

Social Sciences and Humanities in Research on Space Exploration: Results of a Bibliometric Analysis

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Space exploration is an area of research and activity that is usually associated with natural sciences. However, many key questions regarding space exploration concern the social sciences or the humanities, i.e. questions with an epistemological background. Therefore it is obvious that contributions from social sciences and the humanities are instrumental when trying to understand the meaning and impact of space exploration on humankind in its full richness. While the usefulness, even the necessity, of such a multidisciplinary approach is beyond any doubt, it is not clear how well research in the area of social sciences and the humanities is established today in the field of space exploration. This Perspective presents the results of a bibliometric analysis on the research, which has been performed in this field until today. The starting point of this analysis was two books on Humans in Outer Space, which have been published by ESPI in 2009 and earlier this year. The European Science Foundation (ESF), which played an essential role in publishing both books, supported this analysis especially with helpful discussions regarding the methodology and the definition of main questions. The analysis aims to highlight to what extent research on space exploration is being addressed by the social sciences and humanities or whether this multidisciplinary research is still just a subset within natural sciences.

1. Introduction

The exploration of space and the celestial bodies has fascinated human beings since ancient times. However, the level of human interaction with the space environment under exploration has changed significantly since the early ages: initially the human being acted as an observer in a passive role. Since the beginning of the 20th century, the invention of the rocket motor and the following development of ever larger and more efficient rockets allowed physical space exploration to become a reality. During much of this period, space as area of research, discovery and action was a field of study which has been ruled for a long time by “natural sciences” only. Contributions from the “social sciences” have been very rare during the early period of physical space exploration. One of the exceptions was by D.N. Michael, who proposed key topics for research in the Social Sciences already in 1957, even before the first

man had flown into space¹.

The distinction between “natural sciences” on the one side and “social sciences” and “humanities” on the other is often used when comparing fields of academic research. For the purpose of this study, we follow the Merriam-Webster Encyclopaedia, which defines social sciences as a branch of science that deals with the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society.² In this issue of ESPI Perspectives reference to “social sciences” includes: anthropology, history, law, political sciences and diplomacy, sociology, and psychology. The humanities are defined as the branches of learning that investigate human constructs and concerns as opposed to natural

¹ Michael, D.N., “Man-into-space: A Tool and Program for Research in the Social Sciences”, *American Psychologist*, Vol.12, Issue 6 (June 1957): 324-328.

² Definition from the Merriam-Webster Encyclopaedia, 28 Feb. 2011. <http://www.merriam-webster.com/dictionary/social+science?show=0&t=1300788922>.

processes.³ Examples for the humanities include art, history, philosophy, and religion. We refer to the combined field of social sciences and the humanities as SSH.

At the stage of development that has been achieved today, space exploration activities must no longer be seen as purely technological enterprises, due to their more and more evident social, cultural and economic impact on our daily lives. For instance, common rationales for exploring space include advancing scientific research, uniting different nations, ensuring the future survival of humanity and also developing strategic advantages over other countries.⁴ Only the first rationale mentioned relates to the field of natural science, whereas all the other motivations belong to either the fields of social sciences or the humanities.

Social sciences and the humanities are essential to understand the full value and impact of space exploration on humankind.

Therefore, today it is widely recognised that social sciences and humanities must be much more involved in the research on space exploration⁵. In Europe, numerous initiatives such as workshops, debates, conferences and publications have been carried out by the European Space Agency (ESA), the European Science Foundation (ESF), the European Space Policy Institute (ESPI) and others, in order to develop and enhance the interdisciplinary dialogue between scholars from various disciplines and backgrounds. Two book publications, *Humans in Outer Space - Interdisciplinary Odysseys*⁶ and *Humans in Outer Space - Interdisciplinary Perspectives*⁷ (hereafter referred to as “HIOS”) summarise the recent research on space exploration in the SSH

domain.

