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FOR R. J. FORD FROM L. S. NORMAN
SUBJECT: MOL ORBIT ALTITUDES

1. FOLLOWING INFORMATION IS FURNISHED REGARDING YOUR QUERY ON MOL ORBIT FLEXIBILITY, PARTICULARLY OPERATIONS AT LOW PERIGEE ALTITUDES. ALSO, WE ASSUME THAT YOU ARE COMPLETELY FAMILIAR WITH THE OPERATIONAL LIMITS EXPRESSED IN FIGURE 3-1 OF THE SEPTEMBER 1966 SP/DR (MOL). REFERENCE SHOULD ALSO BE MADE TO W. SAMPSON'S BRIEFING OF 16 NOV 1967 ON FILE IN YOUR OFFICE COVERING BASELINE AND NOMINAL ORBIT SELECTION, RANGE OF ORBIT CHANGES AT L-8 DAYS, AND ORBIT SUSTENANCE CONCEPTS.

2. OPERATIONS AT LOW PERIGEE, BUT WITHIN SP/DR LIMITS, FOR MANNED AND UNMANNED FLIGHTS, ARE CONSTRAINED ONLY BY THE MOUNT OF VELOCITY FOR ORBIT SUSTENANCE WHICH IS AVAILABLE USING THE ATTITUDE CONTROL AND TRANSLATION SYSTEM. PRESENT PROPELLANT BUDGET PROVIDES A TOTAL INCREMENT OF VELOCITY INCREASE OF 420 FPS WHICH PERMITS MAINTENANCE OF THE BASELINE 80-187 ORBIT AND A NUMBER OF OTHER ORBITS OF INTEREST WITH A MODERATE AMOUNT OF PERIGEE DRIFT. A CONSTRAINT IS THAT OF THE

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NEED FOR TRACKING THE VEHICLE AND UPDATING THE EPHEMERIS AFTER AN ORBIT ADJUST IS MADE SO THAT THE REQUIRED IN-TRACK NAVIGATIONAL ACCURACY CAN BE ACHIEVED. OPERATIONS PLANS ALLOW FOR THREE TRACKING STATION CONTACTS BETWEEN AN ORBIT ADJUST AND PAYLOAD OPERATIONS. THIS INTERVAL CAN BE REDUCED BY USE OF THE CREW TO REFINE POINTING ACCURACIES THROUGH USE OF THE ATS'S, AND BY TELEMETRY, HOWEVER, THE PREFERRED CONCEPT IS TO ADJUST THE ORBIT NO MORE THAN ONCE PER DAY, AT SUBCYCLE 12 OR 13. THE CURRENT FLIGHT VEHICLE TIME LINE IS BASED ON AN ORBIT ADJUST EVERY 3 DAYS. FOR COMPARISON PURPOSES WE HAVE RUN A PROFILE OF ORBIT SUSTENANCE PER DAY VERSUS PERIGEE ALTITUDE AS FOLLOWS: 80NM - 15 FPS/DAY, 75NM - 19.2 FPS/DAY, 70NM - 27.4 FPS/DAY, 65NM - 46.5 FPS/DAY, 60NM - 113.8 FPS/DAY. THIS PROFILE ASSUMES A 2-BURN ORBIT ADJUST TO RESTORE THE ORIGINAL ORBIT, INCLUDING PERIGEE LOCATION, ON A SELECTED REV EACH DAY. IT IS ALSO BASED UPON CALCU-

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LATED DRAG CHARACTERISTICS AND A PARTICULAR ATMOSPHERE/SOLAR ACTIVITY MODEL, THUS ARE TYPICAL RATHER THAN ABSOLUTE VALUES. IN DEVELOPING THESE FIGURES WE ASSUMED THAT AVERAGE Q WOULD BE HELD AT 16-2/15 FOR TARGET COVERAGE PURPOSES HENCE THE INITIAL APOGEE WAS INCREASED FOR EACH CASE AS PERIGEE DECREASED. IT SHOULD BE NOTED THAT PERIGEE ALTITUDES BELOW 70NM ARE OUTSIDE OF SP/DR LIMITS.

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3. FOR PLANNING PURPOSES ONE CAN USE THE RELATIONSHIP THAT AN ORBIT ADJUST OF ONE FPS AT APOGEE CHANGES PERIGEE ALTITUDE BY 0.56 MILES AND VICE VERSA. THUS, IF THE OPERATIONAL SITUATION PERMITS RELAXATION OF THE ORBIT NAVIGATION REQUIREMENT, IT IS QUITE FEASIBLE TO REDUCE THE PERIGEE ALTITUDE FOR A FEW ORBITS AND THEN RESTORE IT TO THE NORMAL ALTITUDE. FOR SOME CASES THIS METHOD SAVES FUEL.

4. THE SP/DR LIMIT ON MAXIMUM ALTITUDE OF APOGEE IS BASED ON THE ABILITY OF THE GEMINI B TO REENTER FROM ANY PLACE ON THE ORBIT. IF REENTRY IN DAYLIGHT ONLY RATHER THAN AT ANY TIME IS ASSUMED, THEN REENTRY WILL BE INITIATED NEAR PERIGEE, UNDER CONDITIONS ACCEPTABLE TO THE GEMINI B, FOR ALL PLANNED OR CONTINGENCY CASES. PRELIMINARY STUDIES INDICATE THAT, IN SUCH A CASE, THE APOGEE LIMIT CAN BE RAISED TO 320 MILES OR EVEN HIGHER.

