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Social media and popularising space: Philae Lander (@Philae2014) and the journey to comet 67P/ Churyumov-Gerasimenko

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Abstract

The popularisation of space activities is concerned with the public support of, interest in, and understanding of, the benefits to citizens of space science and space exploration. The media, traditional and new, play a significant role in popularising science. While scholars have acknowledged the potential of social media to support public engagement of science, the communication of science by Twitter, a micro-blogging platform or by other social media, is largely under-explored. This paper considers the role of social media in popularising space activities. It focuses on the official Twitter feed of the lander of the European Space Agency's Rosetta Mission (Philae Lander, active between October 2010 and September 2016, to illustrate an instance of popularisation. In particular, it foregrounds a specific element of popularisation, that is, 'doing science in public'. The resulting analysis illustrates that the topics communicated include themes beyond the overt, expected topic, that is, 'the journey of the lander'. Additional themes include references to complex scientific experiments ('space science') and to the business, or organisation, of science, the earthly 'backstage' of Philae lander and the Rosetta mission. The contextual web within which Twitter operates is discussed and the paper concludes by considering the potential role that social media can play in communicating scientific endeavours in space, achieving the goals of informing, enthusing and engaging publics.

Introduction

In October 2016, the European Commission published its *Space Strategy for Europe*[i]. This Communication emphasises the strategic importance of space for Europe, critical for its responsiveness to grand societal changes and notes the consolidated space budget of the EU, ESA, Member States and EUMETSAT represents the second largest public space budget in the world in 2015[ii]. For the EU alone, the budget for space activities is over EUR12 billion in the programming period 2014-2020[iii]. The level of public funding requires public support and thus communicating space science to the public, that is, activities in the field of space applications or of space exploration, is an important activity for European space institutions and researchers. Encouraging public support for budgetary allocations may be achieved through a greater appreciation of the benefits of space for Europe's citizens[iv]. Addressing the 8th Annual Conference on Space Policy, EU Vice President for Energy Union, Maroš Šefčovič, commented that space is linked to many issues however, such links 'are not obvious to many citizens[v]. Thus, he suggested there is a need to communicate the benefits of space activities to citizens[vi]. Communication of space activities also aims to enthuse the public, to increase interest in space, this is particularly so for young people and such efforts are part of wider endeavours to promote entry into careers in space related industries for the development Europe's space capacity[vii]. Ministers of the Council of the EU and of the ESA Council, meeting at the 4th and 5th Space Councils, referred respectively to a recognition of 'the inspirational ability of space activities in attaching young people in to science and engineering' and to the 'value of space exploration for inspiring young Europeans to choose a career in science and technology to strengthen these capabilities in Europe'[viii]. Such themes retain currency[ix]. A further dimension of popularisation is indicated by John Hartman; commenting on the 'complex and significant purpose of popularisation in a democratic society, he states

> [i]n order for a democratic community to engage in discourse and decision making concerning collective intellectual, material and financial resources, it is ideal for all citizens to comprehend the nature and magnitude of the issues and decisions at hand. For if a citizen is unable to cognitively comprehend research funded with public money, the fabric of democracy is clearly weakened[x].

Popularisation raises issues of the democratic governance of science and the question of how citizens are enabled to participate in democratic decision making assumes salience.

Given the acknowledged importance of space to the European Union[xi]; the importance of promoting citizens' understanding of European activities in space and the benefits accruing to European citizens, the nature of space science communication is relatively unexplored. In addition, while science communication in the traditional media has received significant attention, the same does not hold for social media[xii], with the notable exception of Janet Vertesi's work on 'Tweeting Spacecraft' which foregrounds the socio-technical process of scientific knowledge production[xiii]. As McKinnon et al note, the potential of Twitter as an effective public engagement tool for science, is not being realised[xiv]. The importance of the wider online world for mapping public interest in space has been noted; for example, Lee calls for the analysis of trends in online demand for information related to space activities. She notes 'that '[i]nternet trends, which provide continuous data on the evolving public interest in near real time…should be considered for use as a complementary policy tool to monitor and manage the public interest in space activities'[xv].

This paper considers one instance of the popularising science via the use of a social media platform (Twitter)[xvi]. The official Twitter feed of Philae Lander [@Philae2014], was selected to explore an instance of communicating space through the use of social media. The rationale for selection were that it offered (a) a reasonably recent, completed, example of a space activity which received significant traditional media coverage; and (b) a readily available discrete body of Tweets which indicate key elements of institutional/corporate microblogging practices.

