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Memorandum

O : MGS/Mr. Eldon W. Hall DATE: April 3, 1964

ROM : MGS/John L. Hammersmith

UBJECT: Advanced Gemini, Circumlunar Mission

The attached material represents the current status of my attempts to block out some aspects of the launch vehicle and spacecraft systems which are pertinent to the subject mission.

A spacecraft weight requirement is presented and defended, characteristics of a number of stages are tabulated, the pad situation at AMR is summarized, and several candidate vehicle and stage combinations are briefly analyzed. With respect to the latter, weight and performance data are not of uniform quality since some vehicles and stages are in use, or the data was derived from detailed studies, while other data are my own "rough cuts". I hope that I have been sufficiently conservative, however, to forestall radical variations in the event that more serious study of any of these is undertaken.

These rough notes illustrate many of the considerations and engineering problems involved. Financial matters have not been treated. Scheduling played a part only to the extent of aiming at the 1967-1970 time period with minimum disturbance to Gemini and Apollo programs. No conclusions or recommendations are made since the intent has been to work up some raw material for discussion and possible deeper study.

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GEMINI L SPACECRAFT

Reference: McDonnell Direct Flight Apollo Study,
Report 9182, Volume II, Fall 1962

The "Lunar Gemini II" spacecraft was selected from the referenced document as a basis for deriving a reasonable spacecraft weight to be used in performance calculations. This configuration seemed closest to the present Gemini 14-day spacecraft which would likely serve as a design starting point. This hypothetical spacecraft was dubbed "Gemini L". The derivation went as follows:

1. The reference document listed Lunar Gemini II and Gemini 14-day system weights side-by-side.

2. The paraglider landing system weight was subtracted from the 14-day set and the parachute weight of Lunar G. II substituted.

3. The lighter structure for L.G. II was not allowed; the 14-day structural weight was substituted.

4. The gross growth of the 14-day total from that in the document to December 1963 was applied to the resulting L.G. II total. (This growth was approximately 6.8%)

5. Since the Lunar Gemini system utilized a service module and Gemini L would not, the December 1963 adapter weight was added.

6. For the same reason an enlarged propellant capacity OAMS system, based on December 1963 figures, was also added.

The "Gemini L" so obtained weighed 8867 lbs. In the absence of design studies, a round figure of 9,000 lbs. was adopted as reasonable and conservative for rough calculation. The 1,000 ft/sec ΔV capability in the OAMS system could be used for injection ΔV, midcourse corrections, maneuver in the lunar vicinity, or some of the weight could be traded for retro and/or abort rockets. It may be expected that experiment and communication weights will tend to be heavier than allowed.

One of the principal developmental problems associated with the circumlunar Gemini spacecraft will concern the heating problems on the after body on re-entering the earth's atmosphere. Present Gemini shingles are barely adequate for present Gemini missions; much improved shingles would have to be developed, or a decision made to use an ablating surface instead (as with Apollo).

No account has been taken of the possible requirement of a launch escape tower, or of any other abort mode or mechanism. It was presumed that a 72 hour (one way) "free return" trajectory was adequate; and it must be recognized that, in the absence of a service module, no substantial modification of the trajectory is possible after translunar injection. The ΔV required for injection from low earth orbit onto the 72 hour trajectory is approximately 10,300 ft/sec.

WEIGHT

GEMINI 14 Day vs. GEMINI L

	Gemini 14 Day	Gemini L
Command & Reentry Module	4361	5680
Basic Structure	1333	1409
Heat Shield	324	718
Crew System	985	1120
Communications + Instruments	295	742
Experiments	-	90
(Little difference in remainder)		
Adapter	2134	3187
Structure	425	425
Equipment	1130	1302
OAMS (wet)	368	460
OAMS, Useable Propellant (No Retro)	211	1000*
Total S/C Injected	6495	8867

*Provides approximately 1000 ft/sec ΔV.

LAUNCH VEHICLES

It is apparent that there is little choice in launch vehicles. Furthermore, the development of upper stages, or rendezvous stages, is likely.

