**Text Website Savannah**

**About**

While space-based technologies for Earth applications are flourishing, space exploration activities suffer from a lack of public support as well as decreasing budgets. Recent robotic exploration missions have positively influenced public perception by utilizing video and social media communication. How can these new communication technologies be used to better serve human spaceflight?

This website analyses how the Twitter network related to human spaceflight is organized, measuring how influence and relationships are linked, to better capture the best practices and enhance the promotion of space exploration, internationally. We outline the Twitter network and organization related to human spaceflights, and, show how the use of media (i.e. photos and videos) in tweets can affects the notoriety and popularity of Twitter accounts. We investigate the cultural differences of astronaut followers. It is the first study analyzing the use of social media to communicate about human spaceflight, and its potential.

To download the paper: http://online.liebertpub.com/doi/pdf/10.1089/space.2015.0004

**Background + Methods**

*“We cannot be indifferent to space, because the grand slow march of intelligence has brought us, in our generation, to a point from which we can explore and understand and utilize it. To turn back now would be to deny our history, our capabilities”*

- James Michener

The aerospace industry has successfully commercialized Earth applications for space technologies, but human space exploration seems to lack support from both financial and human public interest perspectives. Space agencies no longer enjoy the political support and public enthusiasm that historically drove the human space flight programs. The $16B National Aeronautics and Space Administration (NASA) budget dedicated for human spaceflight in the Apollo era has fallen to $7.9B in 2014, of which 41% is dedicated to operations covering the International Space Station (ISS), the Space Launch System (SLS) and Orion, and Commercial Crew programs. European Space Agency (ESA) maintains a budget of 400M€ for human spaceflight, approximately 10% of its total budget. While mission successes continues under these constraints, financial as well as renewed public support is required for human exploration to become a strategic and high priority among many nations.

*“Exploration is the expansion of the realm of human experience, the redefinition of what it means to be human”*

* David Mindell

Astronauts are the incarnation of space exploration; they embody national prestige, inspire younger generations, and represent a very efficient way to gain public support, therefore, providing an incentive for nations to fund human spaceflight programs. However, astronauts remain very nationalistic: their influence is difficult to spread across borders, especially due to language barriers and lack of identification. This issue presents an obstacle for ambitious international cooperation.

*“While in the astronauts’ country the news coverage is usually very broad and at a prominent place in the newspaper or the TV news, in other European media the space mission usually receives hardly more than a short mention”*

* Gerhard Thiele

What is true among the European countries collaborating within ESA is an even greater reality between different agencies. However, the communication paradigm is rapidly changing with the development of the Web 2.0, an expression referring to the interactive and collaborative evolution of the Internet. Already several examples have reached the public in a very inspiring way: Canadian astronaut Chris Hadfield gained more than 22 million views on his “Space Oddity” YouTube video, and inspired the entire space community, especially the Anglo-Saxon world. The video of the Curiosity landing, demonstrating both the technological challenge of the mission and the human joy of the Ground Control staff, has gone viral and was part of the Google Zeitgest 2012, summarizing the year 2012. Other salient examples have demonstrated an effective use of social network to convey messages, make the space community react and inspire the Web: the Rosetta campaign during the summer of 2014 was a case in point.

Twitter, launched in March 2006, is one of the most notable and used real-time message routing platforms, also known as a microblogging service. The principle is that users can communicate to their network through short instant messages called tweets, limited to 140 characters. The network is based on the “following principle”, in which each user chooses who to “follow” to receive tweets from this account. The nature of Twitter, through its simplicity, utility and mobility, makes it particularly effective platform to disseminate brief information.

Used for many different purposes, from daily chatter to mentioning news, it gathers a broad and diverse public of 271 million monthly active users. Twitter has already been exploited by most of the space agencies to promote space exploration. It started with the NASA campaign around the Mars Phoenix Landing in 2009, followed by the first tweet from space by astronaut Mike Massimino. Twitter has also been used for Live Tweets events (TweetUp, Social, Hangout…) where Twitter users are invited by agencies such as NASA, ESA or CNES to tweet about a subject. Astronauts using Twitter are particularly efficient communicators: they inspire followers by writing their space experiences, they inform by reporting news, they make the public feel closer to them by sharing their personal life and by replying to people.