This Perspective attempts to demonstrate through bibliometric analysis the manifold connections among the various disciplines within the SSH domain pertinent to space research and their relations to the research of natural sciences. The first chapter introduces and explains the methodology used in this analysis. The following chapters analyse the data with respect to the relevant SSH disciplines and the background of the publications’ authors and look at the orientation of the journals, where the related research has been published.

2. Methodology

We started with a bibliometric analysis⁸ of the contributions within the two HIOS books in order to examine how the different disciplines in these two books are linked together. First of all, the HIOS articles dealing with transdisciplinary issues have been selected and divided in separate lists according to their discipline. The selected disciplines were: Anthropology, Art, Culture Studies, Education, Ethics, History, Law, Philosophy, Political Sciences and Diplomacy, Psychology, Religion, and Sociology. Table one shows a summary of the disciplines. In addition each discipline has been given a colour code, which has been used when generating the bibliographic map (see below).

Anthropology	Blue
Art	Yellow
Culture Studies	Brown
Education	Green
Ethics	Orange
History	Red
Law	Purple
Philosophy	Dark Green
Political Sciences and Diplomacy	Light Purple
Psychology	Pink
Religion	Light Green
Sociology	Olive

Table1: The twelve SSH research disciplines, which have been identified from the HIOS books. The colour coding is also used for the generation of the bibliographic map.

In a second step, we transferred this information from a list format to a map configuration: in order to develop the map, the approach known as concept mapping has been employed.⁹ A concept map is a graphical representation where

³ Definition from the Merriam-Webster Encyclopædia, 28 Feb. 2011. <http://www.merriam-webster.com/dictionary/humanity>.
⁴ “How Space is Explored”. NASA (National Aeronautics and Space Administration, U.S.A.). 28 February 2011. http://adc.gsfc.nasa.gov/adc/education/space_ex/exploratio
⁵ Vienna Vision: Output of the ESF/ESA/ESPI Conference “Humans in Outer Space” held at the European Space Policy Institute (Vienna), 11-12 October 2007. Ehrenfreund, P., Peter, N., Billings, L., “Building long-term constituencies for space exploration: The challenge of raising public awareness and engagement in the United States and in Europe”, Acta Astronautica vol. 67 (2010), pp. 502–512.
⁶ Codignola L. and Schrogl, K.-U. eds. “Humans in Outer Space - Interdisciplinary Odysseys” Vienna: SpringerWienNewYork, 2009.
⁷ Landfester, U., Remuß, N.-L., Schrogl, K.-U., Worms, J.-C., eds. “Humans in Outer Space - Interdisciplinary Perspectives”, Vienna: SpringerWienNewYork, 2011.

⁸ Nicholas, David and Ritchie, Maureen, “Literature and Bibliometrics”, London, Clive Bingley, 1978.
⁹ Novak, Joseph D. and Cañas, Alberto J, “The Theory Underlying Concept Maps and How to Construct and Use Them”. Institute for Human and Machine Cognition. 28 Feb. 2011<<http://cmap.ihmc.us/Publications/ResearchPapers/TheoryCmaps/TheoryUnderlyingConceptMaps.htm>>

nodes (points or vertices) represent concepts, and links (arcs, arrows or lines) represent the relationships between concepts. The links between the concepts can be either one-way or two-way. The concepts and the links may be categorised. Thus the concept map shows causal relationships between the various concepts. We refer to this approach as “bibliographic mapping”, because it represents the bibliographic analysis starting with the two HIOS books.¹⁰ The resulting map is shown in annex at the end of this article. The process of generating this map is described in detail below.

The map contains a total of three layers, each of which is characterised by a different shape. The first layer is located closest to the centre of the map and shows an oval shape. This layer contains the articles from the two HIOS books, which have been colour coded according to their discipline, as described above. The second layer contains all the references, which have been quoted by the articles in the HIOS books. This second layer has an octagonal shape and lies a little further from the centre of the map. The first and the second layer contain only information that can be attributed to one of the two HIOS books, reflecting either an article (layer 1), or a reference (layer 2).