Qualification of hardware for manned flight will be a complicating factor. In the following mission plans an attempt was made to stay close to existing developments, proposing minimum modifications.

Short of Saturn V, the only hope for a single launch, direct flight requires development of a hydrogen third stage for the Saturn IB.

The present GLV cannot launch a 9,000 lb. spacecraft. The following plans which utilize it presume its performance can fairly readily be improved a sufficient amount by augmenting the first stage with relatively small, strap-on, solid motors. There is little basis at this time for believing that NASA, or the AF, will buy into the major GLV improvement program proposed by Martin Company and Aerojet General.

CANDIDATE SPACE PROPULSION STAGES

Stage	Burnout Weight	Propellant Capacity Oxidizer & Fuel	Specific Impulse	ΔV with 9,000 lb. S/C	Gross Weight with Spacecraft
Transtage Titan III	4,400	22,900 15,450 & 7,450	314	10,100	36,300
GLV Stage 2	5,700	60,300 38,500 & 21,800	310	16,526	75,000
GLV Stage 2	5,700	26,586 (off-loaded) 16,975 & 9,611	310	10,300	41,286
S-V + IU	7,500	28,200 23,500 & 4,700	430	13,788	44,700
S-V + IU	7,500	18,237 (off-loaded) 15,197 & 3,040	430	10,300	34,737
S-V	5,500	16,026 (off-loaded) 13,355 & 2,671	430	10,300	30,526
Centaur	4,000+	14,368 (off-loaded) 11,973 & 2,395	430	10,300	27,368
Agena D	1,500	13,077 9,409 & 3,668	290	7,547	23,577
Agena enlarged	2,300	22,783 16,392 & 6,391	290	10,300	34,083
2 Agena's (parallel)	3,200	26,154 18,818 & 7,239	290	10,688	38,354

AMR Pads

Pad No.	Vehicle	Responsible Agency	Remarks
11	Atlas	AF	
12	Atlas-Agena	AF	NASA use exclusively
13	Atlas-Agena	AF	Joint NASA-AF use
14	Atlas-Agena (Gemini)	NASA	
15	Titan II	AF	Martin study for
16	Titan II	AF	LeRC estimates 13 months to convert to Titan-Centaur-Surveyor
19	Gemini LV	NASA	
20	Titan III Core	AF	Five vehicles only, then ITL will handle
34	Saturn IB	NASA	
37A		NASA	No launches programmed, under study
37B	Saturn I/IB	NASA	
36A, B	Centaur	NASA	Single blockhouse
39	Saturn V	NASA	Two pads
40, 41	Titan III	AF	ITL Complex

ADVANCED GEMINI, CIRCUMLUNAR MISSION

Some Vehicle Combinations

Mode	Launch Vehicles	Rendezvous Stages
EOR	Saturn IB GLV	Two Agena's (parallel) Gemini L
EOR	Titan III GLV	Centaur (single burn) Gemini L
EOR	Saturn I (2½ stages) GLV	Centaur (2 burns) Gemini L
EOR (tanking)	Titan III Titan III	Oxidizer Tanker Transtage + Gemini L
Direct	Saturn IB (3 stages)	Gemini L

MISSION: Advanced Gemini, Circumlunar

MODE: Earth Orbit Rendezvous, Spacecraft Coupled to Space Propulsion Stage

LAUNCH VEHICLES:

1. Saturn IB (Payload: 33,000 to 35,000)
2. Thrust Augmented GLV (Payload 9,000+)

RENDEZVOUS STAGES: (LV Payloads)

1. Two Agena's in parallel

Dry weight	3,200
Docking adapter and thrusters	2,500
Mainstage propellants	26,154
OAMS propellant	800
Adapter to LV and shroud	2,000
Gross payload to orbit	34,654

2. Manned Gemini L Spacecraft

Gross weight in orbit	9,000

DEVELOPMENT AND AVAILABILITY:

1. Technical difficulty in mating Agena's to the IB.
2. There may be a problem getting IB's.
3. Gemini uprating required for parabolic re-entry.
4. Requires NASA sponsored development to increase GLV capability.