McKinnon et al[xvii] comment that researchers and organisations increasingly engage with social media to promote scientific issues and agendas to the public: this study explores one specific instance. The findings of this study suggest that Twitter communications can play a significant role in communicating space; achieving multiple communication goals.

1.2 Philae Lander and the Rosetta Mission
The Rosetta mission, coordinated by the European Space Agency, was concluded on 30 September 2016 and is recognized as a significant exercise in developing European space capacity. It generated considerable media interest over its decade long mission, involving

traditional, new and social media. The European Space Agency's succinct account of the mission is a useful overview to set the context:

> ESA's historic Rosetta mission concluded as planned, on 30 September 2016, with a controlled impact onto the comet it had been investigating for more than two years. The mission was launched on 2 March 2004, on a 10-year journey towards comet 67P/Churyumov-Gerasimenko. En route, it passed by two asteroids, 2867 Steins (in 2008) and 21 Lutetia (in 2010), before entering deep-space hibernation mode in June 2011. On 20 January 2014, it 'woke up' and prepared for arrival at the comet in August that year. On 12 November, the mission deployed its Philae probe to the comet, the first time in history that such an extraordinary feat was achieved. During the next phase of the mission, Rosetta accompanied the comet through perihelion (13 August 2015) until the end of the mission" [xviii].

This paper considers one aspect of the mission, the lander (named Philae) and how the lander's operations were communicated in the social media site, Twitter. It considers what this preliminary exploration of the official Twitter account (@Philae2014) suggests about the role of social media in the popularisation of space related activities.

1.3 Structure of the paper

Following from this brief introduction, popularisation and science communication is considered, noting key features of the ongoing debate about its form and function. Moving to consider Twitter, the micro-blogging site, its key features are presented before outlining the methodology employed and the treatment of the data, the Tweets of Philae Lander [@Philae2014]. Methodological limitations and challenges raised by Tweets are noted, including research ethics before moving to present the findings of the thematic analysis undertaken. Features of the three core themes identified in the Twitter feed are elaborated in following sections. These themes are (i) the journey to the comet; (ii) science aims and scientific results; and (iii) the earthly 'backstage' of the lander's journey, the scientists and engineers at work at the German Aerospace Centre and other locations. The anthropomorphism of the Tweets is discussed as is the visual dimension of the Twitter feed - the photos, graphics and other images that users routinely include in Tweets. Areas of further research are suggested before the concluding section which reflects on the

implications of the findings in considerations of the significance of social media for popularising space.

2. Popularisation

Popularisation is 'about' the relationship between science and the public[xix]. Popularisation has been defined as the diffusion of scientific knowledge with pedagogic intent'[xx]. A significant debate exists within the science communication field about popularisation, about public understanding of science and public engagement with science[xxi]. Gregory and Millar's review of the treatment of popularisation by scholars notes the position that popularisation is part of the making of scientific knowledge, as well as of the sharing of it[xxii]. They comment that this perspective suggests '[t]hus scientists who popularise are doing science in public'[xxiii].

Significant work includes Hilgartner's seminal 1990 review of popularisation notes the dominant view of popularisation, that pure scientific knowledge exists which is at best 'appropriately simplified' or at worst 'distorted' [xxiv]. His conclusion is noted; namely that this dominant view 'suffers from conceptual and empirical problems and consequently,… has limitations as an analytic tool' but is 'retained for political uses to buttress the epistemic authority of scientists against challenges'[xxv]. (He concedes that such control is necessarily partial given the volume of science based information available to publics.) The reason for directing attention to this debate within the science communication field is to counter understandings of the 'popular' with distorted science. In addition, it directs attention to multiple techniques of exposition as part of popularisation exercises. This particular feature is relevant when considering Tweets; they may function as communication channels of multiple knowledges – 'simplified' as well as 'complex' science[xxvi].

New media and science communication

The potential of social media, including social media platforms hosting, for example, microblogs, blogs and social networking sites, for effective public engagement with science is routinely noted; Stilgoe et al have commented that "[s]ocial media have revealed an enthusiasm for uncontrolled engagement amongst those interested in sites", adding that "less academic attention has been focused on sites of engagement between publics and

science outside of the policy setting…and as such, we know little about the rationales, agendas and activities that are in operation in these newer spaces"[xxvii]. Similarly, Inna Kouper has identified the analysis of the role of blogging in the promotion of more interactive forms of science communication[xxviii].

