EXPANDING THE SCOPE OF ASTROSOCIOLOGY IN ORDER TO SETTLE MARS: AN ESSAY[1]

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[1] This paper is an added item from this author for the 24th Annual International Mars Society Convention (2021) that expands the contents of the slide presentation.

ABSTRACT (updated)

Activities related to space exploration and related activities are overwhelmingly characterized by a STEM-heavy approach; that is, one that focuses most strongly on physical and natural sciences, technology, engineering, and mathematics. The "S" in STEM historically does not reference the social sciences and humanities. While the social sciences are becoming increasingly involved with issues related to outer space, the number of social scientists participating is quite low compared to those scientists involved in STEM education and research. Thus, the human dimension is not nearly studied enough, nor planned for, as humankind increasingly focuses its attention on settling Mars. There is a serious, too often unrecognized, need to add social-scientific planning and analysis to all efforts that seek to place a settlement or smaller population-sized base on the Red Planet. Two major examples will be discussed: (1) The Astrosociology Research Institute's (ARI's) "Astrosociology in the Classroom" project and (2) the high school Tiger Team project in concert with the Barboza Space Center.

[This essay assumes that the settlement on Mars simulated by high school students is a permanent location for humans rather than a temporary mission that will characterize the experiences of earlier missions. The permanence of this settlement means that long-term sustainability is a vital aspect of student exercises and this creates additional challenges for them because the social and behavioral sciences, humanities, and arts are included. This essay also summarizes and integrates some of the past work of this author].

INTRODUCTION

The history of sociology and the other social sciences in terrestrial societies reveals that they were able to supplement the religious explanations that characterized the industrial revolution that began especially in England in the latter1700s and in the mid-1800s in the United States. It exposed that religion was not capable of predicting or understanding the abrupt economic and other social changes that occurred. In fact, it is argued that enlightenment and the scientific revolution made the industrial revolution possible.[i] All of the elements of the societal upheavals that they faced moving from feudal to capitalist economies transformed social structures and cultures. The social sciences grew in importance to study how societies could possibly function as urbanization began to encroach into farmlands as citizens moved into newly expanding cities. Changes occurred. to produce new forms of social problems such as crime, homelessness, and discrimination. The social sciences became necessary to make sense of such new complex realities.

On Mars, the beginning stages of settlement will prove much more challenging due to limited resources and the inevitability of the need to construct the physical structures. Early activities will place stresses on settlers that will become easier over time. Nevertheless, the inability to breath atmospheric oxygen, the need to protect themselves from harmful radiation, and the different gravitational environment will contribute to social forces that students will need to consider.

Indeed, establishing a settlement on Mars will begin at a point that is much more treacherous than what terrestrial societies faced in the sense that evolutionary transformation will not be possible. While modern adaptions can be transferred to a Martian settlement, there will be no infrastructure on Mars from a failing social system to build upon. Settlers will be met with only a failing

atmosphere, dust storms, untilled regolith, and a host of other difficulties to overcome rather than both physical and social constructions already in place. The first settlers will face the most difficult circumstances, as they must build the physical and social structures. Humans cannot survive at all without living in enclosures, but they also cannot live in harmony without a larger culture that includes values and the social norms that protect them.

From scratch, questions that relate to the social sciences require answers that should come from social scientists in collaboration with the physical and natural sciences. These types of questions should be kept in mind while discussing every issue. What type of criminal justice system will be constructed to deal with deviant behavior? What type of political and economic systems will be created? How will settlers with varying religious beliefs interact with one another? What family structures will be acceptable? In general, what types of social institutions will be favored? Unlike what humans in large migrating groups have experienced in the past, living off the land without a spacesuit is impossible. Planning ahead must involve much more than building a functional spacecraft and infrastructure on the Martian surface. Even space architecture should involve social-scientific concepts that can make existing on another planet more livable and sustainable. Despite how habitats are often portrayed in contests and artistic portrayals, there are definitely aspects of a settlement that can affect individuals either positively or negatively, which require research.

Thus, migrating to, and settling on, Mars will prove to be an extremely difficult challenge even with the best technology for spacecraft, habitat modules, and supporting equipment. What makes sustainability possible is the focus on the human dimension that complements the STEM disciplines for an all-inclusive approach. Without significant social-scientific input, the physical sciences and engineering activities will get humans to the red planet and establish physical structures in which people will live, but they will do very little to address the Martian societal matters that refer to the how the settlement operates that requires understanding human behavior.

A Brief History and Definition of Astrosociology

For those unfamiliar with the history and definition of astrosociology, this author founded this academic field in 2004. In 2008, the Astrosociology Research Institute was created to by this author and two others[ii] to formalize and provide legitimacy to the social-scientific approach. It was important to establish astrosociology because the social and behavioral sciences, humanities, and arts were not very influential in the space sector at the turn of the twenty-first century. Simultaneously, those in the social sciences were – and still are – not interested enough in space issues. The traditional space community relied on the physical and natural sciences, and STEM (e.g., the "hard" sciences, technology, engineering, and mathematics). The social sciences remain relatively unutilized even today. For a sustainable settlement, all forms of scientific input require attention, including social-

Figure 1: Astrosociology as Multidisciplinary

scientific ones (see Figure 1). Astrosociology exists because the imbalance between the two branches of science have existed for far too long, which has put humankind's potential future of successfully settling beyond Earth in a precarious position as plans are currently proposed.

