 (as fn. 12).
21 Merleau-Ponty 1964 (as fn. 16), p. 178.
22 Brian O'Doherty, *Inside the White Cube. The Ideology of the Gallery Space*, Berkeley: The Lapis Press, 1976, p. 52.

> *a palpation with the look, it must also be inscribed in the order of being that it discloses to us;* he who looks must not himself be foreign to the world that he looks at. *As soon as I see, it is necessary that the vision (as is so well indicated by the double meaning of the word) be doubled with a complementary vision or with another vision: myself seen from without, such as another would see me, installed in the midst of the visible, occupied in considering it from a certain point […]* he who sees cannot possess the visible unless he is possessed by it, unless he is of it.[23]

To appropriate another O'Doherty quote, with OnSight "the eye is abstracted" from a mobile body "and projected as a miniature proxy into the picture to inhabit and test the articulations of its space".[24]

It is important to note that although OnSight is perhaps the most immersive means of experiencing images of Mars in a screen-based technology that synchronises image, action and movement, the tool is not without its limitations. Being an augmented reality headset, the window onto Mars appears against our real-life surroundings and as such it is not fully immersive. OnSight's window onto Mars only allows the user to *glimpse* a virtual image of Mars. Floating about, occupying a strange space between the user and their real surroundings, the screen becomes the frame that withholds the image of Mars just beyond our grasp. The level of immersion for OnSight then is not the technology's ability to give a full 360° view of an environment (for Mars to invade all areas of vision) but is in the act of movement to reveal the depth of the virtual image.

With OnSight there is the definite wow-factor and seductive novelty of new illusions; like the Victorian stereoscope or 3D TV. With new technologies appearing all the time, perhaps there is something in the ephemeral nature of technologies in re-presenting images of Mars that reflects our human desire to see ever more clearly and in a more immersive manner, to get closer and closer to a feeling of touching and being in the landscape, if only – for now at least – on the level of vision. In a sense then, OnSight reveals a deeper, more insatiable desire that lies at the heart of all types of imaging; to re-live, re-construct or imagine something that is unseen because of its distance from us in time and space.

An Immersive Encounter

This essay concludes with a subjective encounter of OnSight which took place on December 13, 2016 at Imperial College London, and was kindly facilitated by Dr. Steven Banham. The virtual environment encompassed datasets from sols 1526 – 1547 (November 22 –December 13, 2016). During this time the rover had been parked for a few days whilst engineers ran diagnostics on the drilling mechanism; as such the rover was able to image its immediate surrounds in high-resolution detail.

23 Maurice Merleau-Ponty, *The Visible and the Invisible, followed by Working Notes,* Evanston: Northwestern University Press, 1968, p. 135 [original emphasis].

24 O'Doherty 1976 (as fn. 22), p. 18. Original quote: "One 'steps' firmly into such a picture or glides effortlessly, depending on its tonality and colour. The greater the illusion, the greater the invitation to the spectator's eye; the eye is abstracted from an anchored body and projected as a miniature proxy into the picture to inhabit and test the articulations of its space. For this process, the stability of the frame is as necessary as an oxygen tank is to a diver. Its limiting security completely defines the experience within."

Lowering the headset over my eyes and adjusting the headband I looked through tinted glasses at the office surroundings of the Royal School of Mines at Imperial College London. A window slotted down into view. With an almost opaque but luminous translucency this window was hard edged and glowing against the dull grey of the real office carpet and surrounding white walls. But unlike Alberti's fixed veil this window was mobile, almost fragile. Floating and glimmering the window followed the motion of my head, persistently present within my direct field of vision, in front of and against, yet within the office interior. A screen which was simultaneously a window, appearing only for me. A personal portal out onto Mars.

The screen flickered and the laying out of a polygon mesh announced the forthcoming emergence of landscape. The terrain began to materialise, expanding outwards rapidly from my immediate surroundings and into the distance, a patchwork of greys and Martian browns in high and low resolution. Revolving on the spot I looked out towards the mountainous rim of Gale Crater; a dusty grey in the distance, offset against a shimmering soft pink sky.

As I knelt down to examine a portion of the ground, the window shrank in size. Zooming in physically and virtually I saw cracks and crevices in the rocks, the strata in the bedrock, granules of sand and tiny pebbles. As I reached out to touch and feel the surface under my gaze my hand evaporated, my body belonging to a space exterior to my vision.

As I stepped back Curiosity flickered into view. The large immobile body of the rover was coated in a thin film of dust, trapped here, in the virtual image of Mars. As I advanced forth in an attempt to inspect its wheels, Curiosity vanished. In an instant I became the rover, seeing the surrounding terrain from its vantage point, its body merged with mine.

As I walked backwards once more I looked out towards the distant horizon. The environment appeared perversely trapped within a pixel-thin layer, a three-dimensional image held somehow within a two-dimensional display. This was a virtual opening that did not require a click or swipe of the finger to reveal what lay beyond the borders. Here I was present virtually in the image, a presence that relied on my own physicality; the position of my head in relation to my body. A three-dimensional image of Mars that I was in control of revealing.

Revealing. The act of revealing coincided with the act of concealing. Movement enabled me to penetrate the environment contained within the image, but did not allow me to bypass the screen. Movement revealed depth but concealed width. The window could not be enlarged, the frame could not be collapsed, the image-as-screen could not be stepped into.

I looked upon markers in the landscape, upright poles that marked where Curiosity had been and for how long. My gaze lingered and the rover's path became illuminated, snaking through the landscape from one point to the next. A glowing path into the past of a landscape it would not see again. Upon walking towards this point in the landscape I revealed the depth of image, a depth of space, a depth of time.

And yet I was not limited to walking alone, nor to the four walls of the office. I could reach the outer edges of Curiosity's vision through teleportation. Speeding back through time, through space, and into the reconstruction of Mars-as-image.

Figures

1 NASA/JPL-Caltech, http://jpl.nasa.gov/news/news.php?feature=4451 (accessed December 14, 2016).

2 NASA/JPL-Caltech/Microsoft, http://jpl.nasa.gov/news/news.php?feature=6220 (accessed December 14, 2016).

3–5 JPL-Caltech, Photo: Luci Eldridge.

6 NASA/JPL-Caltech, http://photojournal.jpl.nasa.gov/catalog/PIA16847 (accessed March 15, 2014).