A series of Flash Eurobarometers have been issued relating to public opinion on space activities of the European Union in 2009, 2012 and 2014[xxix]; in addition, a Special Eurobarometer has reported Europeans responses to 'responsible research and innovation (RRI) science and technology and in particular their interest in science and technology. Of interest is the finding that 'television is the most mentioned source of information about developments in science and technology (65%), followed by the internet (35%) and newspapers (33%)[xxx]. The Standard Eurobarometer report (Media Use in the European Union reported that 'almost everyday and every day use of social networks amongst respondents in EU28 was 32%, with 47% of European using them at least once a week' [xxxi]. However, while not the dominant channel of citizens' science information, social networks usage is considerable and is, with increasing rates of internet use across Europe, likely to increase in future and is deserving of attention.

3. Twitter

Twitter is social networking and microblogging service. According to the Twitter official site, it is 'for friends, family and co-workers to communicated and stay connected through the exchange of quick, frequent messages'[xxxii]. The messages are called 'Tweets'; these can contain text (maximum 140 characters) or photos, short videos or other images. Senders of messages can make their messages 'searchable' by using hashtags (the symbol #), this categorises tweets under specific topics and facilitates tracking 'conversations' with the same thematic content. Zappavigna comments that enabling 'searchable talk' is what distinguishes Twitter from other social media networks[xxxiii]. One feature of Twitter is that it enables a range of 'modes of participation'[xxxiv]; once registered to access Twitter, a user can (i) follow another user/account; (ii) signal their approval of a tweet by selecting 'like'; (iii) a user can retweet a tweet; (iv) a user can 'reply' to a post, starting a conversation; and (v) a user can copy a link and circulate it outside Twitter. Twitter exists within a wider network of other social media platforms. The relevance of this feature is that content can be further

explored via other social media platforms. Twitter, as other social media platforms, therefore exists within a contextual web; social media routinely provide links to such media as well as to social media sites and to photographs. In this way, in the case of corporate microblogging, in particular, a user can achieve multiple goals in respect of disseminating its materials.

Use of Twitter must be in accordance with Twitter Brand Guidelines which stipulate that each Tweet should be displayed verbatim; users are required to 'always credit Tweets by displaying the account's full name and the @username, and include as much content as possible.'   Twitter recorded 313 million active users at 30 June 2016[xxxv].

4. Methodology and treatment of the Twitter feed of Philae Lander

The Twitter address of the DRL operated twitter feed of Philae Lander is @Philae2014[xxxvi]. The aim of the research was to explore the content over the period (2010-2016) with the wider research question in mind, namely, to consider the role of social media in popularising space. The initial task was to code the entire twitter feed; to identify the key themes and characteristics. This exercise was undertaken inductively, with the identification of thematic categories arising from the data rather than deductively assigning codes to pre-identified themes, in line with a general 'grounded theory' methodology. The value of this qualitative methodological strategy is that it allows for unplanned themes to be identified. Following the identification of the key themes, illustrative tweets were extracted and are presented in accordance with the Twitter Terms of Service requirements. As noted above, a feature of the Twitter account is the 'nested' nature of micro-blogs; a Tweet may exist on its own, with a 140 character 'entry' or it may contain a link to a YouTube recording or link to a website; it may be in 'reply' to another Tweet (itself with its own set of nested relations); it may record the 'comments' from 'followers' and others. The methodological question of the 'boundary' of the Twitter account is evident here. The unit of analysis in the current study was the individual Tweet.

Selecting @Philae2014, the 'official' Twitter account, was deliberate – in Twitter the # is used for 'searchable talk'; a search for #Philae Lander will return the following: @Philae

Lander; @IamPhilaeLander; @Philae_Lander; @Philae2015; @Philaeprobe2014; @ESA_Philae; and @2014Philae. Other, related search terms were #lifeonacomet; #67P. @Philae2014 routinely included #DLR in its tweets (i.e. its 'parent organisation). Instruments on Philae Lander had their own Twitter accounts, for example @Philae_MUPUS.

In addition, and further to a consideration of research ethics and social media research, research ethics were addressed and permission/consent to use the account for research purposes was requested and given by the DLR[xxxvii].   Issues relating to the research ethics of using social media as data are complex[xxxviii]. Salmons comments that while 'it might seem that a study using data from observation of posted information would *not* require consent from participants and/or agreement from the community…the answer is not so straightforward'[xxxix]. The assessment of the public or private nature of participation in online fora is central to this consideration[xl]. This research ethics dimension of internet research has implications for what was included in the examination of the twitter feed. I understood and approached the @Philae2014 account as an institutional account, not an individual account. The purpose of the account was to communicate the work of the DLR which houses the Lander Control Centre. In addition to the explicit consent obtained, it was reasonable to assume that the DLR did not have privacy expectations about the content of its tweets; however, the same may not hold for individuals who posted tweets to this account. For this reason, the only tweets in the twitter feed @Philae2014 that are quoted are those 'by' Philae Lander or other institutions, such as ESA.