ATTRACTIVE FEATURES:

1. Natural follow-on to Gemini in exploiting orbiting operations.
2. Use of "standard" strap-on solids is cheap, minimum difficulty, way to obtain modest performance gain from GLV.
3. Except for solids, all elements are part of NASA program, and, for the most part, of Gemini.
4. Pad availability should not be a problem.

UNDESIRABLE FEATURES:

1. Marginal capability to accomplish the mission.

2. Possible interference with Apollo.

3. Does not advance techniques of orbiting operations beyond Gemini.

4. Other than achieving circumlunar flight prior to Apollo, contributes little to the advancement of space flight that is not already programmed.

MISSION: Advaned Gemini, Circumlunar

MODE: Earth Orbit Rendezvous, Spacecraft Coupled to Space Propulsion Stage

LAUNCH VEHICLE:

1. Titan III (Payload capability to low orbit: 25,000+)
2. Thrust augmented GLV (Payload 9,000+)

RENDEZVOUS STAGES: (LV Payloads)

1. Centaur (No burn prior to translunar injection)

Dry weight	4,000
Docking adapter and thrusters	2,500
Mainstage propellants	17,100
OAMS propellant	800
Gross in low orbit	24,400

2. Manned Gemini L Spacecraft

Gross weight in orbit	9,000

TRANSLUNAR INJECTION STAGE AND SPACECRAFT:

Centaur	23,600
Spacecraft	9,000
Gross weight	32,600
Total ΔV and ΔV required	10,300

DEVELOPMENT AND AVAILABILITY:

1. Titan III scheduled to be operational in mid 1966.
2. Spacecraft production begins near time when present Gemini SC production ends.
3. Gemini uprating required for parabolic re-entry.
4. Minimum modification to Centaur.
5. Requires NASA sponsored development to increase GLV capability.

ATTRACTIVE FEATURES:

1. Natural follow-on to Gemini in exploiting orbiting operations.

2. Use of "standard" strap-on solids is cheap, minimum difficulty, way to obtain modest performance gain from GLV.

3. Essential elements are part of the national space and missile program, and therefore, "proven".

4. Gemini pad will become available at right time, and Titan III complex should be able to absorb this program.

5. No serious development problems.

6. Does not appear limited by LV payload capabilities.

7. Centaur burn not required prior to translunar injection.

UNDESIRABLE FEATURES:

1. Titan III launch vehicle is AF and pad modification would be required to handle Centaur payload.

2. Does not advance techniques of orbiting operations beyond Gemini.

3. Other than achieving circumlunar flight prior to Apollo, contributes little to the advancement of space flight that is not already programmed.

MISSION: Advanced Gemini, Circumlunar

MODE: Earth Orbit Rendezvous, Spacecraft Coupled to Space Propulsion Stage

LAUNCH VEHICLE:

1. Saturn I plus partial use of space stage (Required gross to low orbit: 24,400)
2. Thrust augmented GLV (Payload 9,000+)

RENDEZVOUS STAGES: (LV Payloads)

1. Centaur (burned once to complete launch)

Dry weight	4,000
Docking adapter and thrusters	2,500
Mainstage propellants	17,100
OAMS propellant	800
Gross in low orbit	24,400

2. Manned Gemini L Spacecraft

Gross weight in orbit	9,000

TRANSLUNAR INJECTION STAGE AND SPACECRAFT:

Centaur	23,600
Spacecraft	9,000
Gross weight	32,600
Total ΔV and ΔV required	10,300

DEVELOPMENT AND AVAILABILITY:

1. Technical difficulty mating Centaur to Saturn I.
2. Saturn I "pipeline" has not been filling for vehicles beyond SA-10 for some time.
3. Gemini uprating required for parabolic re-entry.
4. The last Saturn I is scheduled for mid '65. If this were to follow the Gemini program, ending in mid '67, Saturn I production capability will be non-existent without special, and expensive, attention.

