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Astrosociology and the Planning of Space Ecosystems

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Humans can only survive in space on a sustained basis when they live in a social group of some kind, whether a crew for short-term survival or communities and larger social structures for long-term survival. Space societies represent the most stable form of social structure, though they require a large number of settlers, as the following discussion will explore. Humans are social animals. Therefore, social interaction is necessary for people to remain psychologically healthy. With this in mind, it should be apparent that the design of the space habitat and the planning of the social environment are *both* absolutely necessary. It is extremely unwise to send humans into space environments, each of which possesses its own set of physical hardships, without the input of social scientists and humanists. Proper astrosociological research and planning will prove essential, as the physical environment normally focused upon cannot ensure that those who live within habitat walls will thrive socially. In other words, it is not enough to simply place a group of human beings into a safe physical environment and expect a successful outcome.

This paper investigates some of the most important social, cultural, and psychological issues involved with sending humans to locations beyond Earth. Hostile space environments present challenges to health and safety that create stress that affects individuals, social groups, and entire communities (in larger settlements). The relative inattention to the astrosociological issues involved with the successful migration into space environments is troublesome to this author. What follows is a mixture of an exploration of the relevant issues and a set of cautionary messages regarding what can happen if the social sciences and humanities do not receive their due participatory status in the planning and ongoing study of space ecosystems.

I. Introduction

ASTROSOCIOLOGY focuses on astrosocial phenomena (i.e., social, cultural, and behavioral patterns related to outer space, both on Earth and in space environments). While astrosocial phenomena have affected humans and their terrestrial societies, and thus their cultures, the focus here is on issues related to future settlements in space. With only the International Space Station (ISS) and the Chinese Tiangong Space Station currently orbiting the Earth, and only the former with an ongoing human presence, many may consider it too early to worry about preparing for human migration and settlement in hostile space environments. However, the need to plan now is based on setting up humankind to survive catastrophes that might otherwise result in the extinction of our species.

> The future of human life depends in part on establishing ourselves as a multi-planet species, migrating in numbers to create off world communities of sufficient size so that humans (perhaps in radically altered forms) as a whole can survive an event that kills everyone left behind [on Earth].[1]

Remaining a single-planet species does not serve the long-term interests of humankind.

Fortunately, there are clear indications that a significant subset of the world's population is ready and willing to migrate into space on a permanent basis. This raises the ethical issue as to whether or not those responsible for sending these pioneers into space have the obligation to increase their chances of survival to the greatest extent possible. The only way to maximize both survival and livability odds is through thorough and well thought out planning for physical and sociocultural elements of the expedition. Unfortunately, this does not seem to be a high priority for astrosociological considerations. Livability as defined here means a comfortable and happy life, one that is worth living.

Currently, we know so much more about the physical requirements necessary to keep humans alive in even uncharted space environments than we do about how to keep them thriving within their social environments; that is,

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within the human-made physical environment in which the population resides. This reality places a particular segment of humankind in a precarious position in which a random set of circumstances threatens to wipe out an entire space community or society. Of course, the danger can come from outside of the habitat structure, as is possible on Earth, but in a confined and isolated place of limited size, the danger can also come from within. Zombies are not necessary to cause the sudden and catastrophic failure of a space society, though a virus can certainly threaten the well-being of a population. First responders must be trained and ready to act. The danger from within increases the less pre-expedition planning takes place on Earth.

Finalizing plans and implementing them are admittedly difficult to achieve in democratic societies because political leaders potentially change every two years, and presidents and thus space policies potentially change every four years.[2] If affordable, it may be simpler to implement a plan by private corporations or other types of organizations. Their leadership structures are much more stable over time. The difficulties involved with large-scale projects will likely cause planners to reduce the size and complexity to arguably much less successful versions. Many would argue that this is a bad idea.

Still, many others ask, why should humankind migrate into new space environments? Human space exploration and settlement on an increased scale, should it indeed occur, will accelerate scientific and technological progress. It will lead to collaborative efforts unseen in the past. Additionally, this increased level of attention to astrosocial phenomena will contribute to addressing social problems resulting in their mitigation. It is also reasonable that humankind will explore new space environments and settle in them because human beings have been socialized to be explorers.[3] If migration into space is indeed inevitable, then humankind should work hard to make space exploration and settlement as successful as possible. The trend over the long haul is arguably toward a spacefaring society in which space affects more and more aspects of people's social lives.[4] This prediction is based on the historical record that demonstrates progress unless setbacks or social disintegration occur, which are indeed certainly possible outcomes in the future.