The bibliometric analysis presented here provides insight into the relations of social sciences and the humanities on the one hand, and natural sciences on the other, with regard to research topics related to space exploration.

The third layer shows an hexagonal shape and was based on research in Web Database sources (*ISI Web of Knowledge, Web of Science, Scientific Web Plus Beta*): the research allowed tracing references used by the articles in the second layer, which are in turn references from articles of the first layer. This layer is located on the outer part of the map.

The most distant contributions from the centre of the map are somewhat different in nature from the ones inside (i.e. the first three layers), because they do not reflect a reference made in layer 3. In fact, they show articles that have included quotations from at least one reference in one of the first three layers. These articles have been identified during the analysis of the aforementioned databases. They are located on the outer side of the map. Note that they have

¹⁰ Other terms used for such an approach include i.e. “intelligence mapping”. As this term is, however, not clearly defined we use the term “bibliographic mapping” instead.

the same oval shape as the contributions from the first layer. This ambiguity was considered acceptable because these references are located far from the centre of the map and therefore cannot be confused with the contributions of the first layer, which are at the centre of the map.

In a next step, the correlation between articles has been marked by using arrows. References that have been made between articles of one layer and the next higher layer, or references that have been made within the same layer are shown in grey. Red arrows refer to references from a lower layer compared to the article that makes the quotation. It should be noted that the described layers are a bibliographic tool and do not reflect a concise time history. As the articles within one layer have not been published at the same time, it is perfectly possible that an article i.e. from layer 3 quotes an article from layer 2. Nevertheless, it is reasonable to assume that articles in a higher layer are in general older than these of a lower layer.

This bibliographic map helps to visualise the relationships between the various contributions and references and therefore supports the analysis of the data, which is described in detail in the following chapter.

3. Bibliometric Analysis: Disciplines, Authors, Journals

The bibliographic map shows the links between articles and highlights the complexity of their mutual relations. The following questions guide the analysis of the map:

1. Which disciplines refer to work in other disciplines? Do publications refer to each other more or less regardless of their disciplinary background? These questions attempt to understand whether it is the theme (space), which is the relevant category of identification and reference for authors, rather than the discipline itself. Or is a given discipline more relevant, and clear disciplinary ‘silos’ exist in SSH research on space?

2. What is the background of the authors publishing in the field of SSH research related to space? We define three different backgrounds: (a) social scientist publishing on a SSH topic, (b) natural scientist publishing on a SSH topic, (c) hybrid scientist, who has both natural and social science background. The analysis shall answer to the question if natural scientists include SSH related topics in their research, thus entering the SSH domain. Or must SSH related research be

seen as genuine SSH research that happens to deal with space?

3. In which *journals* is SSH research on space being published? Are these journals aimed at SSH research in general, either on space or broader issues? Or are the journals typically on natural science research related to space? The answer to these questions shall identify whether there is a specific SSH community that focuses on SSH topics related to space, or if these are part of the natural science oriented research on space that once in a while picks up SSH type topics. Furthermore, this analysis will allow identifying outlets for SSH research on space.

Disciplines

The purpose of this section is to examine the links between the various disciplines of SSH research and to identify fields with a high or a very low number of relations to the other disciplines.

Figure 1 shows for each of the twelve disciplines the number of links to other disciplines. Ethics makes eight referrals to other fields, showing the highest interrelation with other fields. (Note that the highest possible number would be eleven if a discipline would be connected to all the others). This highlights the fundamental role, which Ethics plays on SSH research related to space since Ethics and its many specialised areas (i.e. normative ethics, applied ethics, descriptive ethics, etc.) addresses questions about morality, which touch a broad range of disciplines.

The next disciplines with many links are Culture Studies and Sociology, which both reference six other disciplines, followed by Anthropology and Political Sciences and Diplomacy, who have five links each.

On the other hand Education, Art, History, Law, and Religion all show two or less links only, pointing to the assumption that these fields are rather closed and quote predominantly work from their own area of research. This is especially evident for education, which is the only discipline showing no outside reference at all.