DEVELOPMENT AND AVAILABILITY: (Cont'd)

5. Requires NASA sponsored development to increase GLV capability.

ATTRACTIVE FEATURES:

1. Natural follow-on to Gemini in exploiting orbiting operations.

2. Use of "standard" strap-on solids is cheap, minimum difficulty, way to obtain modest performance gain from the GLV.

3. Essential elements are directly derived from NASA programs.

UNDESIRABLE FEATURES:

1. Does not advance techniques of orbiting operations beyond Gemini.

2. Probably the only reasonable way to solve the "phasing" problem between ending Saturn I production in '65 and starting flights for this program in '67 would be to interfere with the present Gemini program.

3. Other than achieving circumlunar flight prior to Apollo, contributes little to the advancement of space flight that is not already programmed.

MISSION: Advanced Gemini, Circumlunar

MODE: Earth Orbit Rendezvous, Transfer Oxidizer from Tanker to Space Propulsion Stage

LAUNCH VEHICLES:

Two Titan III Launch Vehicles
Payload capability to low orbit:
25,000+ per vehicle

RENDEZVOUS STAGES (LV PAYLOADS):

1. Oxidizer Tanker	
Dry weight (incl. Thrusters):	3,800
Oxidizer	16,000
400 ft/sec OAMS propellant	1,000
Tanker gross weight	20,800
2. Manned Gemini L spacecraft with Titan III transtage attached (no oxidizer)	
Gemini L (propellants in)	9,000
Transtage (wet)	4,400
Transtage fuel	7,450
Gross weight	20,850

TRANSLUNAR INJECTION PROPULSION STAGE & SPACECRAFT

Rendezvous Stage #2	20,850
Oxidizer transferred (Transtage is fully loaded)	15,450
Gross weight	36,300
Total ΔV (Transtage & Gemini L) (less any used for rendezvous maneuvers)	11,100
ΔV Required for Injection	10,300

MISSION: Advanced Gemini, Circumlunar

MODE: Single Launch, Direct Flight

LAUNCH VEHICLE:

Three Stage Saturn IB, high energy third stage

Paylcad capability to lunar injection conditions: More than 10,000 lbs. with almost any type of hydrogen third stage ever proposed for use on this vehicle, including Centaur, S-V, S-VI, MMM, High-Energy SM

CIRCUMLUNAR SPACECRAFT:

Gemini L

DEVELOPMENT & AVAILABILITY:

1. Two-stage Saturn IB will be man-rated and operational.
2. High energy third stage is new.
3. Gemini uprating required for parabolic re-entry.
4. Pad 37A usage is under study and could be available.

ATTRACTIVE FEATURES:

1. Straightforward operational method to achieve mission.
2. Pad availability probably not a problem.
3. Not limited by launch vehicle payload capability.
4. Profits from NASA developed launch vehicle.

UNDESIRABLE FEATURES:

1. Requires development of a man-rated high energy stage.
2. Possible conflict with Apollo.
3. Escape tower will be required.

DEVELOPMENT & AVAILABILITY:

1. Titan III scheduled to be operational in mid-1966.
2. Tanker is new.
3. Gemini uprating required for parabolic re-entry.
4. Fuel transfer in orbit is new and will require development flights as well as development of transfer equipment.

ATTRACTIVE FEATURES:

1. Natural follow-on to Gemini in exploiting and further developing orbiting operations.
2. Minimum pad availability problems because the dual pad system is designed for high firing rates with little possibility of saturation in near future.
3. Minimum, operational, dual launch problems because identical launch vehicles are used from a single, pad complex.
4. Minimum NASA development problems with propulsion stages since these will all be "man-rated" under the Titan III program.
5. Does not appear limited by LV payload capability.
6. Profits from use of "work horse" standard LV's in contrast to expensive, tailored LV's not used in other programs.

UNDESIRABLE FEATURES:

1. Possible conflict with MOL program.
2. Launch system is AF and not NASA.