

## PROBE DESIGN

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MR. W. COWAN: We have been wrestling now for some months with ARC on the problem of outer planet probe designs. And we have come to some feelings and convictions, as we have gone through this process about these outer planet probes. One of these is that the technology today will support these early missions (c.f. Figure 4-31).

We also feel that there is a high degree of commonality across these missions. This doesn't necessarily mean the commonality of absolute identity, but a commonality which really leads to the cost-reduction we have been seeking; one which allows you to take the technology that you have and apply it. This kind of commonality keeps the cost down because you minimize the money spent on new developments.

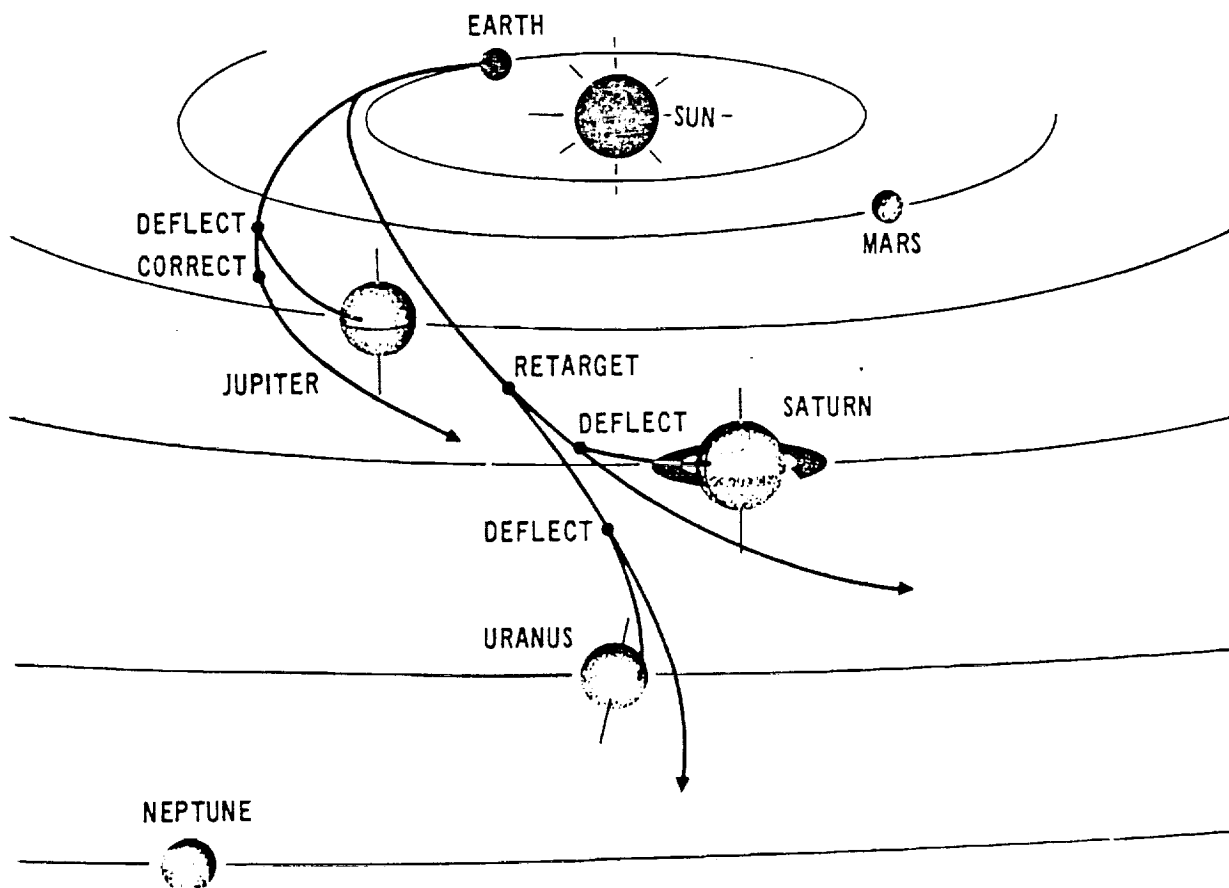


Figure 4-31. Mission Characteristics

And, more recently, because of the confidence that has come from the Pioneer 10 data, we are getting a conviction that an early mission to Jupiter is feasible with what we know today and the materials that we have available.