Mars settlements cannot rely on the traditional model. Constructing the physical settlement must be accompanied by construction of the sociocultural environment inside of it. A sustained settlement must consist of social institutions such as a political system, economy, criminal justice system, and perhaps a military. A larger culture must be established while subcultures will also be established. The physical requirements to sustain life is a necessary condition, but it is not sufficient to provide the long-term sustainability required for a settlement. A population requires structure that becomes increasingly complex as it increases in size, which means that social structures become increasingly important.

With this in mind, astrosociology is defined as the study of *astrosocial phenomena* (i.e., the social, cultural, and behavioral patterns related to outer space). It is a multidisciplinary academic field that includes the social and behavioral sciences, humanities, and arts. That is, it includes academic fields and disciplines such as psychology, sociology, history, political science, anthropology, economics, political science, and archeology. The focus is on the human dimension rather than the physical dimension although both dimensions must work together.

The multidisciplinary approach allows for individuals who may otherwise study astrosocial phenomena in near isolation to interact with one another so they can join a formal network of astrosociological research and also contribute to a growing literature. Also, collaboration between physical and social scientists can allow for solutions to problems that develop that may be inconceivable by physical scientists alone. Collaboration is a key element that is currently lacking.

ASTROSOCIOLOGY ON MARS

While the planning stages before launch are critical for sustainable success, the final settlement location on Mars represents the most important stage, as it becomes the permanent reality for settlers that is completely different from their previous terrestrial existence. Most of which was previously taken for granted no longer become crutches on which to live a safe and thriving lifestyle. Therefore, the physical elements for keeping settlers alive do not ensure a well-functioning Martian settlement. That is, while the physical structures keep settlers alive, they do not directly impact on how they will live inside of those physical structures. There is an important relationship between the physical and social elements that remains understudied due to the overemphasis on the former.

"Astrosociology on Mars" refers to the inclusion of social scientists in the planning of, and presence in, the settlement.[iii] There is much too little consideration placed on the social-scientific forces that will inevitably become fundamental to living in an isolated and enclosed ecosystem. A permanent Martian settlement represents an unprecedented challenge in human history, one that will require the input of categories of individuals too often left out of participation.

> "Astrosociology on Mars" reflects the need to place social scientists – astrosociologists – on the Martian surface along with the expected STEM-oriented individuals. Both branches

of science, the physical and the social, provide benefits to settlers, as they must cope with issues in their physical and social environments.[iv]

The additional focus on social-scientific factors will create the burden of understudied concepts in the sense that too few individuals will be available to study them due to the absence of students who have even heard of astrosociology. It is quite impossible for astrosociology to be on Mars (Figure 2) when astrosociology is not even on Earth as represented in terms of a sufficient number of astrosociologists.

Figure 2: Astrosociology on Mars

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Furthermore, complications will arise because the social forces will interact with the physical elements in ways that place pressures on the success of long-term sustainability. As such, there are multiple areas that relate to astrosociological areas of education and research that will become extremely important for the long-term success of a Martian settlement on Mars. Some of these important areas include:[v]

1) **planning before launch, during transit, and once arriving on Mars**;
2) **physical and social environments interactions**;
3) **space architecture** and **artistic concepts** for habitat modules;
4) **Martian settlement cultures**, both the formal culture and subcultures;
5) **social institutions on Mars**, including the economic system, political system, criminal/juvenile justice system, family structures (including children on Mars), religion, education, health care (space medicine and medical astrosociology), the military, space law and the settlement legal system, sports, and the media;
6) **social problems** in Martian settlements that occur in multiple sectors of the settlement;
7) **behavioral health** that involves numerous sectors of the social system;
8) **mitigating deleterious effects** on Mars from terraforming, as one example;
9) **aging and space gerontology**, which take into account older settlers who lead the way;
10) **planetary protection** of important resources such as area that may harbor life/fossils;
11) **exo-astrosociology** on Mars that involves the search for extinct and extant life;
12) **space archeology** on Mars, which includes protection of artifacts as they are created;
13) **interplanetary relations** between Earth and Mars, and among settlements; and:
14) Martian **planetary defense** from asteroids and comets, but also from other dangers.

The important concern when reviewing this limited list of social science areas of education and research that require serious attention is the fact that they receive very little attention relative to concerns focused upon in the STEM and even STEAM disciplines. Nevertheless, it does provide a map for pursuing future research and instituting new educational programs.

This particular essay will include discussions that illustrate new expansions of traditional approaches as well as insights that could result in other related innovations in the future. The

concept of astrosociology on Mars ultimately refers to the placement of astrosociologists in Martian settlements in order to study and provide impactful solutions to social problems that will arise. However, it also refers to steps that can be taken long before such settlements occur, as the following discussions make evident.

THE SOCIAL SCIENCES: APATHY OR IGNORANCE?

Few social scientists study space issues compared to those in the STEM disciplines. The result is less collaboration in planning for the mission and monitoring of settlement life. As on Earth, research must continue following the landing on Mars and subsequent construction of the habitats and supportive infrastructure. A severe dearth of social scientists educated and trained to understand the problems associated with replicating a social system beyond the Earth represents a problem moving forward that cannot be overstated in terms of its impact on any permanent settlement that may be contemplated.