*“Providing the widest and appropriate dissemination of information concerning its activities”*

* NASA Act, 2010

Being actively involved in this environment is thus an incredible chance for agencies to build the future of human space exploration. The analysis of how people interact within Twitter is particularly easy compared to other social networks, and numerous studies have analyzed the influence, diffusion of information, or nature of networks. A particularly relevant study is to analyze who the most influential Twitter users are likely to spread information at low cost.

While performance-tracking services are provided to agencies and general Twitter statistics are available online, there is a lack of investigation on the Twitter environment related to human spaceflight and how this network is organized. This website aims to provide a general analysis of this environment by quantifying the general existing practices and revealing the trends in the network. To serve this goal, the Twitter network related to human spaceflight was studied.

**Methods**

We analysed the data from 86 different Twitter accounts related to human spaceflight across 5 different space agencies: NASA, ESA, CSA (Canadian Space Agency), JAXA (Japan Aerospace Exploration Agency), and Roscosmos. These included the accounts of astronauts, human spaceflight missions, and space agencies. These 86 accounts represent all the official Twitter account currently related to human spaceflight. For each of these 86 accounts, we used the Twitter Application Programming Interface (API) to collect the number of followers the account has, the number of accounts the account follows, tweets sent and tweets that have been favorited. These results were used in the first part of our analysis, describing the general tendency of the network, and were collected in February 2015. For the second part, we gathered all the tweets posted from these accounts between December 15th, 2014 to April 15th, 2015 (15 000 tweets analysed), the number of favorites and retweets of these tweets, and also if the tweet shared media (picture or video), and if the tweet was a reply.

**General Analysis**

This first part aims at quantifying the current situation of the astronauts and other human spaceflight related missions and entities using Twitter.

The following shows the 86 accounts as distributed among 5 space agencies: NASA, ESA, CSA, JAXA and Roscosmos. NASA has the largest percentage (56 in total with 40 astronaut accounts), likely due to the agency’s size large astronaut corp. ESA and CSA have 13 and 9 total accounts, with 10 and 7 astronauts accounts respectively, while JAXA and Roscosmos have respectively 6 and 5 total accounts, with 5 and 4 astronaut accounts respectively. Appendix A lists all of the accounts studied.

***Pie chart with distribution of accounts by agency***

The date of creation of the Twitter account and the date of the last flight of the astronaut can play a significant role in the influence of the account as shown in the following figures, revealing the distribution of accounts according to creation and last flight. We observe that the most represented categories are the candidates, and astronauts who have last flown in 2011 and in 2010. We observe that, in general, NASA was the first agency to create accounts, followed by ESA, then CSA, JAXA and finally Roscosmos. Accounts were created between 2007 and early 2014.

***Pie chart with distribution of accounts by date of last flight***

***Pierre’s graph of the website (figure 3) static***

The following figure displays the distribution by agency of the basic metrics defining an account: Number of followers, following, tweets and favorites. The graphs show, for each metric, the accounts having the largest number of units.

***Dynamic bar graph for general results***

**Factors of influence *(instead of Tweets content)***

In order to understand how and why an account reaches more people, we analyse the factor of influence of the tweets. In this section, we analysed the impact of all the tweets posted by each account, between December 15, 2014 and April 15, 2015, collecting information such as: the number of times other Twitter users retweeted a tweet from the account, which we call number of retweets by tweet, the number of times other Twitter users favored a tweet of the account, which we called number of favorites by tweet, in this study), the percentage of tweets containing media (photo, video), and the percentage of tweets that are replies to a Twitter user.

The following figure displays the distribution by agency of the impact metrics that we studied: number of retweets by tweet, number of favorites by tweet, percentage of tweets with media and percentage of tweets that are replies.

