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PROBE INTERFACE DESIGN CONSIDERATION

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The subject of my talk is "Probe Interface Design Considerations," a rather nebulous subject. Before I get into the subject, I would like to discuss some of the soul searching that I went through in coming up with this presentation. I think maybe I handled it the right way. Of course, when one first thinks about the interfaces between a probe and a spacecraft, the immediate thing that comes to mind is the technical considerations that are involved. I have done considerable work in both probe design and interfacing of probes to spacecraft; my original approach to this presentation dealt with the technical aspect of the interface. After some initial work on the subject, I realized that my approach was altogether wrong. At that point, I sat back and reflected on some of the designs with which I have been involved over the past ten years. My thoughts went back to the early Mariner design, which some of you in the room may remember, at that time we were designing probes of the Discoverer shape for entry into an 80 milibar Mars atmosphere; I thought of many subsequent designs and up through the current designs we have done where we have looked most recently at the interfacing of this Ames probe to a Mariner Spacecraft. In the process of this historical thinking, I isolated what I think are three aspects of that interface design which are worth talking about today.

- Management
- Mission
- Technical

Those three aspects are: first, the management interface; secondly, the mission design interface which I feel, on this particular mission, the outer planet missions, will be more difficult than anything we have ever dealt with previously; and finally, some of the technical considerations which we have heard about today. I will talk in general about those as we move on.

Let me now address the management considerations.

- o Center Responsibility
- o Science Inputs

Two of the most significant considerations are, first of all, the center responsibility. We have designed missions where we have had both the responsibility for the project, the probe and the spacecraft assumed to be at one center; we have also designed missions where the responsibility for the project and the responsibility for the probe is at one center while the responsibility for the spacecraft is at another center. The distribution of these responsibilities is going to be a major influence in the way we go about designing the interface and handling the technical considerations. It is important that before we progress too far into the technical design decisions, that we are sure we understand the management relationship between the participating centers.

The other point, of course, which will be important is how we organize to get the science inputs into the design.

I think that the current MJU Science Advisory Committee which is chaired by Dr. Van Allen has been very influential in our technical thinking. And when we move into a project, it is going to be of paramount importance that we continue this type of activtiy and that we maintain a good working relationship between the scientific community and the actual technical implementation of the project.

I reflected a little bit on Dr. Rasool's comment earlier today when he attributed the high success rate of the planetary exploration to the fact that we do have such a closeknit interaction between the science and the engineering aspects of a project.

I will now move on to the next subject, I would like to touch on some of the considerations of the mission design.

- o Organization
- o Flyby vs Probe
- o Relay Link Design

We have seen today some specific technical presentations which have shown some point designs for specific missions. I don't think that we have come anywhere near scratching the surface of the complexity of this mission design. I think that first we have to address ourselves properly to make sure that we do come up with a mission design team in a management sense, which is properly represented by both the people who are designing the spacecraft as well as the people who are designing the probe, and as well, a good way to get the science input into the design.

Two further aspects of importance are the flyby versus the probe trade-off and the relay link design.

If we look at the flyby versus the probe question, there has always been, and I am sure there is going to be even more, a difficult decision making process in determining whether the priority should be put into the probe mission or whether the priority should be put into the flyby mission. There is definitely going to be a conflict of interest in what those two mission designs are going to require. And from time to time we have attempted to say, "Well, why don't we just forget about the flyby mission because we are doing other flyby missions and minimize the flyby requirements and optimize the probe mission." Now that may be the easier way out but I don't think it will yield, necessarily, the overall optimum design or the most return for the investment. The most return for the investment is going to be a design which is optimized and adequately considers inputs on both of those two, what I look at as conflicting flyby geometry.