Figure 3: A More Holistic Approach

But why is there such a lack of participation of non-STEM academicians and experts in this particular area of sociocultural research? Why is astrosociological education so severely lacking? One of the important forces that has contributed to this unfocused approach to space exploration has been the emphasis on the physical requirements necessary for a successful short-duration mission. Permanent settlement beyond Earth places unique and extremely challenging requirements that continue long beyond the landing on the Martian surface. Thus, there is a strong argument that can be made that too few social scientists study astrosocial phenomena compared to STEM-oriented individuals who must focus on the physical and natural sciences, which represent their main emphasis. An important result is that far too few social scientists currently exist for planning of missions before launch and the monitoring of the functioning of a settlement over time. The overwhelming focus on STEM has consequences, then, which include the following:

1) the relatively low level of funding for prospective astrosociologists has been devastating for the development of this field;
2) fewer professional social scientists have created a bad enough situation, but it also results in fewer mentors for students;
3) outer space had become the forsaken frontier for sociology and the other social sciences due to a number of factors, many of which require further investigation[vi]; and:
4) those focusing almost exclusively on natural and physical sciences cannot benefit from the study of the human dimension of space exploration and settlement.

There consequences have long suppressed potential social-scientific innovations in the space sector that could have made tremendous contributions in situations that resulted in failures.

Conditions are improving, however, so that the status quo that has largely rejected the social sciences, humanities, and arts have weakened to a point at which a meaningful level of inclusion has become a possible reality. The STEAM movement that added the arts to STEM is one obvious example of this expansion. The emphasis on sociocultural issues related to space began in 2004. Additionally, the focus on the arts within astrosociology began in 2005. ARI's influence is having an impact as well since 2008 with expansion of publications that include the *Astrosociological Insights* newsletter and the *Journal of Astrosociology*.

Nevertheless, there is a need to construct formal collaborative networks consisting of organizations and individuals between astrosociology and the STEM-related disciplines. Those related to the social and behavioral sciences, humanities, and arts must also recognize the importance of space education and research so that a more inclusive approach is possible. ARI is dedicated to help make this possible by emphasizing a more expanded and holistic approach (see Figure 3).

THE "ASTROSOCIOLOGY IN THE CLASSROOM" PROGRAM

ARI and current supporters require assistance in developing astrosociology. The "Astrosociology in the Classroom" program seeks to get astrosociological materials of various kinds into classrooms, as the name implies. Even mentioning astrosociology during lectures or discussions is helpful at any stage of a student's education. The development of this academic field must take place with the assistance from educators that they will bring it up in the classroom (Figure 4). Non-academic professionals who conduct research, and students who expose their teachers to astrosociology and seek to study it with their permission must also step up. The college/university level was the initial focus, and it is still important, as lectures can expose students to this innovative field. Furthermore, a grant proposal under review also seeks to improve on current initiatives at the postsecondary level. The high school level is approached differently, as will be discussed in the following section. The significant assistance from a partnering nonprofit organization has made it possible.

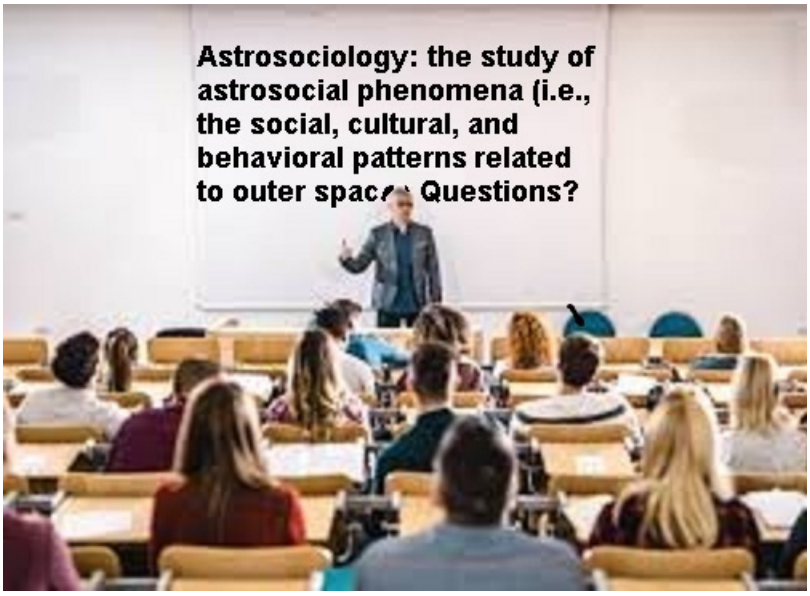

Figure 4: Astrosociology in the Classroom

Why is placing astrosociology into classrooms important? One answer to this question relates to the myopic attention to mission critical objectives without considering elements associated with the human dimension that also impact on mission success.

> "Understanding the universe of space exploration and its practical implementation requires both discipline-specific knowledge to accomplish individual missions

> while also utilizing an interdisciplinary perspective to grasp wider insight into the causes and purposes for the broader collection of space activities."[vii]

The collaboration between STEM disciplines and astrosociology topics is still largely a missing piece, a void in our understanding of what is required for human endeavors of larger scope than missions in the past. Moreover, the interdisciplinary perspective referred to in the quote above includes the social sciences and other non-STEM disciplines.