I would like to take just a few minutes to identify the highlights of this design that has been studied for almost two years. It is a probe design that started out being studied for Saturn-Uranus application; the probe is 35 inches in diameter; it varies in weight from 200 pounds to 350 pounds, depending on the size of the heat shield that is on it, the planet to which it is going and whether it does or does not have planetary quarantine. Basically, it is the same probe used across the several missions that we have looked at for Saturn, Uranus, and/or Jupiter.

Figure 4-32 presents the features of the design. The aft end of the probe has a hemispherical yeast shield after body and proceeding forward we have the equipment cover with its microstrip flat plate antenna, the 66 degree antenna that was described earlier and will be discussed some more tomorrow. The principal feature of the probe design is that everything is packaged far forward. So the CG is far forward, and the probe is then inherently stable, and does not require a parachute or any other separating parts and pieces. This feature supports the goal of achieving the maximum reliability, minimizing complexity, and cost.

The probe was designed as a ten bar probe, however, this vehicle is capable of reaching the 30 bar level or below for Jupiter. I would like to show you one other central feature of this design which Howard Myers talked about this morning and that is the mass spectrometer, which is a central element in the whole probe. The mass spectrometer was designed for a 500 cubic inch volume analyzer section, either quadropole or magnetic deflection and it has an extendable inlet mechanism. The data handling portions of the mass spectrometer are located within it.