4.1 The Twitter account of Philae Lander @Philae2014
The home page of @Philae2014 includes a 'bio' note: On 12 November 2014, I landed on comet #67P as part of @ESA_Rosetta. I am operated by @DLR_en's Lander Control Centre LCC in Cologne. The profile of the @Philae2014 account was: 792 Tweets, 'following' 89; 438K 'followers' and 671 'likes'. 118 photos and videos[xli]. The display of the account can be viewed differently according to device used (on tablet, view by 'Tweets'; by 'Media' and by 'Likes'; on a laptop, view by Tweets; by 'Tweets and Reply' and by 'Media'.)

The first tweet of Philae lander was posted on 27th October 2010 (Philae Lander @Philae2014, "hello world"). The penultimate tweets were published 0n 26th July 2016 (Philae Lander@Philae2014, 'It's time for me to say goodbye. Tomorrow the unit on @ESA_Rosetta for the communication with me will be switched off forever'; and later that day, 'I'm far from Earth and Sun! I'd love to take memories of YOU with me. Please send me a post card from home! #GoodbyePhilae dlr.de/blogs/en/desktop'. The final tweet was posted on 30 September 2016, the day of the planned collision of Rosetta into the comet: #Rosetta, is that you? #CometLanding (Philae Lander@Philae2014).

5 Themes in the tweets of Philae Lander (@Philae2014)

The analysis of the twitter feed involved downloading all Tweets before systematic coding the content[xlii]. Three specific themes were identified: (i) the journey (from the first tweet on 27 October 2010, to the end of the journey, the resting place on the comet, 30 September 2016); (ii) the science of the mission with details of engineering, instruments, the science experiments planned and undertaken and the results; (iii) the 'backstage' of the DLR and other scientific institutions, including the European Space Agency, these tweets related to the scientific and organisational work undertaken to enable Philae Lander's landing.   Non-assigned, or 'miscellaneous' Tweets were those 'about' other activities, such as for example, the competition launched to name the landing site of Philae Lander and other non-repeated /one-off topics. This category included Tweets about NASA activities.

As noted, one feature of Twitter is the facility to enable users post links and photographs; some tweets simply posted links to ESA and DLR produced videos, to other social media platforms, such as YouTube or posted photographs or sketches of the lander and of the comet, its object. This category included some photos of the DLR scientific and project management team members as well as photographs of equipment/instruments and shots of monitors with 'data'.

Each thematic category can be further subdivided; a particular feature is the nested nature of the Tweets. For instance, a single Tweet can include a link to the Twitter account or specific Tweet of ESA_Rosetta which itself can include a link to an external YouTube video about the Mission (e.g see 10 July 2015, Philae Lander @Philae2014). This dynamic feature

of Twitter deserves emphasis; a single Tweet can , 'concertina-like', deliver via a number of formats a wide range of information[xliii]. It also means that the identification of a Tweet as belonging to one or other 'theme' holds only for the starting Tweet.

(i)   Journey to the comet

Tweets about 'the journey' include all tweets about the progress towards Comet 67/P as well as after the landing on the comet. Unsurprisingly, this was the largest category, with over 45% of all tweets categorised as being 'about' the journey. This journey to the comet took over 10 years – on 6th August 2014 the tweet posted was '*Finally! RT @ESA Rosetta: Yes @Philae2014! WE"RE HERE!!! After 10 years 5 months 4 days we are finally at our destination, #comet, #67P.*' Up until that date, the tweets were about the broader mission, including about origin of the lander's name: *'I am being carried by the Rosetta probe. My name comes from a temple in Egypt closely associated with the 'Rosetta stone'* (Philae Lander @Philae2014, 11 November 2010).   The journey included a hibernation period which commenced on 8 December 2010, lasting until 20 January 2014. Over the course of this period, there were regular, on average every two to three days, tweets posted or retweets of DLR or European Space Agency tweets. The tweets posted included comments on the 'view': an ESA retweet: *'Image of the week – Rosetta looks back on earth, http://bit.ly/*mebuXv' (Philae Lander retweeted, 6 June 2011). The distance from earth is routinely recorded: '*My distance from the Earth doesn't just increase, because we're not travelling in straight lines. Sometimes the Earth "catches up" a little',* Philae Lander @Philae2014, 8 November 2011) as is the distance to the comet: *'I am now "just" 90 million km from the comet I'm going to land on in 2014 (and getting closer all the time now'*, Philae Lander @Philae2014, 20 Jan 2012.).