One can conclude that these disciplines are less influenced by other disciplines when dealing with research related to space. Somewhere in between being a very open research discipline and a closed domain lie Psychology with four and Philosophy with three referrals to outside disciplines.

Here it must be stressed that the work presented

in this ESPI Perspective started from publications of the two HIOS books and subsequent layers of references. It therefore does not cover all research, which has been performed within SSH studies in the specific space domain. Therefore the observation that Education, Art, History, Law, and Religion are rather closed fields of research must be seen as a supposition, which needs to be verified in a more extensive study.

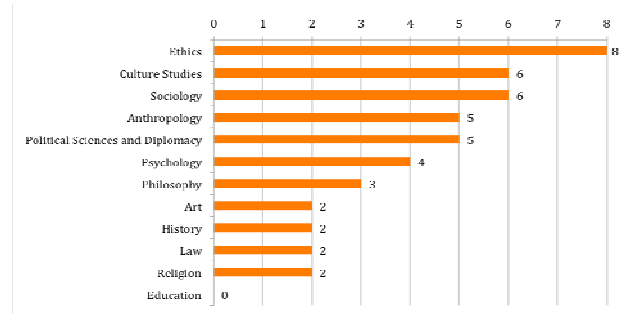


Figure 1: Number of links to other disciplines in the quoted references, by discipline.

After looking at the question of connections with other fields, we examine now if a given discipline is referred to by another research field. The graph in Figure 2 shows the interconnection for each field. The colour coding is identical to the coding used when creating the bibliographic map. Red arrows pointing in both directions indicate that the given research fields are quoting each other. Black arrows, however, go in only one direction, meaning that a given discipline refers to another one without being referred to by work from this discipline.

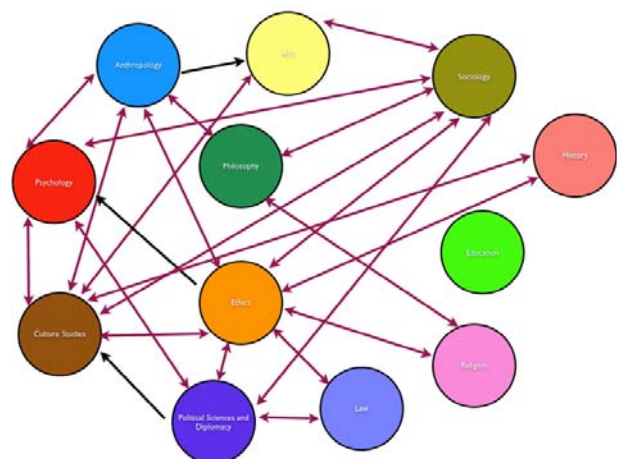


Figure 2: Most disciplines are interconnected with each other as can be seen from the bidirectional arrows (red). Only three cases show a one way link to another discipline.

Finally, it should be mentioned that referrals within the own domain are not shown in Figure 2, as it is ment to analyse the interconnection

between disciplines. All but three arrows are red, showing that the vast majority of disciplines are referring to each other. As it was mentioned above, cross-references between certain disciplines are more frequent, suggesting that these fields belong to a particular common area of research.

It follows from these observations that the dominating theme for most SSH research areas is indeed the topic space, or to be more precise, space exploration. This is definitely true for Ethics, Culture Studies, Sociology, Anthropology and Political Sciences and Diplomacy. These fields could be seen as a kind of catalyst for SSH research on space because they frequently refer to each other, incorporating results from distant research areas into their own analysis and views. Whether some disciplines are rather “closed”, hence the own discipline is the main driver for a given research cannot be concluded so easily. While this may be evident for articles related to education the small number of links to other research areas as seen with Arts, Law, or History may be the artificial result of the rather small-sized sample, which was used in this analysis.