The relay link design is another interesting consideration. At first blush we would tend to think that the relay link design is merely a communications design problem where we are looking at optimizing the parameters involved in the link design, which are the antenna geometry on the spacecraft, the antenna geometry on the capsule, the caracteristics of the range, range rate, range accelerations, and the look angles between the spacecraft and the bus. But that is really an oversimplification of what is actually involved. I think a few of the papers today touched on bits and pieces of that. In particular, I draw your attention to the presentation that was made by Mr. Hyde where he showed flight time as a function of flyby altitude at the planet versus injected weight. Well, that ties immediately into some considerations that were shown previously where we were trying to optimize the relay link geometry for a certain flyby altitude. It now becomes apparent that the relay link flyby altitude is really tied into the flight time as well as to the injected mass and when we consider two-planet flyby mission, then the flyby altitude at the first planet is going to determine what we can do at the second planet. So what was originally just a simple consideration of the link design has some overriding considerations in not only the launch vehicle capability and the flight time but also the subsequent planet mission performance capability.

I think that this interaction is going to be much more than what we have seen on any previous mission. The Viking mission has a rather interactive mission, spacecraft, capsule aspect, but I don't think it is anywhere near as complicated as what we are looking at here.

Moving on to some considerations relative to the technical design, which by no means is the simplist, but I feel possibly one which we have done enough work that we at least understand what are the real problems.

- Relay
- Data Handling
- Power
- Thermal Control
- Guidance and Control

The relay is going to be one of the overriding considerations in this spacecraft probe interface.

One of the things that we have been discussing in this Mariner-Jupiter mission with Ames is how the responsibility of that design should be divided among the participating centers. At first glance, it would seem that possibly the simplest thing to do would be to have one center provide all of the equipment that is on the probe and the other center all of the equipment that is on the spacecraft.

Well, if you pursue that line of discussion a little further, it turns out that the interaction between the receiver and the transmitter is such that both of those pieces of equipment should be designed and supplied by one center, and that the interaction between the antenna and the spacecraft is such that the antenna should be an integral design of the spacecraft. You then come out with a distribution of hardware which is not what your initial intuition might make you feel is the right thing to do. But in overall sense, it may be the better way to implement that design. I am not suggestiong that this is the proper solution, but only that the solution is tied tightly to the management arrangement of which I spoke earlier.

Data handling: This topic has been touched on by several of the previous speakers. We have looked at this problem in a general sense and feel that the ability on board the spacecraft to handle the data that the probe generates is going to be rather straight

forward compared to the kinds of data handling that we are used to doing on the current Mariner class spacecraft.

Power: This interface is one that is rather interesting because on one hand we look at minimizing the overall cost of the project and say, "Well, the way to do that is to use as much of the equipment that is on board the spacecraft to service the probe." That is, for example, to have the capability to do the battery charging on the spacecraft as opposed to on the capsule. While such arrangement could be made, it isn't necessarily obvious that it is the best arrangement in an overall sense because we have turned around and made a more complicated interface between the spacecraft and the probe. And we have also designed a probe which can't be, by itself, tested in terms of its capability to charge its own batteries until it meets up with a spacecraft, which puts us in an untenable position that there could be a fundamental design problem that doesn't get disclosed until later in the program; whereas if the battery charger were part of the probe system, then the interface between those two elements would be checked out earlier in the design. I cite that as a subtle example of the kinds of technical problems that we can get into if we don't understand these things that I talked about previously.

Thermal Control: This is going to be another interesting design interface because the probe is going to have to be considered a major part of the spacecraft in the overall thermal design of the spacecraft. It won't be a simple appendage that is not going to interact with the spacecraft design. And I really don't have a good feel for the exact way in which that problem is going to be handled. We have had several discussions on this. And other than saying we see it as an area that is going to require significant attention early in the design, I don't feel that we have given this one as much attention as it deserves.

Guidance and Control: We have looked at this interface and it appears to be rather straightforward, particularly in our ability to satisfy the probe requirements on the delivery accuracy, zero entry angle of attack and spinning the probe on the spacecraft. We have looked at specific designs where, as far as the probe is concerned, the interface to Mariner is identical to Pioneer.

In summary, I would like to say that in having thought through these considerations, that they are much farther reaching than the simple technical interface but that I believe that a continual cooperative effort between the science and engineering aspects of the design, in addition to the proper management attention early, is going to make this a certainly doable interface design.