A countdown to the destination of the mission, comet 67/P, is periodically provided, for example, 'Mission day 2914 – Distance to target 84 million km', Philae Lander @Philae2014, 23 Feb 2012.   In March 2013, the tweet posted was '*3 days ago #Rosetta and I celebrated our 9-th years flying in space. We started our long journey on 02.03.2004…almost there now*' (Philae Lander @Philae2014, 5 March 2013).

The journey included a Mars flyby (January 2012), and later tweets included retweets of an image slideshow from this and the Steins and Lutetia flybys (10 February 2014). The latter stages of the journey to the comet included tweets about the procedures associated with the identification of the correct landing site. The importance of the event was the subject of different tweets -the lander was the first spacecraft to successfully land on a moving comet. As explained in a tweet of 14 April 2011 '*My anchoring subsystem has 2 harpoons to hold me down securely on the comet's surface after landing #PhilaeThursday'*. The landing was not lightly considered : '*Oh my RT @esaoperations: An inaccuracy of a few mm/sec in orbit determination could lead to completely missing #67P – wow! #comet landing* (16 October 2014).

However, an unanticipated incident occurred. On 12 November 2014, the day of the landing, following the Tweet, '*Touchdown@ My new address 67P! #Cometlanding,* Philae Lander @Philae2014 tweeted '*I'm on the surface but my harpoons did not fire'*. My team is hard at work now trying to determine why #CometLanding'*. The following day, the tweet read '*I'm in the shadow of a cliff on #67P… '*[13 November 2014]. Two days later, communication ceased because the planned solar energy was not enabled due to its location under a cliff. It 'rebooted' on 14 June 2015: '*Hello Earth! Can you hear me? #WakeUpPhilae'* [insert tweet].

There were ongoing Tweets until the lander's battery ran down on 14 November 2014: *'My #lifeonacomet has just begun @ESA_Rosetta. I'll tell you more about my new home comet #67P soon…zzz #cometlanding'*. The next Tweet was on 14 June 2015 when the battery was recharged by solar energy due to the changing position of the comet: *Hello Earth! Can you hear me?*

The immediacy of Twitter as a source of information is evident in this instance; minute by minute, day by day updates about the lander, its position and what was being done about the situation. The volume of 'Retweets', which may be taken as an indicator of engagement with the content of the Tweets, increased to 34, 399 for the Tweet confirming 'touchdown', declining thereafter until the 'wake-up' in June 2015: 30,304 retweeted this Tweet.

The content of the lander's Tweets following the 'wake-up' Tweet related to scientific experiments and results, to the postcards (photographs of earth, of instruments, links to videos). The Tweets ceased on 30 September 2016.

(ii)   The science

The purpose of the Rosetta mission was to study the nucleus of Comet 67P/Churyumov-Gerasimenko and its environment[xliv].   The theme 'science', which accounted for nearly 20% of all tweets- included tweets about instruments aboard Rosetta and about the engineering features of the probe and its instruments; the scientific experiments planned as part of the mission, and the results of these experiments. Illustrative tweets include the following: On 14 November 2011, Philae Lander tweeted: '*I confirm that my @RosettaSD2 went all the way DOWN and UP again! First comet drilling is a fact*'. This tweet included data graphics. The analyses of these data are both on-site but also published: *'I'm excited to announce that my scientists have published the results of all my hard work on #67P last November: ☺ http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-14398/year-all/#/gallery/20130* (30 July 2015).

Vertesi has ponders as to whether 'significant science can be conveyed in 140 characters or less?'. Considering the content of the Tweets 'about science', a preliminary response suggests that Twitter can function to communicate significant science; however its function is as 'mediator'; it is a secondary, not primary communicator of significant science. Relatedly, while it is claimed within the dominant approach to popularisation that one danger is simplification of complex scientific concepts, the tweets of Philae Lander indicate how a layered approach may obviate this 'danger'; the tweets in which science or engineering elements are presented contain, for the most part, links to other sites, where further, more detailed investigation could be carried out by an interested reader. The Tweets of Philae Lander (@Philae2014) contain, over the six year period of activity contain an unanticipated high level of scientific and engineering information relating to the spacecraft.