A related question that nearly always arises when discussing long-duration missions and permanent settlements relates to the following general idea. Why study the planning of space ecosystems and related issues now. The simple answer is that humankind is behind in its understanding of space issues from a social-scientific perspective. The more lead-time that is available, the greater the chance that successful planning will result. Well planned out expeditions or short missions increase the likelihood of successful outcomes.

II. Planning an Ecosystem to Increase the Odds

Of great importance is the idea that settling space is more complex and requires greater planning than is often recognized even by those who may someday mount such a mission or expedition. The planning of human ecosystems before mounting an expedition into space presents an area of study that now requires increased attention. Moreover, it is vital to address the social, cultural, and psychological issues that will exist that combine to provide both positive and negative influences that, in turn, can increase or decrease the odds of sustained survival, and thus affect the level of livability. The thrill of adventure when migrating into space will wear off much more quickly if social problems manifest themselves among the members of the confined population, especially early on during the mission. Planning ahead of launch can serve to curtail these negative possibilities. Social-scientific input is vital to increase the odds of survival and a more comfortable existence in a confined area isolated from the bulk of the human population on Earth. Social scientists can bolster the work of physical and natural scientists to achieve a more holistic approach and interactions between the two branches of sciences in an area that still receives too little attention. By working together to plan for both the physical and sociocultural construction of environments in which the population will live, the chances of success increase tremendously.

Social science research has provided much understanding about the social interactions of humans for more than 200 years, and much of it is applicable to space exploration and settlement. Much of the discussion to follow comes from some of the most applicable lessons learned in "normal" social settings in terrestrial societies as well as research findings gained through the study of analogs such as Antarctic bases, submarines, and Martian simulations on Earth. Valuable data also comes from space stations, especially the now deorbited Mir and the International Space Station (or ISS). Shuttle data also exists. Unfortunately, however, too few social scientists have enjoyed the level of access to some of these analogs and space assets as one would expect is prudent, at least in this author's opinion. Nevertheless, data analysis does exist and social scientists should utilize it to increase the likelihood of success for a human ecosystem in a new space environment, wherever that may be. So much needs to be understood beforehand that it is never too early to start learning even while so few humans live in space at any given time. The only way to ensure success is to train astrosociologists and collaborate with other social scientists in the social science community and incorporate them into the traditional space community so that they can work together to

solve problems that transcend each of their disciplines and even their branches of science. Decreasing the odds of failure by increasing the level of formal collaboration seems like the most prudent course of action.

Herein, the author explores many of the major issues regarding training a population of diverse individuals to become part of a single social order. The individuals who commit to a future characterized by migration into the cosmos each possess different sets of experiences and cultural backgrounds. Without immersion into a single social order, characterized by a single larger culture, falling into a situation of chaos characterized by an increase in social problems is much more likely than the establishment of a stable, sustainable society. A central assumption made here is that the population that ultimately leaves our planet together must be socialized into a single social order that exists *before* boarding their spacecraft; and they must largely accept the ideas (including values) and the norms or social rules that protect these values that comprise a single culture, which is part of the social order. Unless a certain level of familiarity and commitment to a single social order exists before launch, disagreements about such things as political authority, economic opportunities, and a belief in the same (or similar) ideas will potentially doom the expedition before it even begins.

III. Space Environments, Physical Environments, and Social Environments

All issues revolve around the need to plan for a space habitat, the physical environment created by humans, and the social environment, which houses the social structures and larger culture within that habitat that is located in a specific space environment. Social groups and social institutions require planning and construction on Earth and then transplanting them to life aboard the spacecraft and ultimately into the final space ecosystem. Thus, a simulation of the ecosystem begins construction and implementation on Earth during the planning/training phase, becomes transferred to the space travel phase aboard the spacecraft, and finally becomes transferred permanently to the final space society location.

The three types of environments discussed below serve as a conceptual tool to illustrate three important aspects of living in a confined and isolated space habitat. Each element exists on its own, yet all combine and interact to affect the lives of inhabitants. While artificial distinctions, the mental exercise of separating these three types of environments provides a good sense of the various considerations that must receive attention for planning.

A. Space and Physical Environments

An important distinction exists between two important concepts: the space environment and physical environment. The *space environment* consists of the local surroundings that characterize the area in which the physical environment sits. It includes characteristics such as the local gravity field, the level of radiation raining down, and the topography of the planet or moon (if the settlers do not reside in a spacecraft or space station). While the space environment mostly consists of the natural surroundings, humans can certainly alter aspects of it such as digging into the surface of a planet for their benefit.