5. AS FAR AS PERIGEE ALTITUDES BELOW THE SP/DR LIMIT OF 70NM IS CONCERNED, CURRENT DATA INDICATES THAT CONTINUED OPERATION SIGNIFICANTLY BELOW SUCH LIMITS IN THE ORBITAL CONFIGURATION IS NOT ACHIEVABLE WITHOUT MISSION DEGRADATION. FOR SOME CASES MISSION TERMINATION IS REQUIRED AND FOR OTHERS THERE IS LOSS OF RECOVERY CAPABILITY. IN ORDER TO DETERMINE THE ACTUAL OPERATIONAL CAPABILITIES OF THE SYSTEM, STUDIES OF SPECIFIC SITUATIONS AND RECOVERY STRATEGIES OF

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INTEREST SHOULD BE PERFORMED TO DEVELOP THE CONSTRAINTS IN DETAIL. EXAMPLES OF THE TYPES OF QUESTIONS WHICH WE SHOULD EXPLORE ARE: (A) HOW MANY LOW REVS WOULD BE FLOWN? (B) IS PAYLOAD OPERATION REQUIRED DURING OR AFTER SUCH LOW ORBITS? (C) IS MISSION TERMINATION DURING THE MISSION REV OR AT THE NEXT OPPORTUNITY AN ACCEPTABLE ASSUMPTION? (D) CAN THE PERIGEE BE RAISED FOR SEVERAL REVS BEFORE DE-ORBIT TO ALLOW EQUIPMENT COOLDOWN?

6. AERODYNAMIC HEATING DATA CURRENTLY AVAILABLE IS BASED ON MC DONNELL STUDIES OF GEMINI IN A MINIMUM LIFETIME (11 REV) ORBIT. THIS INITIAL ORBIT WAS 80 BY 85 NM, AND THE 11TH REV PENETRATED 420,000

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GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND
DECLASSIFICATION

FT. IN THIS CASE, THE HEATING WAS SUFFICIENT AFTER 11 REVS TO PERMANENTLY DAMAGE THE GEMINI DROGUE AND PILOT CHUTES AND RAISE CABIN AIR AND NUMEROUS PYROS TO TEMPERATURE LIMITS WHICH MADE INITIATING A REENTRY UNSAFE. AFTER COOL DOWN, HOWEVER, REENTRY COULD BE ACCOMPLISHED BUT LESS RELIABLY--DUE TO LOSS OF DROGUE AND PILOT CHUTES. THE VEHICLE IS FULLY CONTROLLABLE IN ATTITUDE FLYING EITHER GEMINI FORWARD OR GEMINI AFT AT LOW APOGEES. HOWEVER, THE GEMINI AFT CONFIGURATION IS AERODYNAMICALLY UNSTABLE AND WOULD PROBABLY REQUIRE MORE FREQUENT ATTITUDE CORRECTION THAN THE MORE STABLE GEMINI FORWARD CONDITION. IF ATTITUDE CORRECTION WERE NECESSARY DURING A PHOTO SEQUENCE,

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SOME PHOTO DEGRADATION MIGHT OCCUR. WITH EITHER THE GEMINI AFT OR GEMINI FORWARD, THE LABORATORY RADIATOR WOULD SUFFER AERODYNAMIC HEATING, AND BELOW 70 MILES LOSS OF LABORATORY THERMAL CONTROL IS LIKELY. WITH GEMINI AFT, THE GEMINI HEATING PROBLEM WOULD NOT BE PRESENT, BUT THE END CAP OVER THE PRIMARY MIRROR WOULD EXPERIENCE A CONSIDERABLE TEMPERATURE RISE. THE EFFECTS OF THIS CONDITION HAVE NOT BEEN ANALYZED.

7. THE FOLLOWING IS AN EXAMPLE OF AN OPERATIONS SEQUENCE WHICH COULD BE CONSIDERED. AN INITIAL ORBIT WITH AN 80 MILE PERIGEE AND APOGEE IN THE 170 TO 230 MILE RANGE IS ESTABLISHED. PERIGEE IS LOWERED ON COMMAND TO AN AGREED-UPON MINIMUM VALUE FOR 2 REVS, FLYING GEMINI FORWARD, THEN IS RAISED BACK TO ABOUT 80 MILES FOR MORE THAN ONE REV. THE CREW TRANSFERS ALL PRODUCTS INTO THE GEMINI B AND REENTERS AT THE NEXT PLANNED RECOVERY AREA. IF THE MINIMUM PERIGEE IS BELOW 70 MILES, AND DEPENDING ON THE ACTUAL PERIGEE ALTITUDE, IT MIGHT BE NECESSARY TO TRANSFER THE CREW TO THE GEMINI DURING THE LOW ORBITS AND DEPRESSURIZE THE LABORATORY, DUE TO LABORATORY HEATING. IT SHOULD BE NOTED THAT, SHOULD PRODUCT BE PRESENT IN THE GEMINI B DURING THE LOW ORBITS DEGRADATION WOULD RESULT DUE TO GEMINI HEATING.

8. IN CASE OF THE UNMANNED VEHICLE, THE SP/DR LIMIT IS 70NM AND THE

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ACTS FUEL BUDGET PERMITS A MISSION OF OVER 30 DAYS AT THAT ALTITUDE. WHILE SHORT PERIODS BELOW 70NM APPEAR FEASIBLE, PAYLOAD OPERATIONS CAN BE EXPECTED TO BE DEGRADED BY NAVIGATIONAL UNCERTAINTIES, PARTICULARLY AS RELATED TO THE SMALL FIELD OF VIEW, AND THE LACK OF A CREW TO REFINE POINTING ACCURACIES.

9. THE NUMBER OF ALTERNATE SEQUENCES IS GREAT, AND EACH HAS AN IMPACT UPON OPERATION. PLEASE ADVISE IF YOU REQUIRE FURTHER INFORMATION.

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