(iii)   The organisation of science

Public communication of results can often represent the end-point of the scientific process. How scientists carry out their work is a relatively 'private' endeavour. One feature of popularisation is 'doing science in public' and a prominent theme of the Twitter feed of Philae Lander(@Philae2014) related to the 'organisation of science' and accounted for around 18% of the Tweets. Goffman's dramaturgical work[xlv] on social life as performance (and performative) and in particular his comments on the 'backstage' of performances are instructive in considering how this theme was presented. Following Erving Goffman's dramaturgical perspective, the backstage is the area where preparations for a performance takes place.   In the current case, the 'frontstage' is the area in space, on and around the comet (and perhaps one achievement of the Tweets is to make the area of space the 'frontstage' through the photographs). Approximately 15% of the tweets were 'about' the Lander Control Centre (DLR) in Cologne; about the team of scientists, engineers and researchers working in this and other sites; and about the meetings between ESA and DLR scientists, particularly focusing on meetings at which critical scientific and technical decisions about the mission had to be undertaken.

The inclusion of details about 'scientists' work' were present early in the twitter feed: the eight tweet, 25 November 2010, refers to how '*my ground engineers are busy preparing for "PC13" – the last chance to checkout my systems and instruments until 2014! #PhilaeThursday*'.   On 22nd January 2012, a photograph was Tweeted with the heading '*It may be Friday evening, but my sims engineers are still hard at work!*'. Philae Lander retweeted ESA Tweets about scientists' meetings, for example a post of 7 March 2013 is a photograph of a group of people sitting in a recognisable (to a researcher) seminar scenario, with the caption '*ESA #Rosetta experts and PIs meet at @esaoperations to discuss #comet rendez-vous 2014. Getting closer!*'). Mission control rooms are the subject of many tweets; for example, '*Here is the control room adjacent to my own. Its used by ISS experts MSL and Biolab htto:twitpic.com/61g5zo,* (16 September 2011). 'The 'human side' of the mission was emphasised in a post of an empty room, with people in the background, with the note '*My controlroom after a more than 100% successful #CometLanding (watch the party in the background)*' (14 November 2014). By the end of Philae Lander's journey, the name (and face) of the Lander project manager was familiar; in the penultimate tweets, a link to a final

video update is Tweeted in which he urges viewers to *'keep on sending your postcards to Philae, we really appreciate them'* [Philae Lander Retweeted] DLR English @DLR_en, *#GoodbyePhilae: Communications unit switched off...A last #VideoUpdate from #Philae's Control Centre at DLR.*

(iv)   The visuals

As noted, Tweets can combine words with images or may only contain a photograph, without words. Sometimes only a link to the image was presented[xlvi]. Visual images included photographs of a lander   - his 'Ground Reference Model – for example, 27 June 2013: *Do you recognize my twin sister at the Lander Control Centre @DLR-de Cologne*? Tweets of graphics were also posted, for example, screen shots of the identification of the comet's location ('*Object Verification'*, 20 April 2012)   Images from Rosetta were routinely posted, Philae Lander @Philae2014 regularly retweeted photographs from the ESA image bank. One of the photos included was of Philae Lander's descent onto the 67P comet, with the caption '*Its me...landing on a comet and feeling good! MT @ESA_Rosetta: I see you too! #CometLanding'* (12 November 2014). Two days later, a photograph of a number of scientists in a room, was tweeted, with the caption *'My science team eagerly looking into the data I collected at another day on the comet'* (14 November 2014).

The 'visual' dimension of this and other Twitter feeds is important; while 140 characters is the character limit, photographs, bar charts and other graphics convey considerably more information than a lexical analysis could capture.

(v)   Tweets beyond the Mission

Approximately 15% of the tweets were coded as 'miscellaneous'; these tweets included comments on a competition to name the landing site, to space related exhibitions and events taking place in different institutions, for example the Tweet of 20th September 2015, contained a photograph of adults and children posing beside a large-size photo of what is recognisably the lander on Comet 67P. The text is '*Ever thought about #cometlanding? Join me on comet #67P today at German Aerospace Day #Tdlr in Cologne!* These additional Tweets are of interest enabling communication of beyond mission information about space science.

