OUTER PLANET MISSION ANALYSIS OVERVIEW

MR. SWENSON: I think we have seen enough of programmatic strategy but before we go into a description of the missions, there are a few things we have to understand, particularly with regard to flying probe missions off the Pioneer spacecraft.

Pioneer is an earth-line stabilized spacecraft, and this presents some unique problems. The schematic for the deflection is shown on the right-hand side of Figure 3-1. At some distance as we approach the planet, we separate the probe, which is spinning in the earth-line direction. After probe separation we deflect the bus in order to miss the planet. The whole idea behind the deflection maneuver is to deflect the bus in such a way as to place it appropriately behind the probe so that the communication angle, the bus aspect angle, is in the aft hemisphere of the spacecraft and, at the same time, the probe aspect angle, after the probe enters and is descending vertically in the atmosphere, is very small.

However, with the Pioneer, we have the constraints that no orientations off the earth line will be permitted, but we will allow perpendicular and/or earth line maneuver capability. We are assuming a very simple probe without any attitude control systems and, therefore, orientations off the earth line are not permitted.

Now with those constraints in mind, the Uranus mission appears as shown in Figure 3-2.

This is a Uranus probe mission flown on a 1980 JU trajectory which is really no longer in consideration programmatically, but it is representative of the type of planetary approach. We approach from nearly right onto the North pole. With the Pioneer spacecraft, we try to swing by on the retrograde side. A Mariner 79 JU would flyby on the posigrade side.

DEFLECTION CONSTRAINTS

- PIONEER BUS
  ORIENTATIONS OFF EARTH-LINE NOT PERMITTED

  PERPENDICULAR AND/OR ALONG EARTH-LINE MANEUVER CAPABILITY

- PROBE
  ORIENTATIONS OFF EARTH-LINE NOT PERMITTED

DEFLECTION SCHEMATIC

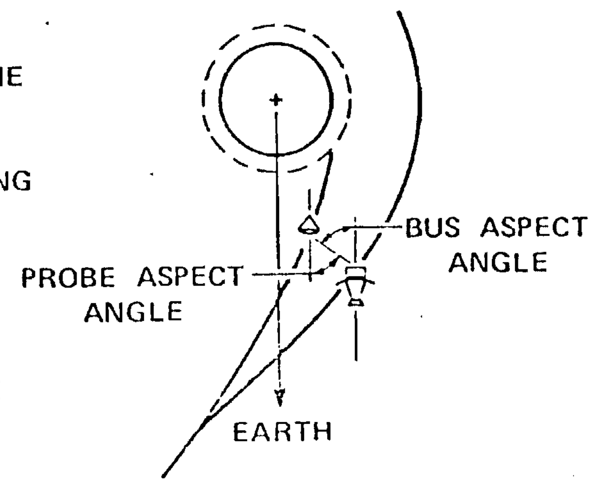

Figure 3-1

URANUS PROBE
1980 J/U

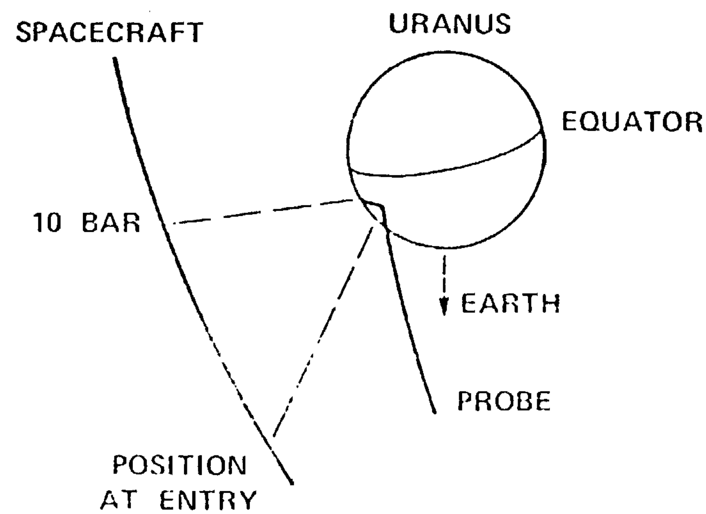

Figure 3-2

SWENSON

The reason the Pioneer flyby is on the retrograde side is to provide a nearly zero angle of attack at entry. The probe hits the atmosphere and descends and is turned by the rotation of the planet during this time. During this descent period, we try to maintain appropriate communication angles.

The spacecraft is pointing toward the Earth, and as shown, the spacecraft is nearly overhead of the probe through the entire descent.