Authors

In order to identify the background of authors, who publish about SSH issues related to space exploration, we have grouped them either as (a) social scientist; (b) natural scientist, or (c) hybrid scientist, who has an academic background in both social and natural sciences. Deciding to which group a given scientist belongs was based on his or hers respective curriculum and educational background, as it is available from i.e. a given publication or the Internet. This analysis was performed for each of the layers individually to see whether the relations between these three groups remain more or less constant, or whether a shift in the ratio between social and natural scientists can be seen. While the three layers do not represent a strict timeline, it is reasonable to assume that the second layer contains on an average older publications than the first layer, as it contains the references for the articles published within the first layer. The same is obviously true when comparing the second and the third layer.

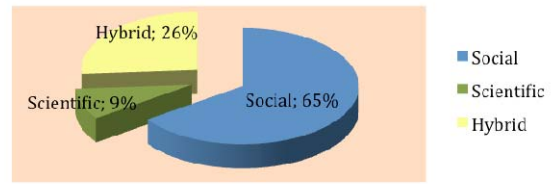


Figure 3: The background of authors within the first layer (N=27).

Figure 3 shows the results for the first layer, which comprises all the contributions from the two HIOS books (a total of 27 authors). Here social scientists are twice as often represented than the other two groups together. Scientists from the hybrid category represent roughly one fourth of the contributions, while less than 10% come from natural scientists.

This distribution changes when looking at the second layer, which contains all the references made in the HIOS books as it is shown in figure 4.

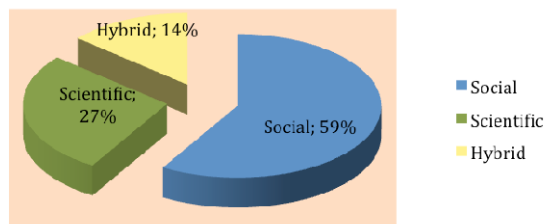


Figure 4: The background of authors within the second layer (N=29).

The group of social scientists is still by far the strongest. However, natural scientists are three times higher represented than before. This is an indication that the work, that has been performed by natural scientists is being quoted and referred to by the social science group. This trend becomes even more evident, when looking at the results in the third layer, which are shown in figure 5.

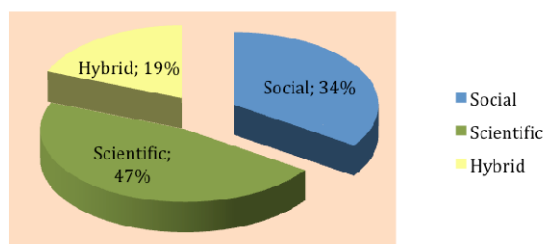


Figure 5: The background of authors in the third layer (N=58). In the third layer, publications from natural scientists are predominant with almost 50% of the contributions, the work of social scientists contributing roughly a third of the research related to SSH. These results can be seen as significant of research topics related to space exploration becoming more and more prominent in the field of SSH. While within the third layer, natural scientists played a prominent role, their fraction became much smaller, at least in the case of the two books that served as reference for this study. This may point to the fact that questions like “Why are humans flying into space?”, “Does life exist elsewhere in the universe?”, “What effects have humans in space on our beliefs, values, and human thoughts in general?” have been raised by natural scientists in the past and have been subsequently discussed in more depth and detail within the SSH community.

Journals

The outlet of the research related to SSH topics in space exploration is almost equally distributed between journals for natural sciences and journals which are dedicated to social sciences or humanities. This is shown in figure 6.

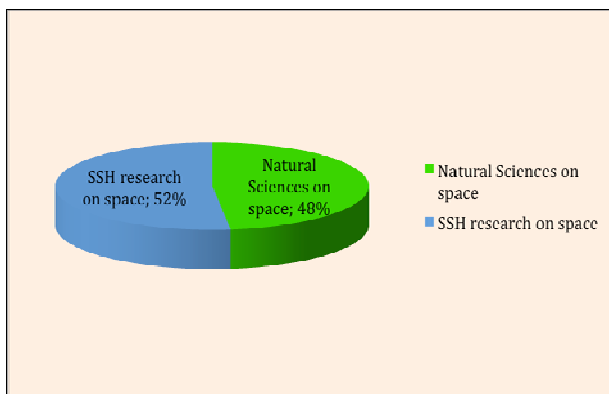


Figure 6: Research on SSH related topics regarding space exploration was published in journals on natural sciences and social sciences almost equally (total number is 29).