***Dynamic bar graph for impact/content results***

Assessing the reasons why tweets are retweeted and how an account gains in influence is crucial to better reach and interact with the public. Sharing media such as pictures or video seems an efficient way to interact and inspire the public. In this section, we quantified this effect. The following figure relates how often an account has been retweeted with how often media was shared in a tweet. Accounts that tend to share more media are retweeted more.

***Plot Pierre Figure 1 in Pierre’s folder on the Github***

A linear regression relating the number of retweets or favorites and the percentage of tweets with media is shown in the following figure.

***Plot Pierre Figure 2 in Pierre’s folder on the Github***

**Interactions by individuals**

***Here, there will be a total of 4 graphs: two graphs will be edge bundling graphs for the following interaction (graph 1.a) and of the replies+retweets interaction (graph 1.b.) and 2 graphs will be with the nodes + link: for the following interactions (graph 2.a) and for the replies+retweets interactions (graph 2.b.). It would be nice to have a good menu where we can choose between these 4 graphs, knowing that 1.a and 2.a represent the same thing and 1.b and 2.b as well. 1.a does not need to be updated, 1.b needs to be updated, and 2.a and 2.b need to be created.***

We define two different methods to better understand the nature of the interaction between accounts: the *following link*, or how accounts follow each other, and the *retweets/replies link*. While the *following link* focuses on how much people are interested in each other, the *retweets/replies* focuses on how accounts interact with each other. These two different methods are very complementary. The first section focuses on the individual interactions between accounts. The following sfigures show chord diagrams of the interactions of the two different methods: following and retweets/replies: on the left the chord diagram of the *following links*, the grey links stand for “follows” and black for “is followed”.

***Keep former Savannah edge bundling graph for following***

For example, between two accounts A and B, 4 types of interactions are possible: A follows B without B following A, B follows A without A following B, A and B follow each other, and finally no interactions between A and B. When we select account A, the link with account B will be black if A is followed by B, will be grey if A follows B or if they mutually follow each other, and there will be no links if there are no interactions. Consequently, the link appears black if account A is only followed by B (no reciprocity). On the right, the chord diagram of the *retweets/replies*: the grey links mean that NASA sent a reply or retweeted a tweet from the corresponding account.

***Plot updated Lucy’s edge bundling graph for replies+retweets interactions***

An alternative to chord diagram seen above is the node and link graph. The following graphs represent the same data than the previous figures. The diameter of the nodes represents the amount of interactions of a specific account and the links the direction of these

***Plot the two nodes + link graphs***

**Interactions by agencies**

***Update by the new plots on the Interactions by agencies folder***

***Replace the text by:***

The figure above presents the same information but gathered by agencies. All of the accounts within an agency are gathered and the interactions are studied. The root of the link represents the percentage of interactions coming from the source agency dedicated to the target agency linked by the link. If the source agency follows more than is followed by the target agency or if it replies and retweets more than the target agency have retweeted or replied to the source agency, the color of the link will be the color of the target agency.

Consequently, the agencies followed less than they themselves follow other accounts from different agencies will have links of their own colors. Similarly, agencies that have received less replies and have been retweeted less times than have sent replies or retweets, will have a link with other agencies of their own color. The color displays thus an exocentric state. For example, NASA follows ESA less than ESA follows NASA, but NASA retweets and replies to ESA more than ESA do. The length of the agency chord is proportional to the number of interactions involving the agency: “follows” or “is followed” and replies/retweets.

**Nationality Analysis**

***Update the graphs***

It is crucial to understand the demographics of the people with whom the accounts interact for several reasons, such as understanding the spectrum of the public that is missing or better designing communication campaigns appropriate to the public. When it comes to astronauts, the impact that they can have on the public, informing and inspiring them about exploration, seems closely related to the nationality of the astronaut and the nationality of the public. Investigating the nationality of the followers according to the astronaut nationality is valuable to better understand the Twitter public and to verify the hypotheses formulated in this paper claiming that social media is an efficient way to reach a broader public in terms of nationality.