The Saturn mission, shown on Figure 3-3, is for a 1981 dedicated mission. Some thirty days prior to encounter with the planet, we separate the probe. We deflect the spacecraft with a ΔV of about 75 meters per second; when the probe enters, the spacecraft is at the location shown on the figure at the time of entry. (Please excuse the artistic license on the figure, the spacecraft isn't quite that far around at the end of the probe mission.)

Again, the communication angles are fairly common, and the spacecraft is directly overhead of the probe during the entire descent.

The Titan mission is a little bit different. Over on the left-hand side of the Figure 3-4 you see Saturn and Titan's orbit at about 20 Saturn radii. The type of intercept that is attractive is an incoming intercept.

Some thirty days prior to encounter with Titan, we separate the probe. After spacecraft deflection, the probe and the spacecraft travel nearly parallel trajectories.

Over on the right hand side of the figure you see a blowup of the area of Titan.

At entry, we position the spacecraft so that we are about a hundred thousand kilometers away. And, then, you can see that at four hours after the entry we are occulted by Titan and we get a RF occultation experiment at the same time.

SATURN PROBE
1981

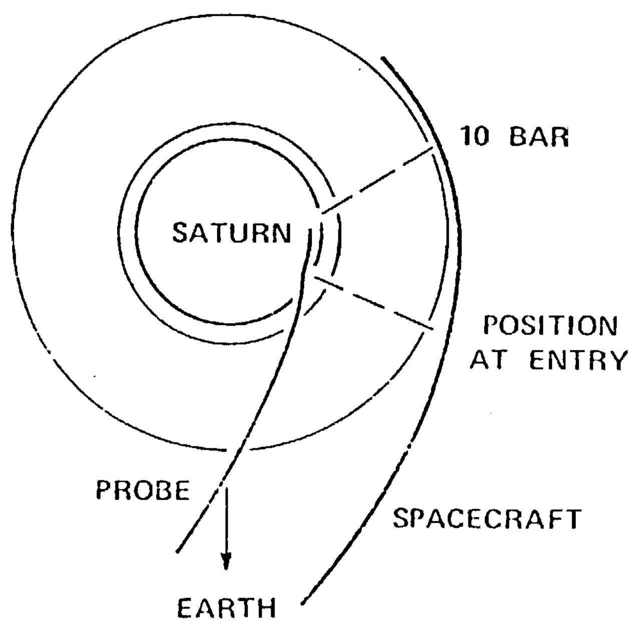

Figure 3-3

SWENSON

TITAN PROBE
1982

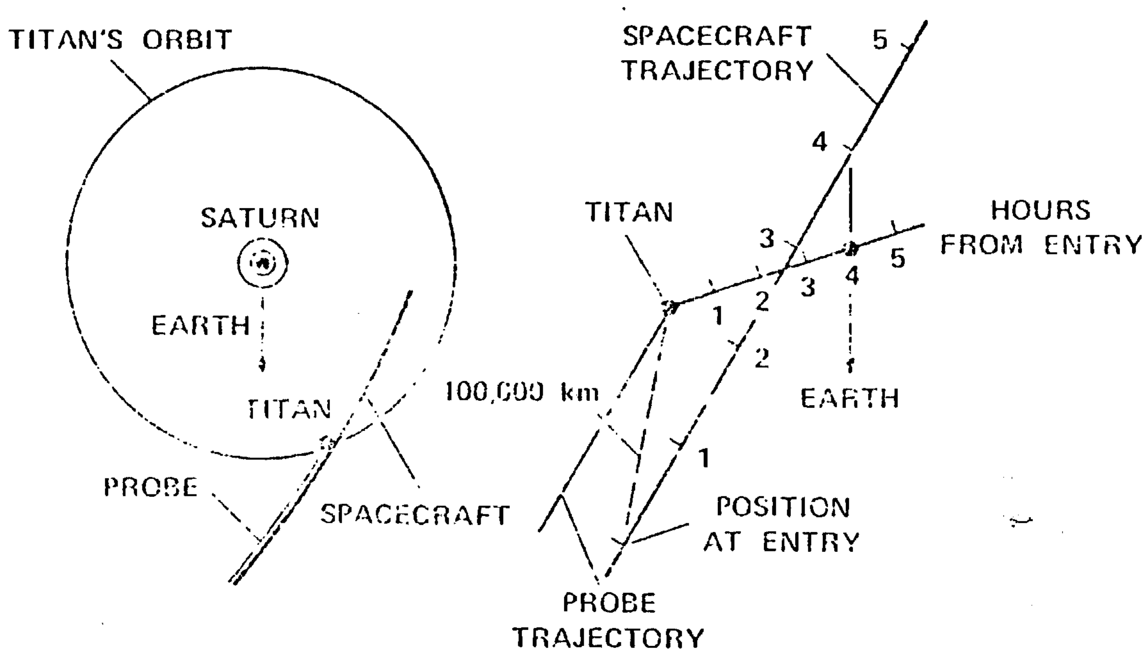

Figure 3-4

The Jupiter probe is shown on Figure 3-5. We have heard a lot about the ephemeris improvement due to Pioneer 10. What it means to us is that the one sigma ephemeris error is now approximately 468 kilometers. What this means, translated into a three sigma entry angle error is that we can now expect to enter very shallow with very small errors. In fact, for entry angles around seven or seven and a half degrees, the three sigma entry angle error is less than half a degree. That means we can be assured within