MANNED MISSIONS, GEOENGINEERING AND PLANETARY PROTECTION – HOW SAFE IS SAFE ENOUGH? E. Persson[1], [1]Lund University (The Pufendorf Institute of Advanced Studies, P.O. Box 117, 221 00 Lund Sweden, erik.persson@fil.lu.se).

Introduction: Sterilisation of landers, rover and other equipment sent to another world (planet or moon) can never be perfect. A sterilization process that would guarantee to kill off all life would also destroy the equipment. This is (for obvious reasons) true to an even larger extent for human astronauts. This means that if and when human astronauts eventually set their foot on potentially habitable worlds such as Mars, we have to acknowledge that if this world is habitable for earth microbes, it will be contaminated. If we ever decide to start geoengineering another world, and maybe even terraform a world that is not presently habitable for humans, it also highly probable that it will become less habigtable for any indigenous life. Making sure, or at least trying to determine the probability that a potentially habitable world is in fact uninhabited will thus be an important step before we start any geoengineering on that world, and possibly even before we let humans land there in the first place.

The questions that will be at the center of the discussion are:

* How sure do we need to be that the world in question is uninhabited before it is OK to perform certain things on that world?

* How do we connect degree of certainty to actual research setup?

* How do we balance the need for scientific certainty with the need to get on with the exploration or exploitation within reasonable time?

How certain can we be and how certain do we need to be?: Establishing that a world is uninhabited is a different kind of task than showing that it is inhabited. They might sound like just opposite sides of the same coin but they are actually from a science point of view, very different. The latter task can be accomplished through one positive finding while it is not entirely clear what it takes to accomplish the former. In my presentation I will suggest that to establish that a planet is uninhabited cannot be done in the same way as establishing that it is inhabited. It will not be a matter of one amazing discovery but of successively updating the probability. In order to give green light for different kinds of activities on the world in light of this we therefore need to answer to separate questions:

* How can we determine the probability that a world is uninhabited?

* How certain do we need to be in order to give green light for different types of activities?

There is no strictly objective way of answering the second question. It is a decision we have to make based on our plans for the world in question, which in turn include science objectives, possible commercial plans and also ethical considerations.

The first question is about thow to connect degree of certainty with research setup. This is the question I will focus mostly on in my presentation. I will suggest that in this particular case, the degree of certainty that a world is uninhabited has to be decided by three factors: The number, diversity and quality of negative observations. These three factors can be measured or at least ordered with respect to certainty in a fairly objective way.

Being in time versus being right: A complicating factor is that practical decision making usually involves a time constraint. This is also true for decisions regarding exploration and even more so for decisions regarding exploitation of other worlds. This can lead to demands that we settle with a lower degree of certainty in order not to delay the missions. On the other hand, it is also very important to consider the safety of both extraterrestrial life and earth life. These obligations demand a higher degree of certainty. How can the conflict between safety and timing be dealt with in a constructive way? First of all, the fact that there is a time constraint means that we cannot postpone the answer indefinitely. If we did, it would mean one of two things. Either a death sentence to all exploration and exploitation plans of other worlds, or a carte blanche for any kind of activity on other worlds as long as no one has positively shown that it is inhabited. Both alternatives seem unrealistic.

The values (scientific, commercial or other) that can be obtained from exploration or exploitation provide us with a duty not to postpone our judgment on whether the world in question is uninhabited for too long. On the other hand, it seems equally clear that our duties to protect the life on another world as well as on our own world are at least as strong and they tell us not to be too premature in our decision.

A Bayesian approach to determining and improving certainty: There is no objectively true answer for how to handle this dilemma. Eventually it comes down to values and the values need to be discussed by experts as well as laypeople. It is, however, also important that the discussionis are scientifically well informed. One thing we can do to help achieve this is to set the stage right for the value discussion by trying to put a number on how certaim we are that the world in question is uninhabited given what we know now and what we can do in terms of concrete sciene missions, to

improve that certainty. Establishing the probability that a world is inhabited cannot be done in the traditional way by using relative frequency as a proxy for probability. If we perform 100 experiments on Mars designed to look for life and one of them provides a reliable unequivocal positive result, it does not mean that there is a one in houndred chance that Mars is inhabited, it means that Mars is inhabited. If we get zero positive results, it does not necessarily mean that Mars is uninhabited. It can just as well mean that we have not yet looked in the right place in the right way. We therefore need a way of translating exclusively negative results into a probability. This is not an easy task, but since it is important and since there will be discussions regarding how certain we are when it is time to decide how certain we need to be, it is still important to get started with this work. In order to get started I want to make two suggestions: 1. We need to base our estimates on the three factors mentioned above (the number, quality and diversity of experiments), and 2. We need a Bayesian rather than a reative frequency approach to estimating the probability, where each new failed attempt to find life leads us to update the probability based on the fact that it is one more failed test, on the quality of the test, and on whether it tests something different or in a different way than previous failed tests. I believe that if we can agree on this we have achieved something important and are at least off to a good start.

A constructive and well-informed discussion about what it takes to establish that a world is uninhabited as well as some idea about how to do it in practice, needs to be initiated as soon as possible in order to prepare for our future in space. The main purpose of this presentation is to set the stage for that discussion.