The following table presents the five more frequent nationalities of an account’s followers for some accounts. ESA is the only agency studied which is not exclusively representing a single country; consequently, the table also indicates the percentage of followers represented from ESA member states. Finally, some followers’ nationality is unknown, which may skew the results, and is indicated in the table. Percentages are based on the total number of followers, except for NASA official account, where only one million followers were processed. For this reason, the percentage of unidentified nationalities was not computed.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Accounts** | **Top 5** | | | | | **Total ESA members** | **Identified** |
| **NASA** | US:  46 % | UK:  6% | Greece:  3% | Canada:  3% | Netherlands: 3% | 23% | 20% |
| **ESA** | US:  27% | UK:  13% | Netherlands: 8% | Italy:  5% | Greece:  5% | 52% | 50% |
| **CSA** | US:  63% | Canada: 9% | UK: 5% | Netherlands 2% | Mexico: 2% | 10% | 32% |
| **JAXA** | Japan: 47% | US:  24% | Russia:  7% | UK:  3% | Netherlands: 2% | 12% | 58% |
| **Roscosmos** | Russia: 33% | US:  15% | Greece:  4% | Belarus:  3% | Armenia: 3% | 20% | 28% |
| **Terry Virts** | US:  47% | UK:  9% | Netherlands: 4% | Canada:  4% | Italy:  3% | 28% | 51% |
| **Clayton Anderson** | US:  55% | UK:  9% | Netherlands: 3% | Japan:  3% | Canada:  2% | 21% | 53% |
| **Mike Massimino** | US:  57% | UK:  7% | Chile:  5% | Indonesia: 4% | Australia: 2% | 19% | 33% |
| **Chris Hadfield** | US:  50% | UK:  15% | Canada:  7% | Netherlands: 4% | Ireland:  3% | 27% | 47% |
| **Samantha Cristoforetti** | Italy: 31% | US:  18% | Netherlands: 11% | Greece:  8% | UK:  5% | 70% | 45% |
| **Alexander Gerst** | US: 27% | Germany: 15% | UK:  9% | Netherlands: 7% | Greece:  5% | 49% | 51% |
| **Soichi Noguchi** | Japan: 52% | US:  24% | Russia:  4% | UK:  3% | Chile:  2% | 8% | 56% |

**Hashtags analysis**

***Update the previous graphs with Lucy’s graphs***

**Conclusions**

General analysis first reveals the distribution of the accounts between agencies, showing that NASA has substantially more accounts than any other agency and is also aggressively using Twitter accounts for astronauts, official entities (NASA People, ISS Research...) and specific Missions (NEEMO, Desert Rats...). This policy, first used for the Curiosity Rover, is called “giving a voice to a flagship product”, where the accounts speak in the first person. We also notice that despite the large number of cosmonauts, Roscosmos is not very involved in Twitter, currently, compared to other space agencies with fewer astronauts. The analysis of year of last flight among the astronaut accounts, shows a dominant minority among astronaut candidates’ accounts. All NASA and ESA astronauts from the 2009 class have Twitter accounts (Jeanette Epps’ and Mark Vande Hei’s accounts have not been included in this paper because they are not yet officially recognized). Results show the importance of astronauts as inspirational figures when involved in social media to inspire and interact with the public.

The basic metrics given by Twitter (Number of followers, following, tweets, favorites) also provide interesting information. Four accounts have a high number of followers: the NASA official account particularly with almost 10 millions followers, followed by the individual accounts of NASA astronaut Mike Massimino, CSA astronaut Chris Hadfield and JAXA astronaut Soichi Noguchi accounts with approximately 1 million followers each. The trends for the number of following, tweets and favorites are less obvious. NASA astronaut Leland Melvin is highest in terms of following, having around 1200 Twitter accounts followed, while most accounts follow < 400 accounts. ESA astronaut Samantha Cristoforetti has the highest number of favorites with approximately 5500 favorites whereas most of the accounts have < 1000 favorites. The accounts tweeting the most are the official accounts: NASA, CSA and ESA, which was expected as they are not only tweeting about the human spaceflight but about the sum total of all space activities.