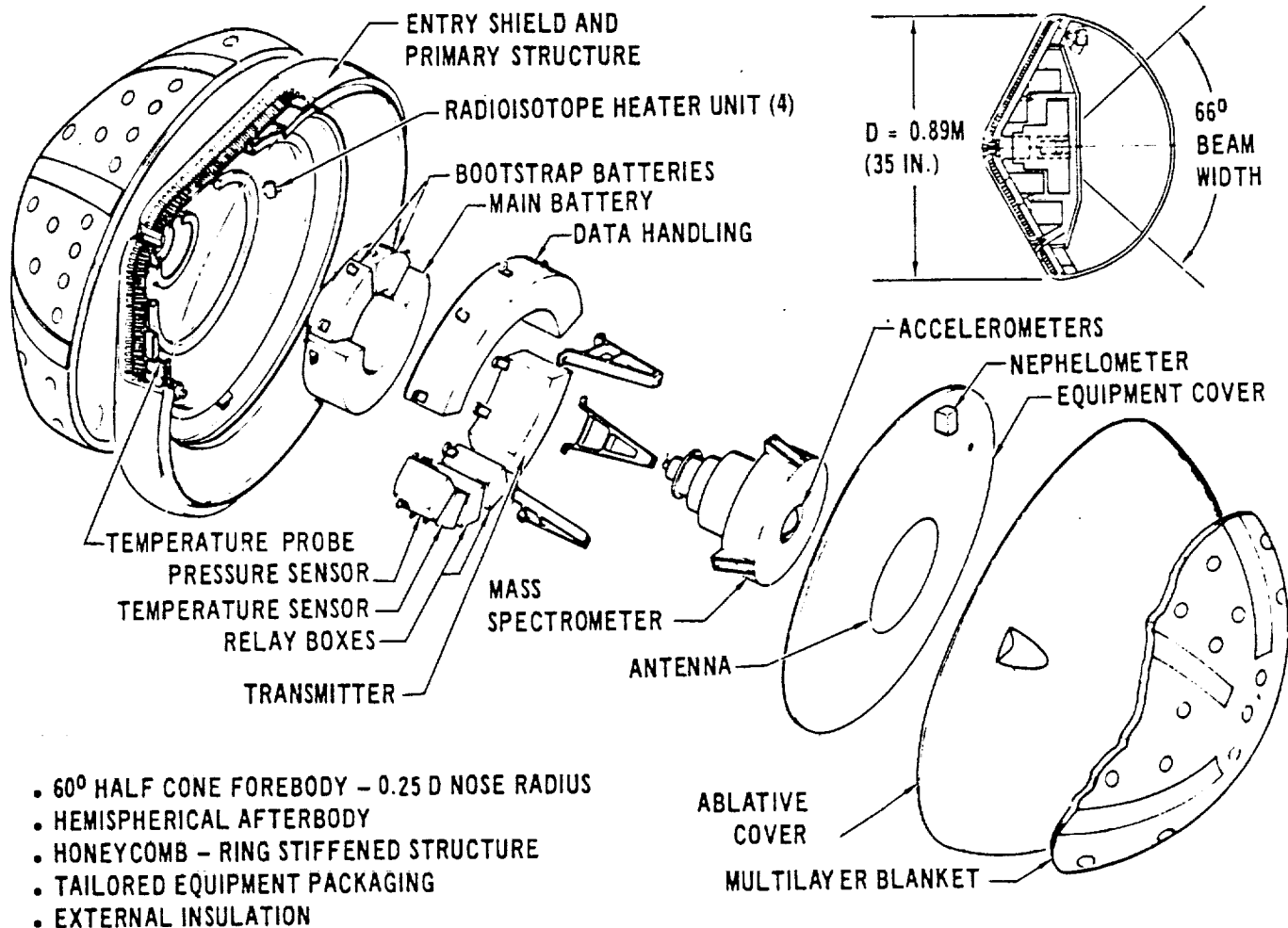


Figure 4-32. Probe Configuration

The probe has an aluminum ring frame structure, a fiberglass honeycomb, a carbon phenolic heat shield, and were all designed around the mass spectrometer as a central structural element. You will notice the accelerometer is mounted inside the mass spectrometer instrument package; placing it on the CG. The batteries are toroidal, trapezoidal batteries. These data handling segments are shown. Throughout the entire flight profile, the CG remains forward.

You will see some pictures in Bill Kessler's presentation tomorrow of the vehicle flying in the ballistics range here at

Ames, and he will have some other data on that and can answer other questions.

The usefulness of this probe, the value benefit of this probe, is related to its ability to do missions at planets; can it be carried by spacecraft that exist or are about to exist? The probe has been designed to be compatible in general either with Pioneer or with Mariner. As was pointed out earlier today, the delivery mode is one in which the spacecraft points the probe at the aim point and then deflects itself and continues with the mission. It also is a relay communication system. The spacecraft maintains Earth lock throughout the entire active portion of the mission and relays the data back. (cf. Figure 4-33)

We have options of swingby and retargeting, and the three principal planets we have looked at are shown on Figure 4-31. We have also taken a cursory look at several of the satellites, and have a small amount of data on Titan.

