BELLCOMM, INC.

SUBJECT: Technical Discussions at Jet Propulsion Laboratory and Ames Research Center
Case 103-2

DATE: January 5, 1967

FROM: D. E. Cassidy
D. Macchia

ABSTRACT

Technical discussions were held at the Jet Propulsion Laboratory and Ames Research Center. The represenatives of Bellcomm were D. E. Cassidy and D. Macchia.

At JPL, discussions were held relating to the sterilization requirements and atmospheric entry heat shield weights for the probes being considered during the 1975 manned Mars flyby studies. JPL's calculation of the heat shield weight for an MSSR type vehicle compares favorably with the 15 to 20% of entry weight estimated at Bellcomm; although, they indicated it could be as high as 25% when all uncertainties are combined. Presently, JPL is not considering any sterile procedures for entry through a planetary probe bio-shield, nor are they enthusiastic about developing such procedures. They do feel, though, that by the early 1970's all probe subsystems will be capable of thermal sterilization.

Ames Research Center, Vehicle Environment Division, personnel are developing techniques for determining the properties of planetary atmospheres with the use of active entry probes and sensors. Upper atmospheric density can be obtained down to a velocity on the order of 10% of entry velocity using .1% accelerometers. At the lower velocity end of entry, direct sensing of pressure and temperature appears to offer a reasonable approach for determining free stream conditions. In addition, analysis of spectral emission from the high temperature plasma is being investigated as a tool for identifying atmospheric gas composition.

[redacted]

FORM 602 (ACC[redacted]NUMBER) 6 2A

N79-71777

(NASA-CR-153791) TECHNICAL DISCUSSION AT JET PROPULSION LABORATORY AND AMES RESEARCH CENTER (Bellcomm, Inc.) 5 p

Unclas
00/12 12394

[redacted]

BELLCOMM, INC.

SUBJECT: Technical Discussions at Jet Propulsion Laboratory and Ames Research Center
Case 103-2

DATE: January 5, 1967

FROM: D. E. Cassidy
D. Macchia

MEMORANDUM FOR FILE

Technical discussions were held at the Jet Propulsion Laboratory and Ames Research Center. The represenatives of Bellcomm were D. E. Cassidy and D. Macchia.

The purpose of the JPL discussions was to determine the implications of sterilization requirements on unmanned Mar's probes accompanying a manned flyby; and, to clarify questions relating to the heat protection and structural penalties associated with landing a payload on Mars from a direct approach at 32,000 fps. JPL was represented by E. Pounder, R. Thompson, and associates.

The purpose of the Ames visit was to discuss techniques being considered by Ames for determining the properties of planetary atmospheres. Ames was represented by A. Seiff, H. Larson, C. James, and associates.

HEAT SHIELD

Jet Propulsion Laboratory personnel did not have data available on the heat protection requirements for unmanned Mars entry probes at the high velocity (32,000 fps) and narrow entry corridor (between 10 and 20 nm) being considered for the 1975 manned Mars twilight flyby. They did agree, though, to run a check point with their heat shield sizing program for a vehicle similar to the MSSR. Part of these results were received at Bellcomm on December 12, 1966. Their conclusions were that the ablation plus insulation material, for the worst case atmosphere (VM-7), represents 9% and 11% of the entry weight for 500°F and 300°F back face temperatures, respectively. They indicated that an upper limit for these values, when all the uncertainties are combined, e.g., atmospheric composition, transport properties, and transport coupling, could be as high as 15%.

Their check of the entry shell support structural requirements, however, have not been determined, to date, due to their heavy work load. It is estimated that the structural fraction should be between 5% and 10%. Based on these values, the original estimates made at Bellcomm of between 15% and 20% for heat shield plus entry shell structural weight compare favorably; although, about 5% to 10% lighter than the worst case.

[redacted]

STERILIZATION REQUIREMENTS

Additional discussions at JPL centered on their opinions and studies of alternate operational procedures to meet the sterilization requirement for planetary entry probes. Particular topics included the current Voyager ground rules which do not allow sterile maintenance or parts replacement within the bio-shield or the transfer of sterile propellants through the bio-shield after terminal heat sterilization.

JPL is not considering the development of sterile procedures for entry through a probe bio-shield, although such procedures may well allow maintenance, parts replacement, or the insertion of sterile sub-assemblies which under current technology could not withstand the terminal heat sterilization. They are of the opinion that sterile entry is not feasible. Their argument is a statistical one; that is, sooner or later an accepted entry procedure introduces microrganisms. In the same statistical sense, one could argue for procedures which have a probability of contamination equal or lower than what is acceptable. (The authors note that a Voyager capsule is sterile only in the statistical sense, since there is no reasonable way to detect the presence of one microbe on a spacecraft).