In contrast, the *physical environment* is defined here as the structure that encloses the settlers, which keeps them relatively safe from the hostile space environment. The physical environment can consist of a space habitat on the surface of a planet or moon, a spacecraft, or a space station. "[T]he physical environment must be capable of reliably maintaining life support as well as protection from space-bound threats to human life such as radiation."[5]. Thus, aspects of the physical environment can both harm the chances of survival (e.g., when radiation levels climb too high), but also improve human chances of survival (e.g., using regolith to insulate the space habitat to protect it from radiation). Many aspects of the physical environment require social scientists and physical scientists to work together to solve potential problems.

Boundaries characterizing the physical environment are necessarily human-made, unlike many of those on Earth created by coastlines or mountains, for example. Of course, many on Earth are also human-made, such as the borders of nations and coastlines. However, the difference in space environments is that humans cannot survive unassisted in the space environment, which exists outside the human-made physical structure. Thus, human settlers in physical environments find themselves confined to a relatively small footprint.

B. The Social Environment

The issues covered by the STEM subjects – comprised of the physical and natural **S**ciences, **T**echnology, **E**ngineering, and **M**athematics – focus on the space and physical environments, the latter of which, of course, ensures continued biological functioning of inhabitants as long as the mechanical elements continue to function properly. However, a point of emphasis here is the fact that a focus on the physical environment is not enough to guarantee long-term survival in a human space settlement. Physically survivable space settlements are not necessarily livable, as social and cultural forces determine the level of livability.

Within the habitat, the *social environment* consists of the physical "space," which is comprised of the interior architecture and tangible objects that settlers can manipulate and see. Habitats themselves place humans in conditions of isolation and confinement that increase the difficulties of positive interaction on an ongoing basis.[6,7] As such, planners and later the builders of the habitat need to incorporate features that reduce stress levels by making the interior of the physical environment comfortable and similar to what inhabitants experienced on Earth.

An extremely important relationship exists between the physical and social environments (and the space environment affects both of them as well). "While the proper engineering/construction of space habitats is necessary to ensure survivability of the inhabitants of a physical environment in space, it remains insufficient to ensure proper functioning of a social environment in space."[8]

> If we truly intend to develop a space colony, we should remember one fundamental rule: construction of the social environment is just as important for survival as construction of the physical environment. The social construction of a space colony refers to the idea that settlements in space involve the creation of a social environment in addition to the physical environment.[9]

The concept of the social environment exists as a contrast to the space and physical environments so as to illustrate the idea of three levels of settings that range from outside of the habitat to the interior. They include (1) outer space for spacecraft and space stations or outer space and surface of a planet, moon, or asteroid, (2) the habitat itself, which is the physical environment, and (3) the social environment inside the exists inside the habitat. These three layers each require careful consideration to ensure the survival of the population, and the social environment arguably requires the most attention at this time because social scientists have largely ignored it in the past. After all, the social environment is where the inhabitants actually live.

IV. Space Ecosystems and Ecologies

The *space ecosystem* consists of the physical and social environments that interplay with one another to make the human experienced social reality what it is.[10] Thus, the combination of well-functioning physical and social environments is crucial to the survival of the settlers. The concept of a space ecosystem relates to the relationship of these two environments. For example, the architecture within a space habitat (i.e., the physical environment) can encourage healthy social interaction as when a park with real green grass or a substitute brings people together during their leisure hours. Similarly, the use of physical space can encourage people to gather and interact or promote isolation depending on its design. Other features can also improve life in the habitat.

> Changing conditions of light during the day and variation including the playful and surprise situations create positive stimuli. To counteract physical enclosure, architecture can operate mechanisms such as lighting systems that change intensity and color to simulate the cycles of the sun, use virtual technologies to bring the outside in - the surrounding outer space - and natural elements of Earth, including water and plants. On the other hand, the contemplation of art in its multiple forms as well as its practice nourishes the symbolic structures of the brain.[11]

Building several pre-planned actions and features into the space ecosystem can result in individuals suffering from less stress, and thus they can live more healthy lives.

Those who choose to travel into space on a long-duration or permanent space expedition will inevitably reside in an enclosed physical environment unlike anything most of them had experienced on Earth (unless the training takes this into account, of course). No one has ever lived in such an environment on a sustained basis, however. Again, the need exists to make at least some of the internal surroundings similar to what they experienced on Earth. Familiar surroundings make life aboard a spacecraft or within a space habitat much more bearable and can go a long way toward inducing a sense of greater livability, which represents a much higher level of existence than mere survivability.