Thus, ARI is working to increase astrosociology in academia and beyond. At the postsecondary level, this program initially aimed to first add materials to lectures for various social and physical science classrooms, and expand then from there. One model of an expanded presence is the Introduction to Astrosociology course taught by Dr. Gerhard Sonnert at Harvard University. This formal expansion of astrosociology on the *astrosociological frontier* represents an extremely important move forward.[viii]

Figure 5: Astronomy and Astrosociology

A good placement for astrosociology during introduction courses is when discussing science and technology in society. Social science courses include this discussion already although they tend to focus on terrestrial matters. There must also be a push in STEM-related courses. For example, astronomy courses already include the biographies of important astronomers and how they advanced their discipline (Figure 5). Expanding the human dimension is a much-needed development so that knowledge about how astronomical work affects the various segments of societies can bring in social-scientific insights that are often glossed over. A convergence between the two branches of science will propel progress much more quickly. The work has already begun within departments in universities although this is still largely taking place as informal associations among educators.

There still exists considerable resistance and ignorance, as mentioned. This is important because looking up at the stars in the night sky and failing to recognize how space affects societies and, furthermore, failing to imagine that migration away from Earth in the rapidly upcoming future has long placed constraints on the potential of successfully settling Mars.

> "…the improvement of space-related education is not a competition between the two branches of science, but rather, dependent on a new unwitnessed level of cooperation and collaboration. STEM and astrosociology must exist, and thrive, together."[ix]

The physical without the social is characterized by serious limitations. While humans are the central component to conducting any form of scientific investigation and adding to any body of knowledge, the human dimension receives inadequate integration into how science is carried out. This situation can be improved through greater formalized interaction between students and educators. Unsurprisingly, undergraduate students are interested in space and astrosociology.[x]

The main reason for getting astrosociology into classrooms is to begin to address the imbalance between the physical and social sciences. There still exist serious drawbacks to the development of astrosociology seemingly affecting a bulk of the social sciences and humanities. One difficult

challenge is the stance that "Outer space is not my area," or "space is a weird topic," or "aliens, crop circles, and UFOs are examples of pseudosciences." This type of reaction is still very much too common because space has traditionally existed outside the social science purview. The forsaken frontier syndrome is a real detriment that holds back progress. Getting astrosociology into classrooms is the solution for this problem.

Again, a significantly more holistic approach will result in a change of the status quo that will inevitably result in the chances to construct a sustainable settlement on Mars. A one-sided effort cannot succeed wherever humans live in any ecosystem, as humankind has proven throughout modern history on Earth. In a place such as the Martian environment that surrounds the Martian architectures, failure can easily result in chaos, deviance, and even death. The astrosocial forces that shape societies must be included in understanding how a proposed Martian settlement will likely function in terms of all aspects of its existence such as the economic and political system.

THE FIRST CLASSROOM ON MARS

The First Classroom on Mars program, which could be thought of as the first classroom *about* Mars, was initiated by Bob Barboza via the Bob Barboza Space Center (see Figure 6). Conceptually, this program creates a simulation in which high school students work on projects that are relevant to the tasks necessary to sustain a Mars settlement. The "first" aspect of the title refers to the idea that lessons need to be learned on Earth before the attempt of actually settling Mars ever takes place. The first classrooms are preparatory initiatives that introduce students to key concepts related to settling Mars. As will be discussed, a key difference moving forward is that astrosociology will be introduced as a central component to defining how the first classroom on Mars is organized.

Initially, this program exclusively focused on the physical and natural sciences. However, in 2021, Bob Barboza contacted this author to propose altering the focus of this program to include a new emphasis on the social and behavioral sciences, humanities, and arts (that is, astrosociology). This alternative approach has resulted in an innovative pedagogic approach that emphasizes a strong collaborative structure between the physical and social branches of science. In effect, this emerging educational structure combines the Astrosociology in the Classroom and the First Classroom on Mars programs into a hybrid one. This is unprecedented!

There are consequences related to the traditional approach associated with space exploration. The extreme focus on STEM-related issues results inevitably in the continuation of too little funding for the likelihood of social science education focusing on outer space to expand to an extent that is necessary for the future. Currently, fewer social scientists involved translates to the scarcity of mentors. This in turn means that there will continue to be fewer social science students focusing on space issues; that is, focusing on astrosocial phenomena. The continuation of this status quo is untenable if humankind is truly serious about settling in other space environments.

THE TIGER TEAM HIGH SCHOOL PROGRAM

Historically, Tiger Teams have been used to react to crises that require immediate attention and problem-solving efforts. The original purpose of the Tiger Team approach was to quickly put

together a group to solve an immediate problem facing an organization. Problem-solving processes represent the key reason to deploy Tiger Teams because problems occurred that elements in the organizational structure could not address due to an unprecedented problem that falls outside normative procedures. Often, a temporary reorganization to pull workers into the newly-formed team is required or even pulling in input that normally does not exist at all.

Figure 6: Tiger Team Instructors & Students

> The sobriquet "Tiger Team" was invented by the press during the 1970 Apollo 13 crisis. The first Tiger Team was NASA's mission-control team that figured out how to return the astronauts safely to earth. NASA's sensational success made Tiger Teams part of our lexicon and a popular management practice. The phrase Tiger Team became synonymous with a temporary expert problem-solving team.[xi]

In contrast to the classical model, modern Tiger Teams have evolved to "eliminate the need for crisis motivation by integrating advanced teamwork tools with total problem-solving heuristics."[xii]

In essence, the temporary nature of the classical Tiger Teams is exemplified by high school students due to the fact that they graduate from the program after their semester ends. On the other hand, the fact that each team consists of students who must assume different physical *and* social occupations reflects elements of the Modern Tiger Team structure. Voices from a number of members from varying backgrounds can provide a consensus to resolving a problem that is frequently impossible from a single perspective alone.