Sharing media in tweets definitively increases the popularity of the accounts in terms of favorites and retweets. Many accounts sharing media in tweets are the accounts whose astronauts have recently flown, which could explain why they are massively retweeted. However, we observe that some accounts sharing an important amount of media, whose astronauts did not fly yet or have flown a long time ago, are still retweeted and favored. Despite the “flight effect”, sharing media is thus an efficient way to inspire people and to have a broader impact on the Twitter public.

Finally, taking into account the three different metrics (number of followers, number of favorites and number of retweets), we selected the top 10 astronaut accounts presenting the best practice. We then defined a last metric taking into account these three parameters. The number of followers indicates the size of its audience and its potential reach, the retweet metric indicates the reach of the account, the ability to generate content with pass-along value, and the favorites indicates the personal impact that tweets can have on users.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ranking** | **Number of Followers** | **Number of Retweets** | **Number of Favorites** | **Total** |
| 1 | 06_13_2013_us-flag.gifMike Massimino | Samantha Cristoforetti | Samantha Cristoforetti | 1280px-Flag_of_Canada.svg-2.pngChris Hadfield |
| 2 | 1280px-Flag_of_Canada.svg-2.pngChris Hadfield | 1280px-Flag_of_Canada.svg-2.pngChris Hadfield | 06_13_2013_us-flag.gifTerry Virts | Samantha Cristoforetti |
| 3 | 1280px-Flag_of_Japan.svg.pngSoichi Noguchi | 06_13_2013_us-flag.gifTerry Virts | 1280px-Flag_of_Canada.svg-2.pngChris Hadfield | 06_13_2013_us-flag.gifTerry Virts |
| 4 | André Kuipers | 1280px-Flag_of_Canada.svg-2.pngJeremy Hansen | 06_13_2013_us-flag.gifScott Kelly | 06_13_2013_us-flag.gifReid Wiseman |
| 5 | 06_13_2013_us-flag.gifReid Wiseman | 06_13_2013_us-flag.gifClayton Anderson | 06_13_2013_us-flag.gifReid Wiseman | André Kuipers |
| 6 | Samantha Cristoforetti | André Kuipers | 1280px-Flag_of_Japan.svg.pngKimiya Yui | 06_13_2013_us-flag.gifMike Massimino |
| 7 | Alexander Gerst | 06_13_2013_us-flag.gifDouglas Wheelock | 1280px-Flag_of_Japan.svg.pngSoichi Noguchi | 1280px-Flag_of_Japan.svg.pngSoichi Noguchi |
| 8 | Luca Parmitano | 06_13_2013_us-flag.gifCady Coleman | Anton Shkaplerov | 06_13_2013_us-flag.gifScott Kelly |
| 9 | 06_13_2013_us-flag.gifNicole Stott | 1280px-Flag_of_Japan.svg.pngAkihiko Hoshide | Alexander Gerst | 1280px-Flag_of_Canada.svg-2.pngJeremy Hansen |
| 10 | 1280px-Flag_of_Japan.svg.pngKoichi Wakata | Tim Peake | 06_13_2013_us-flag.gifDouglas Wheelock | 06_13_2013_us-flag.gifClayton Anderson |

At first glance, the following and reply/retweet interaction graphs show different results: while the following interactions are linking a lot of people in the network, we observe that the retweet/reply interactions link many less accounts together. The interactive graph is very useful for the understanding of these interactions, and this paper could only present the static version.

Astronauts and space agencies tend to be followed in majority by Twitter users from their own country (for ESA official account or ESA astronaut Alexander Gerst, the total ESA member nations is taken into account). Only CSA account is more followed by American Twitter users than Canadian ones. However, the percentages indicate that the followers are well distributed within different countries with a significant amount of followers from different countries. In general, American people are the Twitter users following the most other accounts related to human spaceflight, followed by people from the United Kingdom, which is in accordance to the Twitter demographics. In addition, the Netherlands and Greece are particularly active at following Twitter accounts related to human spaceflight. This analysis show that the public following Twitter account is very diverse and do not only represent citizens from the space agency or astronaut’s country. Finally, deeper analyses need to be done, using the nationality of the followers from all the astronauts’ accounts. Particular attention is paid on ESA astronaut and the distribution of their followers over the European countries. More results of this study is available on the website in an interactive fashion.