On the other hand, the experiences of Mir crewmembers demonstrates that much can go wrong, which can increase stress and thereby lessen the quality of social lives. Examples include territoriality; volume limitations or overcrowding; noise; housekeeping issues; hygiene/cleanliness problems; life support issues in a closed atmospheric system; confinement, isolation, and separation; scheduling and coordination conflicts; boredom and monotony; lighting issues (as previously discussed); and emotional outbursts and mental illness.[12] The pre-launch planning and training process can eliminate some of these problems and reduce the severity of others.

Furthermore, an *ecology* includes the inanimate objects, organisms such as plants, fungi, bacteria, insects, animals, and human beings. Another issue that speaks to the complexity of constructing a space ecosystem involves the correct mixture of organisms to enhance the chances of survival for human beings. Ecological considerations are important elements of any planned long-duration space mission. This raises an important question when one considers ethical questions involving contamination of other cosmic bodies. What types of organisms are appropriate for things such as ensuring healthy plant growth? What types of bacteria do people need to survive? Beyond the societal considerations, planners must make crucial decisions about what type of ecological system to

construct and how to keep it viable over the entire targeted period, whether measured in days, years, or decades. Even something as seemingly simple as the growth of plants still receives ongoing investigation aboard the ISS and researchers continue to learn new insights.

V. Space Communities and Space Societies

The social environment is only a geographical area in which the population resides. It does not possess a structure or organization of its own. These elements require construction as well. The organization of the population within the social environment is the most crucial element as far as regulating the social lives of the people. A population itself consists of a collection of individuals in the same place at the same time, but it does not involve any sort of organization or involve any sense of belonging to any type of social order in and of itself. You can place a population into a space habitat, but that does not make it a community or society of any kind if the individuals do not feel a sense of cohesion and belongingness. A shared culture is required along with social organization. While evidence exists that crewmembers aboard spacecraft orbiting the Earth during short missions often experience very few negative interactive effects,[13] the likelihood of serious problems during long-duration spaceflights brought about by stress is much greater,[14] which has received much attention for quite a long time since this early study.

A. Social Structural and Cultural Issues

The social environment consists of the interior of the physical environment where the settlers live and interact with one another. More precisely, it provides a location for the social interactions that create a shared social reality, including the shared cultural ideas that render them cohesive as a group. Social solidarity or a strong sense of unity is vital for survival of the group, especially in isolated and confined conditions. They must rely upon one another to survive through their expectations of reciprocal rewards, both tangible and intangible.

Durkheim (1893)[15] distinguished between *mechanical solidarity* – which is based on the homogeneity of individuals who feel connected by similar work, education, religion, and lifestyle – and *organic solidarity* – which is common on Earth in industrial modern societies and is based on an interdependence that arises from specialization of work and other dimensions of life that requires mutual reliance. The shift from one form of solidarity to the other occurred on Earth during and following the industrial revolution. For space societies within social environments, however, the emphasis on organic solidarity is imperative. A diverse group of individuals must rely upon one another from the beginning, so mechanical solidarity will not suffice.

Beyond biological sustainability concerns, a society based on organic solidarity will require a great many individuals with specialized skills and diverse backgrounds.

> As on Earth, a small group or community structure cannot sustain a growing population, nor can it accommodate the needs of a large starting population. Communities are homogeneous in nature, while space societies need to be heterogeneous by nature with a larger population size. There needs to be a high division of labor – including [formalized] statuses and roles…[16]

Organic solidarity requires thousands of individuals rather than hundreds. The exact number remains a subject of debate among social scientists, and falls outside of the scope of this discussion, but numbers range from hundreds to hundreds of thousands for a permanent space settlement. Planners will need to think carefully about the division of labor among the inhabitants and determine the best complimentary scheme possible. Practically, the space community serves as a temporary structure for plans in which population growth occurs in migratory stages rather than sending the entire compliment at once.

Part of the planning process involves settler selection and deciding which criteria are most important. Part of the planning process involves determining the makeup of the population selected. Heterogeneity over a high number of social dimensions is desirable. Homogeneity contributes to failure more readily. Diversity is the key to long-term survival and prosperity. Occupations, skills, cultural backgrounds, race and ethnicity, the balance of the sexes, and age ranges all serve as important examples of criteria needing attention.