In the area of SSH related journals *Space Policy* is by far the most prominent of the 13 journals from this area. For the natural sciences no such leading journal can be identified. Most works appear in *Acta Astronautica* and *Advances in Space Research*.

These findings do not point to a straightforward conclusion. It does not appear that a strong SSH community exists that publishes its research predominantly in SSH related journals. On the other hand, it is also evident that research on topics within the SSH domain is not being published predominantly in journals related to

natural sciences. This confirms that the related research, which may have been triggered by questions that have been put forward by natural scientists first, has been picked up by scientists from the SSH community.

Recalling the results from the previous section about authors, where natural scientists have been in the minority compared to social scientists at least in the first two layers, one could conclude that journals for the natural sciences are more often used for publication, as expected. This could also be due to the fact that publications with authors from both fields are generally more frequently published in journals related to natural sciences.

Additional evaluations

So far we have analysed data from the first three layers only. When we include also the final layer, which is the one referencing scientific work published in the first three layers (for details, see the chapter on methodology) we get a suggestion about the focus of SSH related research on space exploration. One of the most important topics in the current discussion on space exploration seems to be associated with the discovery of other life forms, even if these should be of microbiological nature, and the implication of their discovery on the human system of values and ethical rules.

The human attempt to explore space provides essential insights into the human being and humanity at large. These questions must be addressed by a multi- and transdisciplinary approach, to the benefit of both natural and social sciences and humanities.

4. Conclusion

The bibliometric mapping as presented in this issue of the ESPI Perspectives series proved to be a valuable tool for acquiring insight to the current status of research in the social sciences and humanities, on topics related to the exploration of space. The analysis was performed starting from research, which has been published within the last two years by ESPI in two books on *Humans in Outer Space*. In a second step, all references and references of references relating to this research have been included in the analysis. As the basis for this analysis is a subset of research on space exploration, which has been performed in the social sciences and the humanities, the presented work can be considered as a proof of