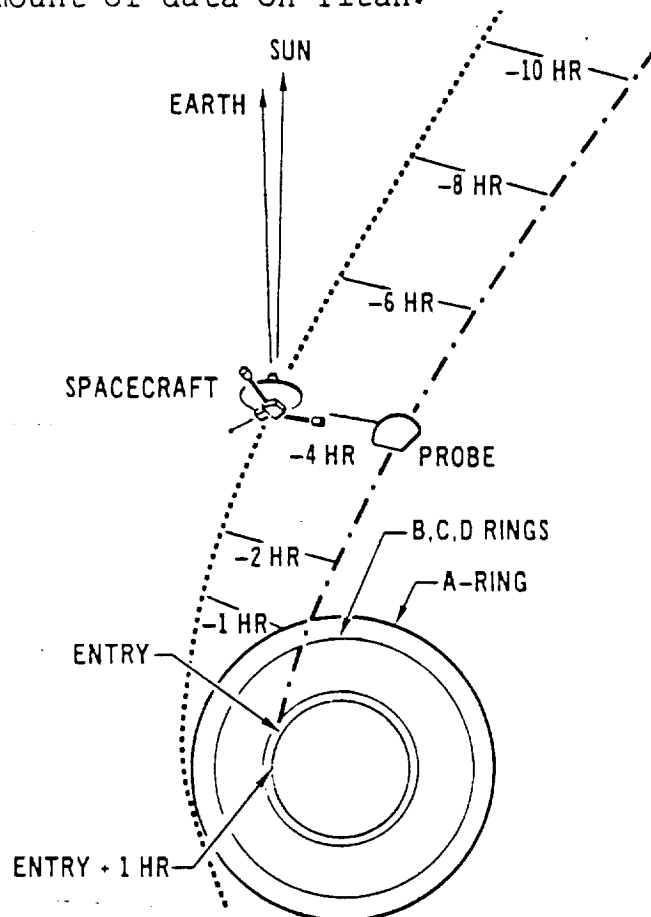


Figure 4-33. Planetary Arrival

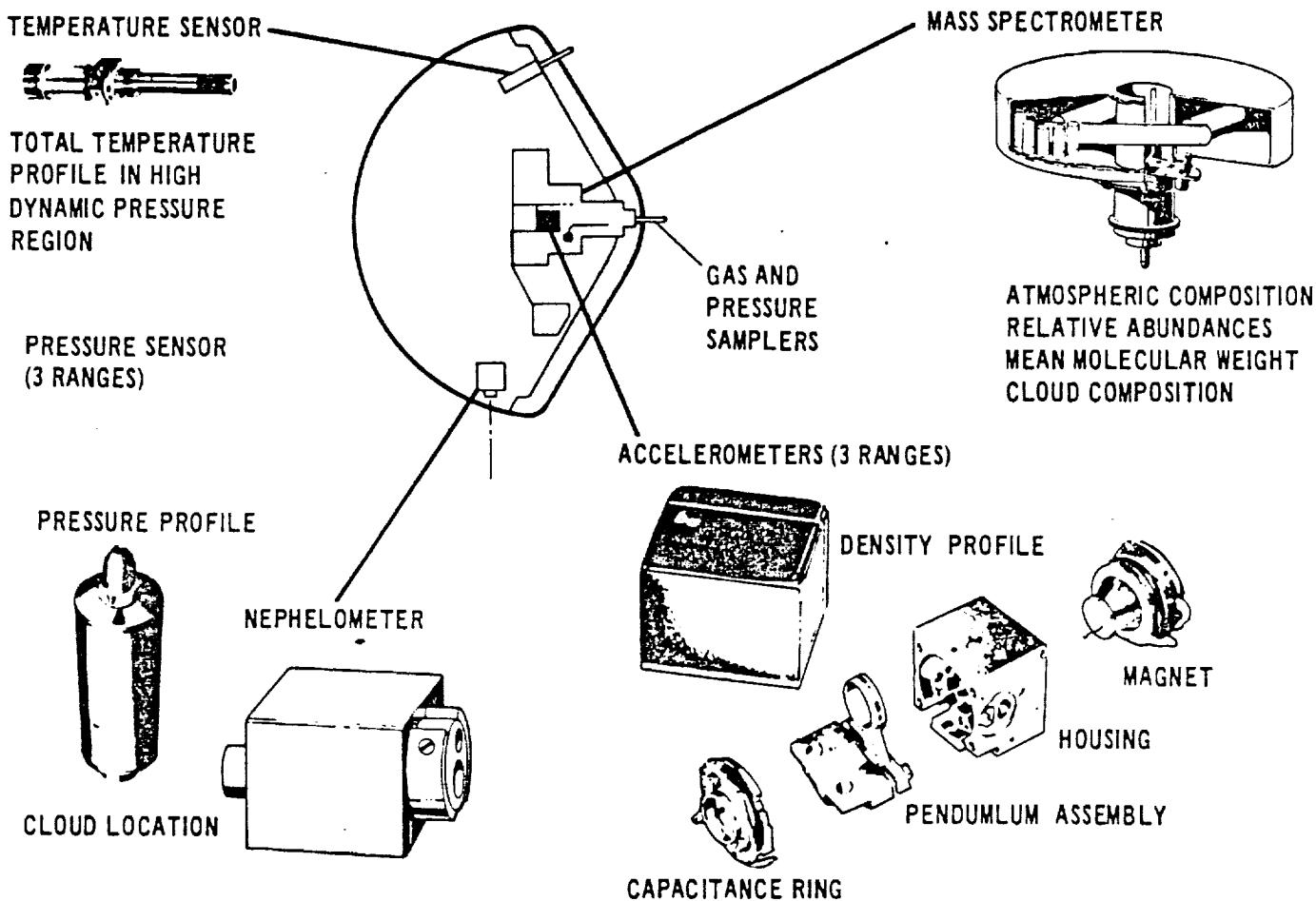


Figure 4-34. Science Payload

The instruments we have identified are shown on Figure 4-34. It is perhaps slightly more than a minimum package. A minimum package might be just the first three instruments, accelerometer, temperature, and pressure measurements; but as a basic package, if you add the mass spectrometer, the nephelometer and perhaps some other candidates, such as the IR radiometer or the gas chromatograph. There is some capability to put some other instruments on board, depending on the weight constraints that you would have. Shown on the figure is the basic package that was looked at. These instruments, either exist or are expected to exist, ready to go, without a lot of new development, by the time an outer planets probe is launched.

The active life for the probe is very short. It is passive throughout most of the mission. Carried on the spacecraft for most of the mission total time, it is released from three to seven weeks before planetary encounter depending to which planet you are going. It coasts along on its own; has a multilayer insulation blanket around it as shown on the exploded view. Shortly before it enters the sensible, high altitude atmosphere, it is activated, it then has an active period during the entry that could extend up to about an hour. As you saw from the phasing curves this morning, in an attempt to maximize the certainty of communications you try to maximize the relationship of the flyover geometrys, the choice of frequencies; and in terms of the constraints of the electronics. As Carl said this morning we are working with a 40-watt solid state transmitter. We did this deliberately because that represents a threshold in knowledge.

Now what else affects design? Certainly, the kind of environment that a probe is going to find itself in is a principal driving force. I have reflected this on Figure 4-35 in deceleration terms. I have reflected it principally for the three planets. These general comments also relate to the heating environment as well. The kind of variation you see on the figure is reflected in the heat shield thickness. Tomorrow there is going to be further discussion on the specific sizing of the heat shields, although I will show you a weight statement in just a few minutes. But notice that as the angles get steeper, as the atmospheres go from warm to more dense, and the boundaries shown represent the extremes of the NASA SP defined atmospheres, the extremes of the potential design conditions go up. The probe was designed originally for 800 G's, with a thousand G ultimate, for the Saturn-Uranus application. It was designed at a time when it was thought that the Uranus, and this was for a Pioneer case at that time, entry angle uncertainty might be as much as 15 degrees. Therefore, if you were to aim at a box in this area, you would