Preparing selected candidates is another important consideration. Social and cultural forces that shape the life of a single person and a population on a much larger scale through a process is known as *socialization*, which consists of the adoption of the ideas and acceptable behaviors of a particular culture to which a person belongs. We tend to take this for granted because for people born on Earth, this process takes place most strongly over the first decade of life and continues until death. Individuals who visit or move to another culture recognize this and may even experience "culture shock." For potential space settlers, their resocialization process must occur in a comparably very short span of time. The process of letting go of old ideas and behaviors in favor of new ones consistent with their potential space society is a difficult experience. They must buy into the cultural and social constructions presented to them, or they will potentially commit deviant acts later on. The larger the initial population, the less involved planners need to be in terms of trying to select complementary individuals on a number of different social and cultural dimensions.

B. Social Institutions

The social institutions consist of stable patterns of behavior and relationships that function throughout a society. They provide order and structure and control behavior through various means, most commonly through normative standards consisting of rules and shared expectations. The "normative order" exists to allow citizens to know what is expected of them and how to follow the rules properly. The planning of a space ecosystem and space society requires the construction of social institutions and this includes how they operate once the population size is large enough to require these structures.

Examples of major social institutions include the economic system, the political system, education, religion, the legal system, the family, medicine, and the criminal justice and juvenile justice systems. One example should suffice to provide a good idea of what is involved. With all the variations of social institutions in the world today and those that have existed historically, a great many examples of each institution exist that can be copied or modified. Which ones planners select and how they interact with one another will result in the space society's normative order. It is also important to remember that social institutions interactions can alter the intended purpose of a single social institution. The larger culture and subcultures also influence them.

Deviance is universal in every society on Earth, so it will not disappear just because humans live in a new ecosystem, in another place in the social system, or somewhere beyond elsewhere in the Milky Way. The criminal and juvenile justice system (assuming the presence of juveniles) provide law enforcement to protect citizens and the laws that govern them. They provide social control. Planning for the existence of deviance in its various forms is important because lawlessness can erupt rather quickly and forcefully. Other aspects of the criminal justice system include the courts that interpret the law and apply them to particular situations and the corrections arm that implements punishment such as fines and incarcerations. Even a smaller grouping of people must implement some type of response to the deviance that they will experience so that they can maintain social order. The government must also cope with various types of social problems that will exist, as discussed soon.

C. Medical and Physiological Issues

Space medicine focuses on the biomedical aspects including the detection, diagnosis, and treatment of illnesses and injuries. The basic approach is to find a physical cause and fix it. Medical practice is more reactive than proactive or preventative for the most part. What type of approach will exist in the space society? Constructing a medical institution requires much thought. However, an important practical concern always remains with medical institutions, as all others. What is the best way to construct a medical institution that limits its bureaucratic features and thus limits its level of social control?[17]

Medical astrosociology, in contrast, focuses on the social and cultural dimensions of illnesses and injuries that occur in space societies. By adding these two dimensions, medical astrosociology provides insights into why the medical approach alone does not tell the whole story and may not solve the problem that seems quite confined to a medical solution. For example, a patient may refuse to take medication because it violates his or her religious values. On Earth, medical sociology and medical anthropology developed for an important reason; namely because biomedical issues alone could not treat patients adequately. Terrestrial medicine required a more holistic approach. Together, space medicine and medical astrosociology provide a more inclusive understanding of the medical condition that occurs within the context of society and culture.

Additionally, medical practice can discriminate, as when hospitals refuse medical care to certain "types" of individuals or they receive substandard care. These types of issues lie beyond what a physician normally thinks about and thus can continue or worsen over time without his or her direct knowledge. Medical astrosociologists focus on this type of issue and provide research findings so that those responsible within the medical institution's administration can potentially act upon them.

The space environment exposes the human body to forces not experienced on the Earth. Examples include variable gravity fields and high radiation levels.[18] These differences can cause stress and anxiety, which may in turn result in deviant behavior. Again, the physician does not know about everything that occurs in the lives of patients beyond the hospital, doctor's office, or clinic, yet a feedback effect may worsen a patient's biomedical condition and make treatment much more difficult.

Another example involves ethical dilemmas that will inevitably occur, which require decision-making that must use criteria that goes beyond the dictates of space medicine.[19] Sometimes physicians and nurses do know about larger societal conditions such as having to make a decision about how much medicine to provide one individual when the supply of that medicine is dwindling too quickly. Does the physician use up the entire supply for one person or save it by reducing the dosage or even refusing to provide it at all? These are difficult decisions.