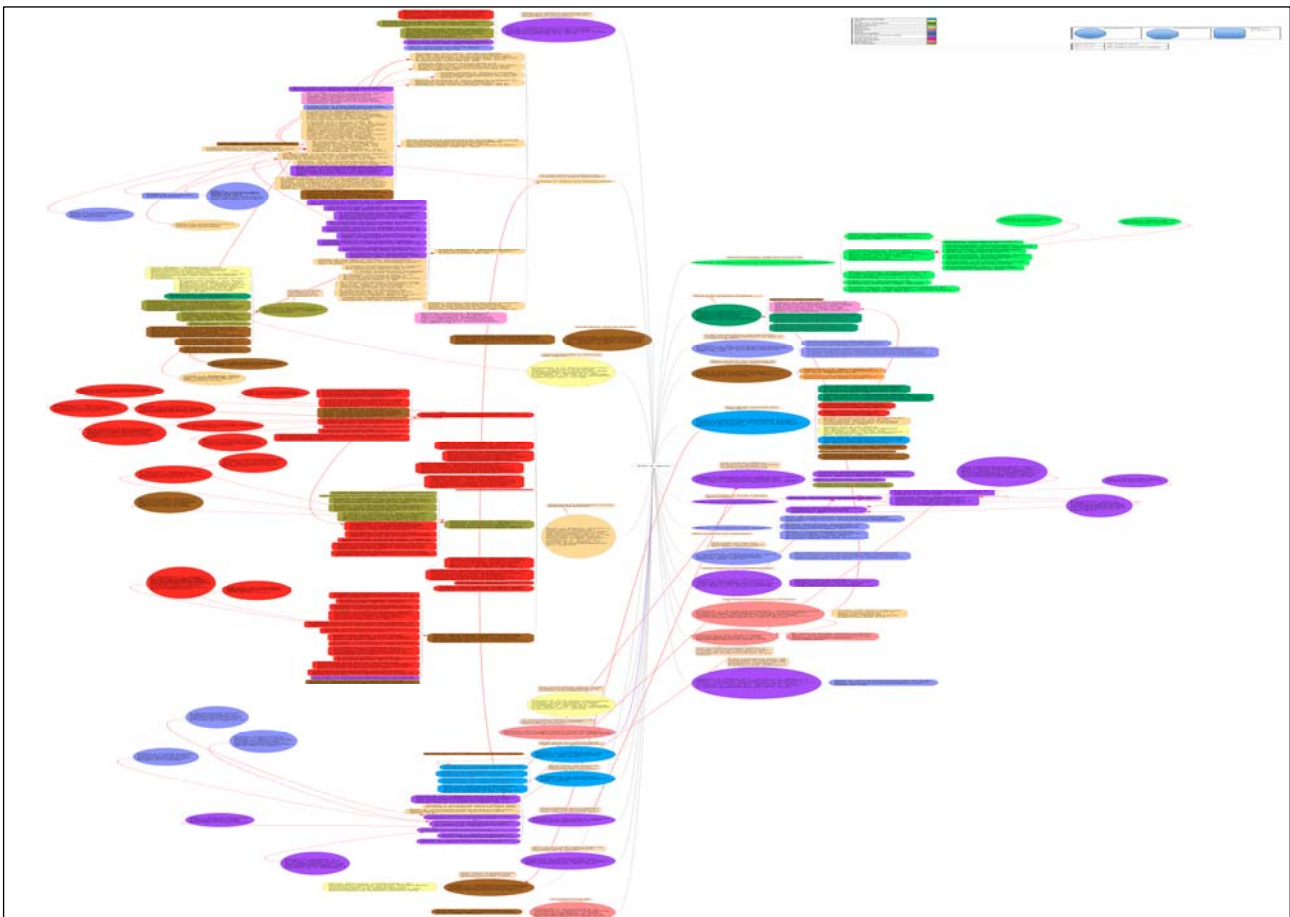
concept for more extensive future investigations. Nevertheless, the results provide a good understanding on certain aspects of the research field, despite its limited sample base.

We could demonstrate that the theme “space” and specifically space exploration is indeed the motivation and driving force for research being performed in the social sciences and humanities on this topic. Specifically Ethics, Culture Studies, Sociology, and Anthropology are research areas that cross-reference each other frequently, because these fields cover many of the key questions associated with space exploration.

From the background of the authors it can be concluded that certain research questions have been picked up more and more by the community in social science and humanities in recent years. While in earlier phases related questions had been addressed predominantly by the natural sciences community, this has

changed in the last years. The entire set of research questions is very broad, ranging from “Why do humans explore?” to “How does Humans in Space impact our thoughts and system of values here on Earth?” From this analysis we can conclude that today the most prominent questions are related to life in the universe in general. It appears that the possibility that humans may not be alone in the universe stimulates the most mind-provoking thoughts in us. However, the related ethical questions are not linked to intelligent life forms alone and cover all kinds of life including very primitive life forms, i.e. microbiological life forms. Research in Europe has today achieved a respected standard on this important topic. A European Space Policy that formulates bold goals for space exploration must include fundamental research on these key questions, in order for social sciences and the humanities to safeguard and enhance the role of Europe’s intellectual leadership in this fundamental area.

The Authors wish to convey special thanks to Mr. Diego de la Hoz del Hoyo (ESF Visiting Junior Science Officer) and to Dr. Rifka Weehuizen (ESF Science Officer) for many useful discussions and their helpful suggestions during this study. Without their support this work would not have been possible.



This map shows the result of the bibliometric mapping starting with the contributions from the HIOS books, which are shown as oval shape along the middle of the map. References to these articles and the references of the references form the next two layers. The last group of articles are shown again in an oval shape at the rim on both sides of the map. For more detailed explanation about the generation of the map see the section on methodology.



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