Figure 7: Astrosociology in Leadership Position

As depicted in Figure 7, the field of astrosociology has moved to the central

location, as one student per team is designated formally as the astrosociologist who is in the leadership position. The subjects studied and problems faced come from both the physical and social sciences, so that an astrosociological influence permeates throughout each students' experiences. Thus, Tiger Teams incorporate astrosocial phenomena while solving all the problems.

> "Each team includes at least one astrosociologist in training, who serves as the team leader. Together they solve challenging real-life problems, conduct reverse engineering, study cybersecurity, and carry out science experiments necessary for our simulated Mars missions."[xiii]

The astrosociological element enriches students' experiences in unique, underrepresented ways.

Five-Member Tiger Teams	
Team One: Life Sciences	**Team Two: Engineering**
Astrosociologist (Leader) / Team Member #1 **Major: Astrosociology** Minor: Space medicine	**Astrosociologist (Leader) / Team Member #1** **Major: Astrosociology** Minor: Space architecture
Team Member #2 **Major: Space ecology** Minor: Behavioral ecology	**Team Member #2** **Major: Space architecture** Minor: Habitat construction
Team Member #3 **Major: Agriculture** Minor: Horticulture	**Team Member #3** **Major: Mechanical engineering** Minor: Habitat construction
Team Member #4 **Major: Biology** Minor: Microbiology	**Team Member #4** **Major: Chemical engineering** Minor: Space architecture
Team Member #5 **Major: Botany** Minor: Hydroponics	**Team Member #5** **Major: Electrical engineering** Minor: Civil engineering
Team Three: Medical	**Team Four: Social Sciences/Humanities/Arts**
Astrosociologist (Leader) / Team Member #1 **Major: Astrosociology** Minor: Medical sociology	**Astrosociologist (Leader) / Team Member #1** **Major: Astrosociology** Minor: Sociology
Team Member #2 **Major: Space medicine** Minor: Medical Astrosociology	**Team Member #2** **Major: Astrobiology** Minor: Exo-Astrosociology
Team Member #3 **Major: Biomedical engineering** Minor: Medical Anthropology	**Team Member #3** **Major: Space Archeology** Minor: Space society construction
Team Member #4 **Major: Medical psychology** Minor: Medical Psychology	**Team Member #4** **Major: Planetary Geography** Minor: Political economy
Team Member #5 **Major: Medical astrosociology** Minor: Space Medicine	**Team Member #5** **Major: Space law** Minor: Space arts

Figure 9: Original Tiger Team Concept

Another of ARI's new core initiative stresses familiarizing each of the participating high

Figure 8: Collaboration!

school students with astrosociology. Doing so, allows those whom are interested in space to serve on the various "Tiger Teams." This program works well in junction with the Bob Barboza Space Center (see Figure 8) that is located at the Ontario International Airport in southern California. It integrates physical

and social science students in simulations related to living and working on Mars. Of shocking significance is the very fact that the astrosociologist on all Tiger Teams serves as its leader, because this creates an unusual – and overdue – emphasis on the importance of collaboration among the various sciences. The STEM-related fields and disciplines finally interact with the social sciences, humanities, and arts. While this program is quite small at the current time, there are indications that other parties from the United States and other parts of our globe have become interested in potentially replicating this program.

The first conceptual design of the Tiger Teams for the first session consisted of four teams that included five members (see Figure 9). However, the first scheme for the Fall 2021 semester consists of three teams with ten students in each. These students were introduced to the academic field of astrosociology for the first time. The original Tiger Team configuration may be attempted in the Spring 2022 semester although this is still under consideration. Also, additional students have become aware of the program and have demonstrated enthusiasm for it.

Figure 10: Flight Suit Patches for Students

As depicted in Figure 9, each Tiger Team consists of a combination of STEM disciplines and astrosociology subfields and topics so that the physical and astrosocial fundamentals of the settlement simulation are included. Moreover, each team focuses on a single aspect of the mission. For example, Team Three is oriented as the medical team. It includes space medicine, medical astrosociology, and biomedical engineering. While the designated astrosociologist is the team leader, the physical and social elements are both included in how it is structured.

Familiarizing high school students with astrosociological concepts is a very good start. Students in future semesters will be provided with flight suits that include ARI's patch (as shown in Figure 10). The Tiger Teams as now formulated address students at the high school level, which is important for both the First School on Mars and the Astrosociology in the Classroom programs, as the latter incorporates the social sciences while the former expands to the high-school level in addition the postsecondary level. By combining the two programs together, a unique set of circumstances is created in which young people are exposed to a scholastic environment in which the social sciences receive an equal emphasis.

The objective for this unique combined program, which places high school students in a classroom with astrosociology and STEM-related subjects, is to prepare them to think differently about space. It provides the opportunity for those who pursue the physical and natural sciences to become more open to incorporating social-scientific elements in their research. Conversely, social-science-oriented students can become more open to expanding their experiences beyond their comfort zone. If students from traditionally separated education and research careers can become more

inclined to combine their approaches, then the chances of settling Mars successfully on a long-term basis would increase exponentially. While this type of pilot program itself could only affect a limited number of students, it could conceivably be replicated elsewhere so that the postsecondary level is affected, as an astrosociological pipeline can be constructed.