The area of space medicine within a confined and isolated physical environment represents one of the most important set of issues to consider. The biomedical-based scenarios that may arise are difficult enough to anticipate,

but the complications brought about by astrosocial phenomena make responses even more problematic. Part of the problem, then, is that the social and cultural forces that impinge on the patient and others often do not reveal themselves very readily. Thus, a holistic approach that combines the biomedical, social, cultural, and psychological issues serves as the best model. Planners will need to keep this in mind.

VI. Social Problems in the Space Society

No one can predict the future, of course, though one can make educated guesses based on known facts and wise extrapolations. One of these extrapolations deals with the fact that a significant category of humans both approves of space exploration *and* wants to live in an extraterrestrial human ecosystem. Therefore, finding willing volunteers is seemingly relatively easy. Without planning, however, including living in the social order before leaving Earth, the chance of successful long-term survivability and livability in a space ecosystem remains relatively unlikely. One must expect social problems to occur and devise plans to respond to them in reasonable ways. Many social problems will seem quite familiar while others could very well spring up that seem unfamiliar. The space society's government and other social institutions need to be flexible enough to develop new strategies to respond to new types of social problems.

Defining social problems has always been rather problematic because they affect different categories of people in different ways. It is difficult to be value free for this reason, and social scientists often find themselves in the crosshairs as each side of a social problem may view him or her as biased in favor of the other side.[20] Thus, it should be clear that the definition of social problems is not easy to pin down precisely. With this in mind, one may define a social problem as a social condition (such as discrimination) or a pattern of behavior (such as substance abuse) that harms some individuals or all people in a society (such as pollution) and that a sufficient number of people believe warrants public concern and collective action to bring about change.[21] It is a condition that a significant number of people believe requires a remedy through collective action due to the failure to achieve individual and collective goals adequately.

Often, the powerful inhabitants or elites of a society define what is and what is not a social problem. In such cases, the less powerful, which consist of the great majority of the population, find themselves under some form of social control that makes it difficult to decrease the level of harm they are suffering. In any case, perceptions of social problems are subjective and those harmed seek to uncover empirical evidence to prove that some type of harm is indeed occurring on some level of social reality.[22] Their responses may fall within the guidelines of society's approved behavior or perhaps even become categorized as forms of social problem themselves. The planning of a space ecosystem must take into account how to define such conditions and how address them.

Social problems are inevitable in any society, including those in outer space environments. Inevitable social change itself can cause new social problems to spring up or evolve into new forms. New situations or conditions will manifest themselves that unintentionally harms at least a segment of the population. In an enclosed space habitat structure, the possibility of a catastrophic failure that threatens the entire population is possible. Disagreements and conflicts will occur even in the best-planned space societies, so one group may intentionally harm another, in which case the harmed group defines the situation as a social problem. Therefore, some social problems that can potentially harm categories of the population will potentially involve purposeful actions and policies.

Social policies, and indeed sometimes, social institutions exist to address private or government defined social problems. Examples of governmental responses to social problems: the welfare system and unemployment insurance address poverty/unemployment, and the criminal and juvenile justice systems address crime and delinquency. A private entity such as a for-profit corporation or a nonprofit organization may address the same or similar social problems. Any society, whether on Earth or beyond must be able to respond to social problems of various types.

One set of social problems that seems unavoidable in terrestrial societies consists of the various forms of social inequality (e.g., sexism, racism, religious persecution, social class, and social stratification). Social inequality is another universal found in various forms in terrestrial societies. How can one plan to eliminate or at least reduce social inequality? Further, how do the government and other social institutions react to its existence? Do they attempt to reduce it? Alternatively, do they contribute to it in obvious or clandestine ways?

Moreover, in a space society, those who suffer find themselves in an enclosed physical structure with nowhere to escape from the harm perpetrated against them. Although social problems will manifest themselves just as they exist on Earth, the exact characteristics are unpredictable. Moreover, they will most likely differ in some ways from one space society to another. When social problems become too intense, citizens may respond in various ways that include the use of protests and that may escalate into violence. Demonstrations may occur when law enforcement acts in ways considered inappropriate. In extreme cases, riots may erupt in which participants go into seemingly mindless rampages. Within a confined physical environment, these types of extreme actions may even threaten the

integrity of the life support system. This brings up the issue about how to protect these systems not only from riots, but also from purposeful sabotage.[23]

VII. Convergences among the Social Sciences and between the Two Branches of Sciences

Just as the social sciences can only conduct limited research when they fail to collaborate, the two branches of science cannot continue to function relatively independently of one another in the study and then implementation of space ecosystems.[24] The planning advocated here is impossible without formal collaboration between social scientists and physical scientists, for example. STEM-based research is important, but it does not address all of the issues that the construction and life within the space society will create.