**Conclusions**

This study aims at giving a good understanding of the human spaceflight environment in Twitter, quantifying the trends in the network and presenting the good practices of the existing accounts. Only the 5 space agencies studied (NASA, ESA, CSA, JAXA, Roscosmos) seem to be active on Twitter, with NASA being highly represented with more than 60% of the accounts. The candidate astronauts of the different agencies seem to be aware of the importance of communicating and inspiring people on Twitter. Using Twitter actively to share personal experiences, information or to interact with the public is now a widely spread practices in the human spaceflight world. While only a few accounts have more than 1 million followers, some accounts show good practices in term of following their followers back and be involved with their audience, such as ESA astronaut Samantha Cristoforetti. Being close to one’s audience helps broadcasting the astronaut prestige and promoting the space exploration endeavour. It is also a powerful way to inspire the young generation to undertake STEM studies.

The content study has verified the hypothesis stating that sharing videos or pictures fosters the spread of the tweets and increases both the audience size and people’s interest.

The network analysis showed how these accounts were linked to each other. Finally the followers’ nationality analysis gives a good understanding of which nations are very active on Twitter and who is the audience of the astronauts. This excitement about human spaceflight should be an incentive for governments to be more involved in an ambitious space exploration program. Twitter accounts are able to reach a diverse public in terms of nationality as the percentage showed.

This study gives a first insight of the human spaceflight Twitter accounts. However, some limitations are inherent to the study. First of all, Twitter is only one example of social media, and despite its popularity, communication campaigns need to cover numerous existing social media to reach different type of people, or to promote human space exploration in different ways. The tweet content analysis was time restricted and only took into account the most tweets. Finally, the number of identified followers’ nationalities was also limited.

Further studies need to be performed on different social media, with extended data collection in terms of time. A study aiming at more intensively characterizing the demographics of the influencers and their relative influence would be very useful to improve the public impact of communication campaigns on social media.

Communicating on social media is a promising way to inform, interact and inspire people and society, and thus seems to be very appropriate to take the public along for the ride of human space exploration. The Web 2.0 is a formidable tool to move advocates, ambassadors, and collaborators and can be the place to start building an international collaboration to develop an ambitious space exploration program.

**Authors**

***Update the description removing Dava, as now, it is difficult to publish something with her***

***I will ask Lucy and Kelly if they want to send me a short bio and their picture***

***Update for my bio:***

*Pierre Bertrand is a graduate student in a dual degree at the Massachusetts Institute of Technology: Master’s in Aerospace Engineering and Master’s in Technology and Policy. His research with his advisor, Professor Dava Newman, focuses on spacesuit kinematics assessment using wearable sensors and stochastic estimation algorithms. He worked with the David Clark Incorporated Company and the NASA Johnson Space Center performing experiments on different spacesuits, informing designers about human-spacesuit interaction and mitigating the risk of astronaut injuries. His research demonstrated the capability of performing in-suit sensing with in-field applications and real-time monitoring, and has several implications for future planetary exploration.*

*Through the Technology and Policy Program, he performed research in public engagement and international cooperation for space agencies. He designed an interactive web application useful for space agencies to better understand the social media network related to human spaceflight, based on a big data study he performed on the Twitter platform. He is also working on a research project in collaboration with NASA on how to implement efficiently open innovation, crowdsourcing and citizen science.*

*Pierre also developed human physiology expertise conducting an experiment on the impact of driving with Google Glass, collecting several physiologic measures. With his colleagues, he won 1st place at the Human Factor and Ergonomics Society of New England student competition.*

*Before his experience at MIT, Pierre graduated with a Master of Engineering degree from Ecole Centrale Paris, where he worked with Professor Christophe Laux in EM2C laboratory of combustion on the characterization of atmospheric reentry plasma.*

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