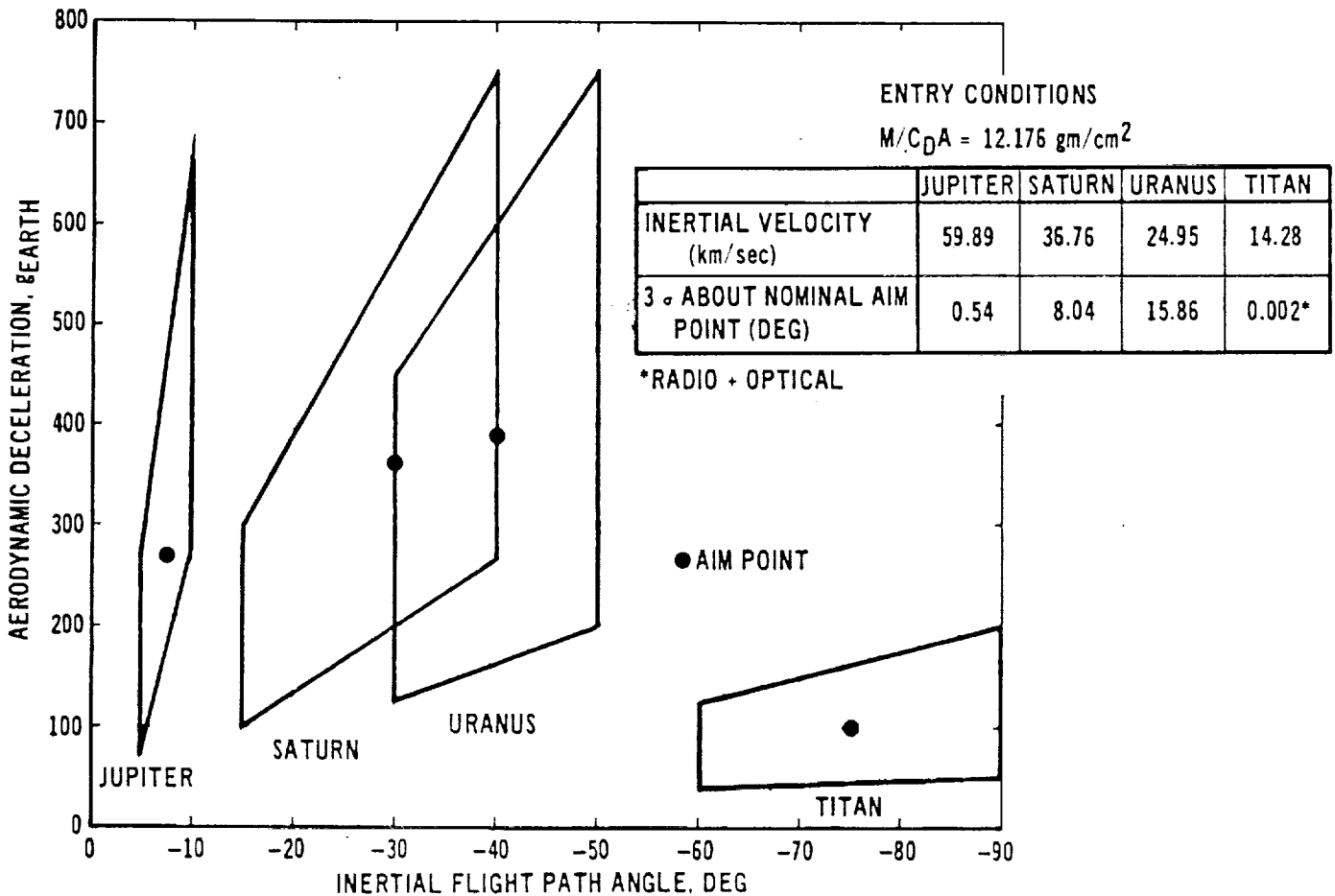


Figure 4-35. Entry Deceleration Envelopes

be just within the bands. There is always some dilemma here in terms of selection of design criteria so that you don't make them so overly conservative that you drive your design off scale and run your costs up, in a situation which implies a non-feasibility to do the task that can really be done.

So what we are seeing here is that as you are able to resolve your uncertainties in either atmosphere and/or the angle to which you can aim, then you can resolve uncertainties and your design margins can go up. This particular probe, is designed to the 800G level, and you see on the figure, from a G standpoint for flat entry angles near grazing at Jupiter, the G load problem essentially goes away.