three sigma that we will enter no steeper than eight and no shallower than about seven. This means that the heating is greatly reduced, the accelerations are likewise greatly reduced, and if the atmosphere is as friendly as we now think, we will be able to get in with a lot of less heating.

The conclusions to all the mission analysis work can be put into three main categories as shown on Figure 3-6. We have plenty of launch capability for the Saturn and the Jupiter-Uranus trajectories that we have looked at for Pioneer. We have 480 kilograms with a ten-day launch window off of a Titan/Centaur/TE 364.

In the Jupiter case, we have capability up to about eleven hundred kilograms.

In all cases, the probe separation occurs about 30 days out, with the exception of Jupiter where we separate about 50 days out. And in all cases, the ΔV to deflect the spacecraft is less than eighty meters per second.

The entry angle of attack for the probe is always low, less than twenty degrees.

In the communications area, the range is always less than a hundred thousand kilometers. The probe aspect angles can be made to be very low and the spacecraft aspect angles are common to all

PIONEER JUPITER
1980

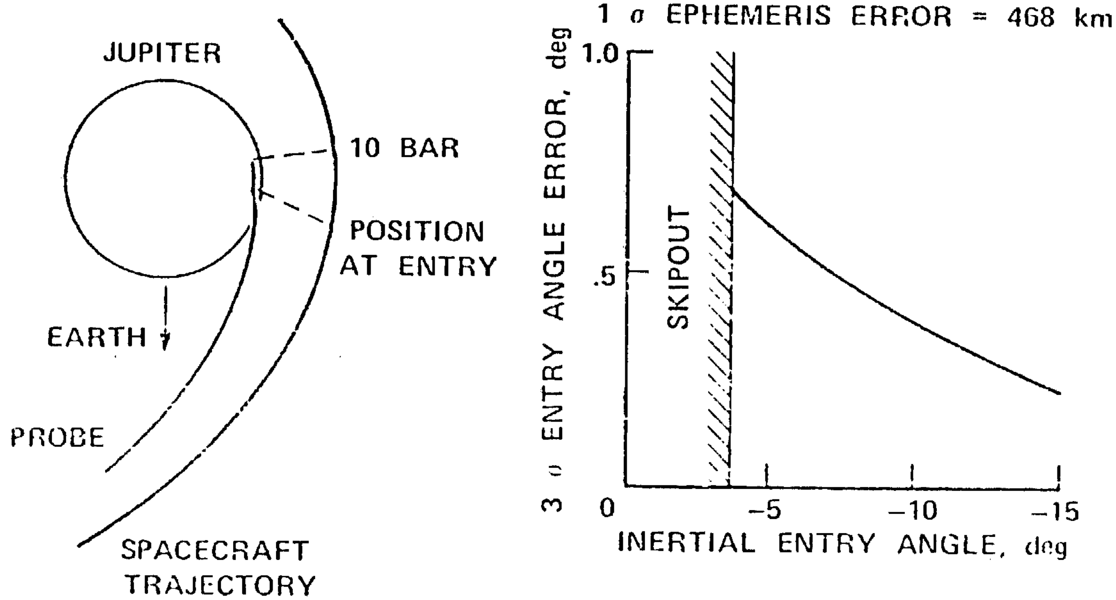

Figure 3-5

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CONCLUSIONS

- LAUNCH CAPABILITY
  480 kg 10-DAY WINDOW
  TITAN III E / CENTAUR / TE 364-4

- PROBE DELIVERY
  SEPARATION 30 DAYS OUT
  $\Delta V \sim 80$ m/sec
  ENTRY ANGLE OF ATTACK LOW

- RELAY COMMUNICATIONS
  RANGE ~ 100,000 km
  PROBE ASPECT ANGLE LOW
  SPACECRAFT ASPECT ANGLES COMMON

Figure 3-6

of the missions we have considered. That is, they all lie in the aft hemisphere of the spacecraft.

With that as a backdrop of a description of the missions, the next speaker, Lou Friedman, of JPL, will discuss taking these missions and determining what the guidance and navigation requirements are for the probe mission.