A GROWING ASTROSOCIOLOGICAL PIPELINE

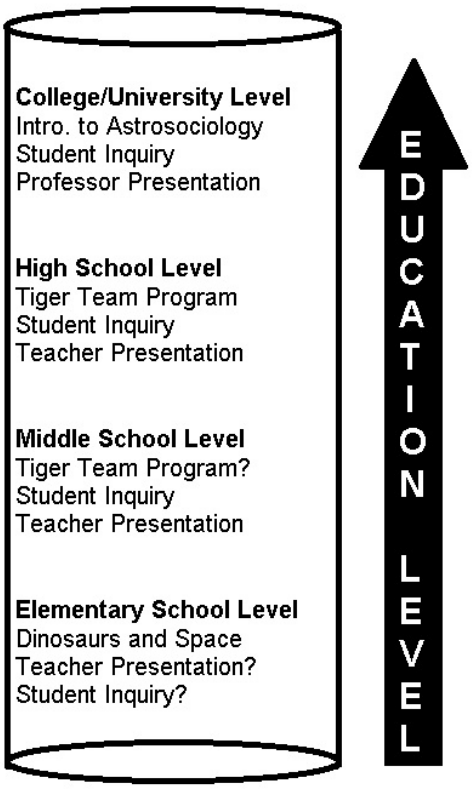

Figure 11: The Astrosociological Pipeline

An important type of social structure to establish on multiple fronts continues to be preparing college students opportunities to study astrosociology in the classroom. This includes writing term papers, theses, and dissertations approved by their professors. The status quo characterized by the astrosociological frontier has made this a very difficult proposition for students. However, with the expansion of the Astrosociology in the Classroom program that now reaches high school students, it is becoming increasingly feasible to expect that students at all levels can be exposed to astrosociology in various social science, astronomy, and other types of classes and courses.

The message to those students who are inclined to become a social scientist yet want to pursue space education and research is that there is a growing number of pathways to follow that allow for both realities to occur. Collaboration among those in and between various sectors of societies such as those dealing with space professionally, education, family, the economy, and the political system is absolutely necessary because there is an imbalance – indeed a number of inequalities – that have made the pipeline extremely difficult, if not impossible, in the past. Fortunately, it seems as though the past aspects of the status quo that disfavored a significant presence of the study of human behavior as it relates to space has lessened in terms of its impact on future pedagogical organization.

The astrosociological pipeline is only possible due to hard work by a number of individuals and organizations. Dr. Gerhard Sonnert, ARI, and the Barboza Space Center are some of the key elements that provide the pipeline with the potential to allow the astrosociological frontier to be settled, which is equivalent to the growth of astrosociology on Earth. In the education institutions, growth can come from students, educators, and outside sources. It is quite amazing to consider that the very existence of this pipeline is potentially transformative, perhaps not today although quite possibly very soon. The development of astrosociology will definitely benefit from this trend.

Middle and Elementary Schools

Figure 4 clearly illustrates that teaching about what is necessary to settle the astrosociological frontier is certainly possible via educator presentations, which is a normative way of teaching, but a vital way to expand astrosociological knowledge is also via student inquiry. Students at various

levels of education may become familiar with, and excited by, their own exposure to astrosociology via social media, friends, and other pathways. Those in the latter categories will potentially inquire to their teachers and professors at all levels of the pipeline about learning more about astrosociology and asking for permission to write assignments focusing on it

The ultimate approach is to familiarize students at levels below high schools about astrosociology so as to create an upstream pipeline. However, the astrosociological pipeline actually moves in two directions from the high school level. While the university/college level is often independent, as exemplified by the Harvard University example, it also can move students up the ladder while also informing students in lower educational levels as well as depicted in Figure 11. At the elementary school level, teachers must largely take the responsibility to inform students of the existence of astrosociology. On the other hand, parents and other family member may provide an introduction to astrosociological ideas to young students.

Space is already a subject of great interest to most children along with dinosaurs. Regarding space, the most familiar aspects of space exploration is a focus on rockets and astronauts with hardly any details about the social and cultural forces that impinge on it. The complex social-scientific details that these students must learn at higher levels of education need not be emphasized although the basics can certainly excite some students to become interested in astrosociology. This is even potentially true for elementary school students.

REPLICATING TERRESTRIAL SOCIETIES ON MARS

The successful functioning of any social group depends upon a shared culture and interacting parts – that is, in this case, students contributing from different backgrounds – that create a stable and largely cohesive social structure. As students cooperate to solve problems associated with making the settlement on Mars possible, they must do so in the context of the fact that they would be living in human-based ecosystem, or space society, as the population expands.

> An example of existing knowledge applicable to space involves society's institutions in the context of replicating a society in space (i.e., a space society) ... In order to place a population of human beings in an isolated and dangerous space environment, planners must construct these institutions (e.g., government, family, economy, and criminal justice) to regulate social life just as they function to do so on Earth. Though social groups will adapt to space the best they can manage, the basic organizational patterns have been tested over thousands of years. They are unlikely to change on a fundamental level. Thus, data available from the study of space analogs is especially relevant to early settlements as well as the early history of all new ones.[xiv]

Replicating a social system on Mars is a complicated process. It becomes increasingly difficult as the population increases. This requires an increasing level of formalization in turn, which means that the replication of groups and institutions familiar in terrestrial societies becomes progressively important. Sustainability ultimately requires stability in terms of how societies function, which necessitates that they must avoid undue conflict and deviance.