The best approach is to forge new convergences among scientists within the social/behavioral sciences and the physical/natural sciences, which will most likely result in the most unforeseen types of scientific outcomes. However, the encouragement of convergences within each of the two branches is also important. Multidisciplinary and interdisciplinary approaches can provide greater understanding based on a more holistic approach. This applies to all areas of planning, implementing the construction of the space societies, and the training of the potential individuals who will live in them.

VIII. Training of Astrosociologists and Interested Social Science Students

Today, there are far too few students in the social sciences and humanities involved in the study of space-related issues. Astrosociology was founded on the principle that the education and training of social scientists, behavioral scientists, and humanists is absolutely necessary for the advancement of space exploration for both humans living on Earth, and those who choose to travel into space for a limited time or those who migrate into space for a long period of time or even permanently.

Astrosocial phenomena already affect human lives and the progress of societies for a relatively small cost, and therefore understanding them should become more important to science and society. However, the future of humankind may well depend on its ability to live in space environments in addition to remaining planted on the surface of the Earth. For these reasons, it is clear that the training of astrosociologists and related science students is quite late indeed. As astrosocial phenomena become more pervasive and impactful, failure to study them will result in decreasing social science input and thus more (or continued) speculation.[25] This makes the planning of space ecosystems much more problematic and ultimately it makes the outcome of the plan less likely to succeed.

IX. Conclusion

This discussion only touches the surface of the issues related to planning long-duration and permanent space societies. The main contributions here deal with expressing the complexities involved in understanding the space environment, the physical environment, and the social environment – and how they relate to space ecosystems and space societies. Another contribution relates to pointing out the need to develop complex planning and implementation of that planning on Earth *before* launch in order to re-socialize and properly orient the potential settlers. This type of program can only succeed with the involvement of social scientists, humanists, and artists specializing in space issues. In practical terms, it is acknowledged here that the full implementation of such grand projects on Earth involves prohibitive costs and resources, though some sort of scaled-down pre-launch planning and training is absolutely necessary. What remains is selecting which aspects to implement and which to discard.

Planning for life in space environments requires action right away here on Earth in terms of conducting further research and experimentation to guide planners most reliably, and social scientists, humanists, and artists must participate in far greater numbers. The field of astrosociology makes it possible for those interested in space issues who happen to not approach them from a STEM-related background to work together to build a growing body of literature and a community that has only tenuously existed in the past and was characterized more by isolation than organization of social scientists. Furthermore, a greater level of convergence is required to make the planning for successful migration into other parts of our solar system possible. The two branches of science must work together to forge a more holistic approach on a formal basis.

Campaigns already exist to send humans to Mars, and perhaps first to the Moon, on a small scale; and at least one of them expresses an inclination to ramp up the population size over time. How many of the issues discussed here have received their due attention? Crew-sized missions based on a quasi-military command structure can overcome many of the issues discussed here on a short-term basis, though a larger population and especially one that plans permanency cannot overcome them over time.

Again, the type of planning of space ecosystems discussed here is admittedly complex, expensive, and even overwhelming in many ways. However, such an approach, if implemented well enough, will provide the best

possible chance for a positive outcome characterized by a stable and livable space society. Failing this, the potential negative elements increase in the areas in which planning is incomplete or even nonexistent. The quality of life in the space ecosystem is determined in large measure by the quality and implementation of the planning. You get what you plan for, in essence. Thus, there is a range along a continuum starting from no planning at all – that results in chaos from the very beginning -- to a well-planned effort – that results in the type of positive outcome that the planners expect. Practically speaking, the reality will fall somewhere in the middle of the continuum.

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References

[1]Harrison, A. A., "Astrobiology: Where Science Meets Humanistic Inquiry," *The Journal of Astrosociology*, 1(1): 13-30, 2015, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/Journal/JOA-Final/JournalOfAstrosociology-Vol1.pdf [Cited 08 August, 2015].

[2]McCurdy, H. E., *Inside NASA: Hight Technology and Organizational Change, John Hopkins University Press*, Baltimore, 1993.

[3]Finney, B. and Jones, E. M. (eds.), *Interstellar Migration and the Human Experience*, University of California Press, Berkeley, CA, 1984.

[4]Pass, J., and Harrison, A. A., Shifting from Airports to Spaceports: An Astrosociological Model of Social Change toward Spacefaring Societies," *AIAA Space 2007 Conference & Exposition*, AIAA 2007-6067, 2007, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/Contributions/Space%202007%20Articles/Airports%20to%20Spaceports.pdf [Cited 03 August 2015].