Figure 4-36. Mass Properties

SUBSYSTEM	SATURN/URANUS WEIGHT (LB)	JUPITER WEIGHT (LB)
STRUCTURE	28.9	28.8
HEAT SHIELDS	81.6	182.0
HEATERS & INSULATION	15.3	15.3
COMMUNICATIONS & DATA HANDLING	21.1	21.1
ELECTRICAL POWER	20.0	20.4
PYROTECHNICS	8.2	8.2
SCIENCE PAYLOAD	24.2	24.2
INSTRUMENTATION	1.6	1.6
PLANETARY QUARANTINE	16.3	16.3
WEIGHT MARGIN (10%)	21.7	32.0
PROBE WEIGHT	238.9	349.9
LESS: BIOSHIELD	-11.6	-11.6
INTERFACE WIRING	-2.3	-2.3
EXTERNAL INSULATION	-5.9	-5.9
AT ENTRY	219.1	330.1
LESS: ABLATED MATERIAL	-19.0	-123.3
END OF MISSION	200.1	206.8
C.G. & INERTIAS AT ENTRY		
X AXIS C.G. (IN.)	8.62	7.96
I <sub>X</sub> (ROLL) (SLUG - FT <sup>2</sup> )	5.61	9.82
I <sub>Y</sub> (PITCH) (SLUG - FT <sup>2</sup> )	3.63	5.97
I <sub>Z</sub> (YAW) (SLUG - FT <sup>2</sup> )	3.52	5.86

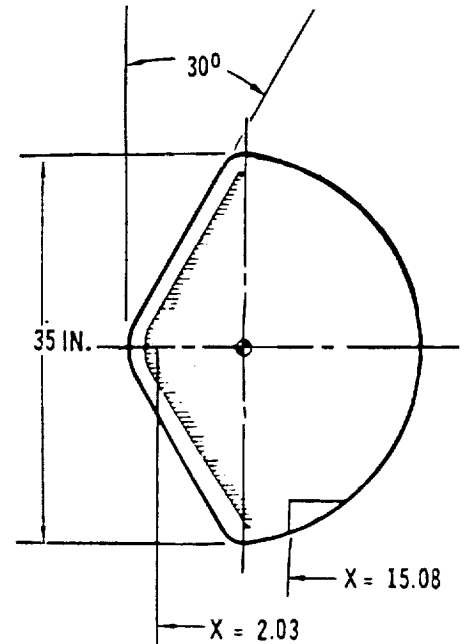


Figure 4-36 presents the weight story for Saturn-Uranus broken down by subsystem, leading to a total weight of around 250 pounds. And for a Jupiter probe at seven and a half degree entry, around 350 pounds. Both of these are with planetary quarantine.