5.1 Anthropomorphism

A final, evident, point about the twitter feed of Philae Lander, @Philae2014, is its marked anthropomorphism, that is the attribution of human characteristics and emotions to non-human entities. Anthropomorphism is a key device used to communicate the activities of Philae Lander (and the various instruments attached to the lander). The personalisation of Philae Lander was achieved through standard techniques such as the use of the first person singular to refer to its activities. This is a common practice in science communication[xlvii]. At least one Twitter user responding to Philae Lander tweets(@Philae2014) referred to the belief that the lander was directly sending the tweets. Janet Vertesi's comments about the personalisation or anthropomorphism of 'tweeting spacecraft' are apposite and she identified similar themes in the Twitter feed of @MarsPhoenix: she notes that 'spacecraft Twitter feeds usually give the impression of the robots speaking directly to their fans who maintain the suspension of disbelief as they address the robots as individual agents.' However, suffice it to note that, the 'narrative' of the Rosetta mission was 'brought alive' by tweets such as : '*Hello world* ☺' (Philae Lander @Philae2014, 27 October 2010); 'Its my birthday…' (2 March 2011), and recognition of human traditions*: '3 of my 9 subsystems were built using advanced technology from a crashed alien spacecraft. Yes, even spacecraft enjoy #aprilfools day ;-)* [Philae Lander @Philae2014, 01 April 2011].

The contextual web within which the Twitter feed is located also functions to reinforce such anthropomorphism and enable the 'imagining' of Philae (and Rosetta). The ESA animated film, *The amazing adventures of Rosetta and Philae,* featured Philae and Rosetta as 'sentient beings' with their own voices, and follows them though their experiences.

Commonalities with NASA spacecraft microblogs (as identified by Vertesi) included another feature of spacecraft tweeting to each other. This was a feature of the Philae Lander Twitter account and included retweeting the ESA_Rosetta Tweets. A review of the 89 accounts 'followed' by @Philae2014 reinforces this 'spacecraft community'; nearly all are space institutions or space actors, rather than members of the public

One element of anthropomorphism relates to determinism. Vertesi, in her analysis of 'Tweeting spacecraft', refers to how 'when the spacecraft speaks with a single voice and

appears to have an agency all of its own, the people who make the spacecraft work seem to disappear and become invisible[xlviii]. This did not occur in the Tweets of @Philae2014, as the number of Tweets in the 'organisation of science' theme evidences. While Philae Lander is accorded human features ('cold', 'lonely' et cetera), 'agency' rests firmly in the hands of the scientists at the Lander Control Centre at DLR. One Tweet, early in the Twittter feed does refer to '*I'm going to land on a #coment but I'm a robot. Landing humans on a #astreroid will be much harder http://bit.ly/n512R4 via ESA* (21/11/2014).

A feature of the Tweets' trajectory could be evidence of an increasing reference to the work of the LCC team, with other scientists and engineers. This is of interest; the determinism generated by anthropomorphism is held in check by the 'backstage' focus on the work of scientists; Philae Lander is not an autonomous agent but one directed by humans. This may be seen as relevant in considering humans in space (see Pramling and Saljo 2007) and as pointed out above, counters Vertesi's comments.

Vertesi comments regarding the NASA allocation of staff to Twitter duties (spacecraft tweets), the question is what it hopes to gain from this practice. In response, the need to enthuse young people [xlix] A comment from astronaut Helen Sharman on a BBC programme, *The Big Think, Should we go to Mars (aired 11 April 2017)* is instructive in this regard, *she* spoke about the 'return' from robotic versus human endeavours in space; she suggested that the return (in respect of public interest and positive response to activities) was far higher for human than robotic activities; thus the logic of anthropomorphism is evident; humanising robots/instruments generates a greater 'return'.

5.3 Evolution of the Twitter feed

The Twitter feed was active over a six year period. An overview of the entire twitter feed indicates how the approach of author of the Tweets changed over time. In particular, there was a marked increase in the use of photographs and in embedding videos. The focus of the tweets 'improved'; the initial 'chatty' information-less tweets were replaced by tweets containing links to specific topics. This may reflect the process what Vertesi noted at NASA; while the Twitter feed was started as 'something of a lark but as its numbers of followers

grew to over 40,000 fans, NASA Press Officers from Headquarters took notice.', i.e the professionalisation of institutional micro-blogging. There was a greater tendency over time to use DLR tweets and input/content: the third final tweet (27 July 2016) was a 'retweet' of the DLR video with the, by then, familiar face of the project manager. The final tweet represented 'closure' *(#Rosetta, is that you? #cometlanding' Philae* Lander @Philae2014, 30/09/2016). Of interest is the feature that the reader would have to know about the planned collision of the Rosetta probe into the comet in order to make sense of the tweet. This single tweet was retweeted 2,144 times.