[5]Pass, J., "The Astrosociology of Space Colonies: Or the Social Construction of Societies in Space," *Space Technology and Applications International Forum (STAIF) Conference Proceedings*, Volume 813, Issue 1, 2006, pp. 1153-1161, p.1155.

[6]Harrison, A. A. *Spacefaring: The Human Dimension*, University of California Press, Berkeley, CA, 2001.

[7]Vakoch, D. A., (ed.). *On Orbit and Beyond: Psychological Perspectives on Human Spaceflight*, Springer-Verlag, Berlin, 2013.

[8]Ibid. 5.

[9]Ibid. 5, page 1153.

[10]Hearsey, C. M., and Pass, J., "The Astrosociological Paradigm: The Interplay between Ecologies and Environments." *Proceedings of the 50th AIAA Aerospace Sciences Meeting*, 09 – 12 January 2012, Nashville, Tennessee. ARI Virtual Library: http://www.astrosociology.org/Library/PDF/Space2011--EcologiesAndEnvironments.pdf. [Cited 02 August, 2015].

[11]Durão, M. J., "Embodied Space: A Sensorial Approach to Spatial Experience," CP1103, Space, Propulsion & Energy Sciences International Forum (SPESIF-2009), edited by G. A. Robertson, 2009, p.402, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/Durao_SPESIF2009.pdf [Cited 09 August, 2015].

[12]Dudley-Rowley, M., *The Mir Crew Safety Record: Implications for Space Colonization*, *Space 2006 Conference & Exposition*, AIAA 2006-7489, 2006, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/MIR%20Safety%20Record.pdf [Cited 08 August 2015].

[13]Kanas, N., Salnitskiy, V., Grund, E. M., Weiss, D. S., Gushin, V., Kozerenko, O., Sled, A., and Marmar, C. R., "Human Interactions in Space: Results from Shuttle/Mir, *Acta Astronautica*, Volume 49, Number 3-10, 2001, pp. 243-260.

[14]Space Studies Board, *Human Factors in Long-Duration Spaceflight*, National Academies Press, Washington, D.C., 1972.

[15]Durkheim, E., *The Division of Labor in Society*, The Free Press, New York, 1893 (1964).

[16]Pass, J., "Deviance in Space Habitats: A Preliminary Look at Health and Safety Violations," *Physics Procedia*, Volume 20, 2011, pp. 353-368, p. 361, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/SPESIF2011--Deviance-in-Space-Habitats.pdf [cited 10 August, 2015].

[17]Kotarba, J., "Social Control Function of Holistic Health Care in Bureaucratic Settings: The Case of Space Medicine." *Journal of Health and Social Behavior*, 24 (September), 1983, pp. 275-288.

[18]Pass, J., "Space Medicine: Medical Astrosociology in the Sickbay," *AIAA 46th Annual Aerospace Sciences Meeting and Exhibit*, AIAA 2008-1465, 2008, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/ASM2008_MedicalAstrosociology.pdf [cited 08 August 2015].

[19]Pass, J., "Medical Astrosociology: Ethical Dilemmas in Space Environments," AIAA Space 2009 Conference & Exposition, AIAA 2009-6539, 2009, ARI Virtual Library: http://www.astrosociology.org/Library/PDF/Pass_EthicalDilemmas.pdf

[20]Manis, J. G., "The Concept of Social Problems: Vox Populi and Sociological Analysis," *Social Problems*, Volume 21, Issue 3, 1974.

[21]Kendall, D., *Social Problems in a Diverse Society* (4th edition), Pearson, Boston, 2007, p. 4.

[22]Crone, J., *How Can We Solve Our Social Problems*," Pine Forge Press, Thousand Oaks, CA, 2007.
[23]Ibid. 16.
[24]Pass, J., and Harrison, A. A., "Astrosociology: Outer Space, the Convergence of the Social Sciences, And Beyond," chapter in *Handbook of Science and Technology Convergence*, edited by Bainbridge, W. S., and Roco, M. C., Springer Science + Bussiness Media, New York (to be published in 2016).
[25]Pass, J., "Educating Astrosociologists: The Need to Bring Outer Space Into Social Science Classrooms," *Pacific Sociological Association (PSA) Conference*, Oakland, CA, 2007, ARI Library: http://www.astrosociology.org/Library/PDF/PSA2007 _Educating%20Astrosociologists.pdf [Cited 05 August 2015].