An important aspect of the Tiger Team's efforts, then, must include solving aspects of settlement life that deals with behavioral and interactive complexities. It is important to take into account

historical lessons associated with negative impacts on societies as well. Constructing a settlement, both physically and socially, requires attempting to take advantage of the good and eliminate the bad. This is important for both the Tiger Teams and the construction of the actual Martian settlement. Working through both physical and social matters now is extremely important for the success of space societies into the future. A comprehensive understanding of these types of issues by younger students will ultimately result in their chipping away at the status quo by infusing the space sector with a renewed emphasis on astrosocial phenomena.

Social problems will inevitably occur. Thus, students need to be wary about simply solving a physics problem, for example, without taking into account the impact on the human dimension. Another example relates to another focus of the Tiger Team, namely working on cybersecurity issues without taking into account how possible solutions affect others in the settlement. There is a larger human dimension that necessitates the need to integrate the physical and social elements into every procedure undertaken. The advantage of the Tiger Team program is the fact that it combines astrosociology with otherwise non-socially-related problem solving. The real world of human behavior, wherever it exists, is a complex combination of physical and social domains. Taking this into account for students at an undergraduate and even earlier time frame is essential to making a future Martian settlement sustainable and livable.

Space Architecture and Astrosociology

The mere physical construction of a space habitat that supports human life is another example of a necessary although insufficient condition. A human can technically survive in an enclosed and isolated physical structure, but that does not necessarily mean that the social conditions in that structure are conducive to a thriving community, and conditions could worsen as a space society on Mars becomes more complex organizationally.

Figure 12: Outside Architecture / Inside Garden

Architectural decisions have implications for both practical recreational and working conditions *and* how the settlement is intended to operate. For example, a corporate or government sponsored settlement will differ from a penal colony in terms of how the physical elements are constructed. "Leaving Earth will require a re-evaluation of our societal values, cultural practices and preferred governance systems."[xv] This type of re-evaluation is intimately related to how the modules are designed, as it informs how the residents will interreact on a daily

basis. If punishment is not the motivation for design, then it is important to avoid architectural elements that are conducive to negative experiences in everyday social life. Social structures are also affected. Quasi-military governmental structures that were appropriate for small groups of astronauts in the past may not be the best solution in large settlements, especially when their orientation is a focus on scientific objectives such as the search for Martian life, for example.

Decisions about what types of architectural designs are beneficial versus detrimental to settlers involve a series of compromises. One area of architectural decision making involves the overall design itself. Should modules be separate physical structures, which would require settlers to don spacesuits to move around the settlement or should they be linked together as shown in Photo #1 in Figure 12? Another example is whether farming should be designed as a strictly functional matter such as an unemotionally pleasing hydroponic room or should it be more esthetically pleasing such as part of a garden (see photo #2 in Figure 12, for example). Function will not always result in a positive outcome while form can become the best solution for various situations. Human needs may even compromise the best functional architectural resolution.

Thus, upscaling solutions derived in the classroom requires imaginative thinking for students. Space architecture is important even when working on solutions to a scientific problem. Solutions derived must fit well into how the overall, or a specific, social structure functions. How these resolutions are designed may not fit well into a human ecosystem. Interestingly, not all settlements will require the same types of implementations as they relate to their physical and/or social requirements. The need for aesthetic surroundings and other architectural matters may seem of secondary importance, but long-term or permanent residence on Mars is not a trifle area of concern and must be thoroughly investigated.

CONCLUSIONS

The development of astrosociology is important because it continues building a community of individuals focused on outer space from social and behavioral science, humanities, and arts perspectives. Such voices have been relatively quiet throughout the space age. Beyond this, the development of space exploration has historically taken place with a singularly strong commitment to focus mostly on the STEM-based disciplines and academic fields to the detriment of the social sciences. The objective for this pilot high school program is to eventually get more social scientists involved in the study of astrosocial phenomena while convincing those in the traditional space community to accept them and work with them.

Thus, a few interrelated facts cannot be overly emphasized. Based on the history of space exploration and visions of settlements beyond Earth, it has long been painfully clear for many social scientists that sociology and the other social sciences have failed to be influential in the space sector.[xvi xvii xviii xix xx] Concurrently, too many of those outside of the STEM disciplines have demonstrated relatively little interest in space issues. Abundantly clear is the fact that this cannot continue, especially as humankind contemplates migrating beyond Earth, which is fraught with dangerous environments that challenge human survival. It is essential to provide spacefarers with all the knowledge available, including that related to the human dimension, so that they can potentially solve problems related to physics as well as social problems whenever they arise. It cannot be predicted which types will reveal themselves.

There is a growing need for social and physical elements to converge much more formally in order to produce an unprecedented holistic understanding about what it will take to settle Mars on a sustainable basis.[xxi]. Such a convergence between the social and physical branches of science is a great step forward that must involve students becoming aware of this overwhelmingly growing necessity. A holistic approach that integrates all levels of education and research among students, educators, and professionals is the best path forward.