6. Future research

As noted above, privacy and other ethical issues informed the approach to the examination of the tweets – only the 'official', DLR (and ESA) Tweets were included. This approach, while justified, is not ideal; the dialogical nature of Twitter may be obscured by this methodological choice - there were instances of exchanges between Philae Lander (@Philae2014) and individuals, indicating a public engagement, rather than public understanding of science, role that may be accorded to Twitter as a specific online forum[l]. A study of reception of Tweets is warranted. The methodological issue of defining the 'unit of analysis', of the boundary of datasets comprising social media data, may be further explored in such instances. Is it valid to confine analysis to the individual tweet?   The analysis presented remained, as appropriate for its purpose, at a 'headline' level, a more detailed exploration of the 'contextual web'[li], or rather 'inter-textual' web that Twitter inhabits, as one of a variety of sources of information, will serve to highlight the ways in which communication can be reinforced. It may also inform our understanding of how journalists use microblogging sites as science news sources – as Brian Trench comments '[w]e still do not have precise accounts of how, in the making of individual stories, journalists reporting science use the internet as a resource'[lii],

Importantly, the content of the twitter feed of Philae Lander [@Philae2014] illustrates an 'opening up' both of the actual mission on which it was deployed but also, and perhaps more importantly, the opening up of the world of research to the non-research publics. This is evidenced by the inclusion of photographs of the 'scientists' space(s)' and by including links to scientific articles. The Twitter feed offered a number of different uses by users and

in this sense can be described as 'agile' science communication.   Arceneaux and Schmitz Weiss suggest that productive strand of research could explore what types of conversation are occurring on this platform, how often and what networks is it creating…[liii]. The possibilities to explore the phenomenon of microblogs and their use is a fruitful and beneficial area to study for understanding another part of today's changing new media landscape. The same sentiment holds for understanding new routes of science communication in the area of space and the creation of networks, especially of amateur scientists, is of interest. Finally, Vertesi's comments about microblogging and release of data constitute an interesting area for future investigation, particularly relating to 'citizen scientists' - a prompt for this paper was a Tweet from ESA_Rosetta about '*how amateur astronomers are helping me keep an eye on #67P* 97/08/2015).

7. Conclusion

The role and nature of social media in popularising space, as one aspect of (space) science communication, is deserving of empirical research. While statements as to the importance of the online world are routinely made[liv], the specific content of different sites is a neglected area of research. This paper has explored one of a number of available social media platforms, the Twitter feed of Philae Lander (@Philae2014). The multiple themes addressed in the tweets over the course of the account's activity, 2010 to 2016, suggest that Twitter, as one of a range of social media, can play a significant role in communicating not only the scientific mission, with its instruments and proposed experiments, but can also communicate the work of scientists, in Goffman's terms, the 'backstage' of Philae Lander's performance. '

Doing science in public', a specific feature of popularisation, is realised in the Tweets. The specific themes of the Twitter communication by Philae Lander (@Philae2014), the journey, including the extraordinary landing event; the scientific goals and instruments contained in the lander; and the work of a pan-European team of scientists drawn from different European scientific organisations, as well as wider, global space endeavour, were emphasised at different points over the six year period.   In addition, the inclusion of visual content, directly showing photographs and of links to videos, presents another dimension of the communication of space. The amplification and reinforcement of messages of other,

related-bodies, especially the European Space Agency, but also NASA, in the Twitter feed of Philae Lander is also of note. To conclude, media, including social media, operate in the context of preparations for a new space strategy for Europe; the Roadmap for these preparations commented that "the European Space Strategy would take into account the work started under the Communication *Towards a Space Strategy for the European Union that Benefits Its Citizens* and the Communication *EU Space Industrial Policy: Releasing the Potential for Economic Growth in the Space Sector*[lv]. These Communications foreground the importance of space for European citizens. The recently introduced Communication, Space Strategy for Europe, reinforces the message of the strategic importance of space; space technologies, data and services have become indispensable in the daily lives of European citizens'[lvi]. Communicating science in a way which promotes citizen scientific literacy and understanding is an oft-expressed goal; the example of the Philae Lander Twitter account, illustrates how social media have the potential to operate as sites through which the public, and others, can access multi-layered information of space-related activities and results. 'Simplification' does not necessarily lead to 'distortion' as discussed in the debates about popularisation. Following McKinnon et al's 'cautious optimism about the potential contribution Twitter can make to democratic discourse', the same 'cautious optimism' can be directed towards Twitter's ability to engaging publics as part of a science communication strategy.

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[vii] L. Ryan,'"Putting Space more at the service of Europe and its citizens": The governance of European Space Policy and the 'Scientific Citizen', *Theorising European Space Policy*, (eds) T.C. Hoerber and E. Sigalas, pp.37-58, 2016

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