JPL personnel also regard sterile subsystem insertion techniques to be unnecessary since current indications are that by the early 1970's all sub-assemblies will be capable of thermal heat sterilization. If this is so, the authors note that consideration should then be given to post maintenance heat sterilization of completely assembled probes on the launch pad or even during a manned mission.

Current Voyager plans call for the replacement of a sterilized probe by an identical probe at the launch site if any malfunctions are discovered. The authors questioned this philosophy for complex and physically large probes and suggested that perhaps sterile repair procedures should be developed simply because malfunctions are almost certain to occur and it will be difficult to replace the probe (i.e., there is a size and cost at which something is repaired rather than replaced). JPL suggested that the probes will be pretested sufficiently to insure that malfunctions do not occur after the final heat cycle.

JPL is not considering the possibility of transferring propellants into a probe after sterilization since such a procedure violates Voyager ground rules. Actually, Voyager propellant requirements are relatively small and none of the envisioned mission modes require high propellant fraction (low tank weight) propulsion systems. Thus, there has not been any real need for a re-examination of this ground rule. Their initial thoughts on the possibility of sterile transfer of propellants were pessimistic.

In summary JPL has concentrated its efforts on satisfying the Voyager ground rules and have not given much thought to any alternate procedures.

AMES RESEARCH CENTER

Alvin Seiff, Chief-Vehicle Environment Division, and associates are developing techniques for determining the properties of planetary atmospheres with the use of active entry probes and sensors. It is felt that the upper atmosphere density profile can be determined quite accurately with an on-board three-axis accelerometer. This technique is limited to the higher velocity portion of entry due to accelerometer bias errors. Utilizing .1% accelerometers and instrument scale changes, the practical limit of this technique would be down to a velocity on the order of 10% of the entry velocity. Below this velocity, a direct sensing technique is required. An additional difficulty in upper atmospheric density sensing is the determination of altitude and, therefore, flight path angle. For a nominal 90° entry angle, altitude errors are less sensitive to entry angle errors than at nominally shallow entry angles, but a very low ballistic parameter is required to provide sufficient slow down for data transmission following communication blackout. This problem could be alleviated somewhat on large probes entering at shallow angles where attitude sensing and rate control could be employed to resolve motion along the flight path to motion normal to the planet surface.

A direct sensing technique under consideration is presently restricted to the subsonic range of free stream velocity, although it could be extended into the low supersonic range. Pressure and temperature sensors on the vehicle surface plus accelerometer readings are used to determine free stream density, temperature, and velocity. This method generally requires post-flight simulation to correlate all measurements, including trajectory patching and atmospheric composition data. The technique was successfully demonstrated in the earth's atmosphere at 130,000 ft and Mach .9 with a 50° blunt cone entry shell.

Ames personnel believe that atmospheric composition can be determined by analyzing the radiative emission from the gases in the shock layer in front of the entry probe. They are basing the technique on the fundamental properties of gases to radiate in identifiable bands, lines, and continual characteristic of the particular gases involved. In the case of a nitrogen-carbon dioxide-argon atmosphere, a highly probable mixture for Mars, the CN molecule, for example, is a very prominent radiator in the 3500 - 3880 Å band. By choosing to "look" at this band, the recorded intensity (which is a function of flight conditions) can be used to determine the free stream mole fractions of nitrogen, carbon dioxide, and argon. By choosing additional bands, e.g., Swan C_2 system (4200 - 5200 Å), the uncertainties in gas identification are reduced.

Since discrete wavelengths are looked at, the problem of ablation products interference is reduced (assuming the spectral properties of the hot ablation products are defined). In addition, the sensing probe would be placed at the stagnation point where the least contamination from ablation exists.

There is some difficulty as to the number of possible gas mixtures and the amount of data (and, therefore, transmission bit rate) required to define the gas composition. Since only discrete wavelengths (bands and lines) can be recorded during the spectral scan, Ames personnel are attempting to identify characteristic radiators for other candidate gas mixtures in addition to the N_2 - CO_2 - A mixture just mentioned.

D. E. Cassidy

D. Macchia

1013-$\frac{DEC}{DM}$-csh

Copy to
Messrs. W. C. Beckwith - NASA/MTP
P. E. Culbertson - NASA/MTL
F. P. Dixon - NASA/MTY
E. Z. Gray - NASA/MT
M. Gruber - NASA/MTY
E. W. Hall - NASA/MTS
T. A. Keegan - NASA/MA-2
D. R. Lord - NASA/MTD
M. J. Raffensperger - NASA/MTE
A. D. Schnyer - NASA/MTV

G. M. Anderson
C. L. Davis
J. P. Downs
D. R. Hagner
P. L. Havenstein
W. C. Hittinger
B. T. Howard
D. B. James
H. S. London
K. E. Martersteck
R. K. McFarland
J. Z. Menard
I. D. Nehama
G. T. Orrok
I. M. Ross
T. H. Thompson
J. M. Tschirgi
R. L. Wagner
All Members, Division 101
Department 1023
Central Files
Library