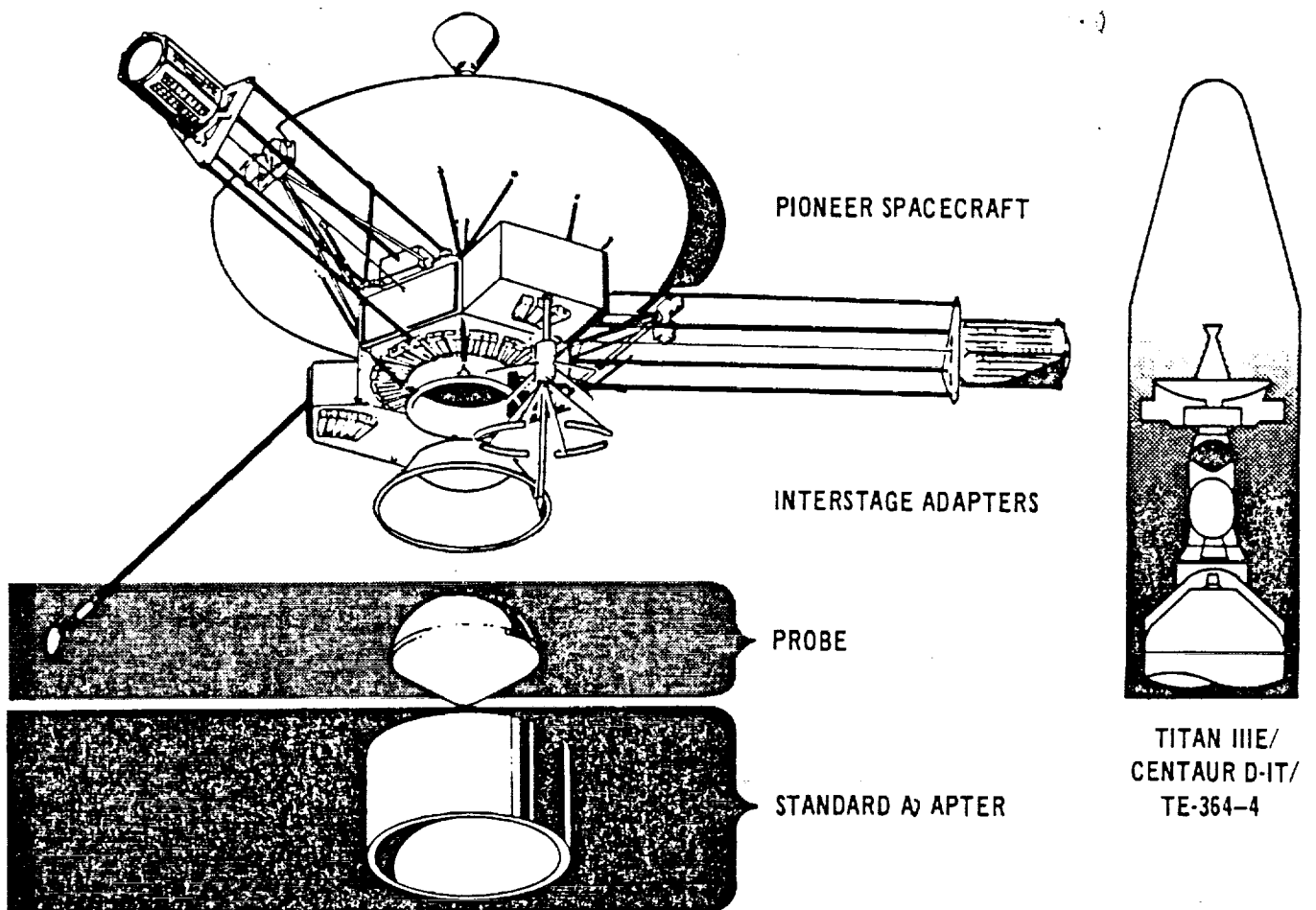
The essential difference between these two is in the heat shield weight. As Sam will show you tomorrow, the carbon phenolic heat shield thickness varies from approximately two inches for the Saturn-Uranus case to three inches for the Jupiter case.

As far as the probe is concerned for the Jupiter mission, there is no other change except a slight rounding of the aluminum



structure to provide for the extra carbon phenolic material as it rounds the corner. The probe itself is at the same external diameter. There are perhaps one or two small scale changes on the instruments. Fundamentally, the design is one that is common and almost has identity in most aspects and, therefore, costs and development and all can be minimized for this set of instruments.

Figure 4-37. Launch Vehicle and Spacecraft Interface



We have shown on Figure 4-37 for illustrative purposes the probe on a Pioneer spacecraft. I would like to reiterate that these early missions, although we see them going on Titan III Centaur, it is anticipated, as time goes on, the shuttle will become available and that there may be applicability of these

probes on these and similar spacecraft for those kinds of missions. But for the present, we are planning for the Titan launch vehicle and either the Mariner or the Pioneer spacecraft. Because the probe is essentially an autonomous, passive device, except for minimal transfer of electrical power during the coast phase and minimal attachment and heat interface support, it should then be compatible with either of the two spacecraft.

MR. CANNING: There was a question on spinning, and the answer was that the system is spinning at five RPM.