Therefore, "Expanding Astrosociology in Order to Settle Mars" presumes that social science is largely missing and there is the need to get astrosociology into the classroom so that a pipeline from the high school level, and even lower, allows social science students studying astrosociology to move into postsecondary schools and eventually into the space sector. It refers to the need to bring the non-STEM academic fields and disciplines to a point of at least near equal footing in the planning of the mission and to a much better understanding about human behavior in transit to, and living in, Martian settlements. The social and behavioral sciences, humanities, and arts all have their roles to play along with the STEM disciplines and fields. While the problem in the past has been the overwhelming focus on the latter, the need can be addressed successfully if the mindset changes on an unprecedented basis, which is increasingly necessary as plans for sending humans to Mars are accelerating.

At the outset, in contrast, the Astrosociology in the Classroom program alone focused almost exclusively on postsecondary students, which was a limiting approach. Together, however, the First Classroom on Mars that includes Tiger Teams and the Astrosociology in the Classroom pieces exist to engage educators, professionals, and students in increasing the status of the human dimension of space exploration and settlements. That is, this hybrid program is aimed at providing students with opportunities to pursue space education that includes a social scientific perspective. By placing the astrosociologist in the leadership position of each Tiger Team, high school students are introduced to astrosociology, which has never existed before. Moreover, they flip the normal script by informing students that the social sciences are just as important as the STEM disciplines. This pilot program is limited, but it lays the foundation for a new approach. Mentorships from the university level downward will also become much more possible once astrosociologists enter academia and the space sector in adequate numbers.

At this moment, settling Mars is not practical because the social sciences are not ready. It is vital to expand astrosociology in order to settle Mars successfully and sustainably. Thus, settling Mars without inclusion of the social sciences will be difficult, and perhaps impossible. This is a conundrum! How do you educate and train enough social scientists? How can those in the STEM disciplines attract social scientists? Answers to such questions boil down to the fact that progress must occur within and between both the social sciences and physical sciences. If the pace can be accelerated and the participants expanded, then a sustainable Martian settlement is much more probable and closer to reality in the relatively near future. This will require greater funding for astrosociology's development directly as well as new and existing programs that support it. The case here demonstrates that it is possible is to integrate astrosociology into previously existing programs with adequate funding.

The types of programs such as those described herein are aimed at modifying the status quo that devalues social science input, as many have argued has been the necessary case since the Mercury

program, which was based on a practical need to rely on physical science, mathematics, and engineering, as the first astronauts entered into the unknown, NASA wanted to select astronaut candidates with outstanding physical, psychological, and biological attributes. In contrast, the great majority of Martian settlers will not embody "The Right Stuff" [xxii] characteristics of that era, nor should we expect them to live up to such an archaic standard.

For astrosociologists, the high diversity characteristic of the settlement population will necessitate a high number of social-scientific investigations in the actual settlement, as settlers will exhibit a variety of statuses and associated roles. This lesson is important for the members of the Tiger Teams as they continue to work in their analog settlement simulations long before humankind actually sets foot on the Martian surface. Integrating the social and physical sciences early for students will provide them with well-rounded backgrounds as they advance to their next educational level.

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[ii] Originally, the Astrosociology Research Institute was founded by Jim Pass, Marilyn Dudley-Flores, and Thomas E. Gangale in 2008.

[iii] Pass, Jim (2020). "Astrosociology on Mars." Chapter in *Space Exploration – A Step Forward*. Intech Open, publisher. URL: http://www.astrosociology.org/Library/PDF/JPass_ AstrosociologyOnMarsChapter.pdf.

[iv] Ibid., page 6.

[v] Pass, Jim (2020), "Astrosociology on Mars." Chapter in *Space Exploration – A Step Forward*. Intech Open, publisher.

[vi] Pass, Jim (2004), "Space: Sociology's Forsaken Frontier." [Paper presented on October 16, 2004 at the California Sociological Association (CSA) conference in Riverside, CA]. URL: http://www.astrosociology.org/Library/PDF/submissions/Space_Sociology%27s%20Forsaken%20Frontier.pdf.

[vii] Hardersen, Paul (2013). "The University of North Dakota – Space Studies Program." *Astrosociological Insights*, 2(3) October, p. 18. URL: http://www.astrosociology.org/Library/PDF/Newsletters/ARI-Newsletter_Vol-2_Iss-3_10-2013.pdf.

[viii] The *astrosociological frontier* represents the scarcity of astrosociology in the classroom. It refers to schools at all levels without a social-scientific approach to the study of space issues and the transmission of the lessons learned to the next generation of students at each level of education.

[ix] Pass, Jim (2013). "The Future of Space-Related Education: STEM and Astrosociology Together." *Astrosociological Insights*, 2(3) October, p. 17. URL: http://www.astrosociology.org/Library/PDF/Newsletters/ARI-Newsletter_Vol-2_Iss-3_10-2013.pdf.

[x] Ibid., pp. 4-7.

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[xii] Ibid., p. 4.

[xiii] Barboza, Bob (forthcoming). "Astrosociologists are Training Astronaut Tiger Teams for Simulated Mars Missions." *Astrosociological Insights*.

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[xv] Edwards, Erin (2020). "Will Our Cultural Baggage Permeate Our New Homes in Space?" *Astrosociological Insights,* 8(1), p. 14.

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