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NACA - Lewis

Cleveland, Ohio
April 10, 1958

MEMORANDUM For Associate Director

Subject: Minimum man-in-space proposals presented at WADC, January 29, 1958 to February 1, 1958

1. The purpose of a series of meetings at WADC under the Chairmanship of Mr. E. Barton Bell was to hear proposals from various contractors on the quickest way to put man in space.

2. Proposals fell into two rough catagories: (a) a blunt-nose cone or near-spherical zero-lift high-drag vehicle of a ton to a ton-and-a-half weight, and (b) a hypersonic glider of the ROBO or Dyna-Soar type. The first catagory of vehicles used existing ICBM vehicles as boosters; the second used more complex and arbitrary multiplex arrangements of existing large-thrust rocket engines. A number of contractors looked at the zero-lift high-drag minimum weight vehicle as the obvious expedient for beating the Russians and the Army into space. Others, notably Bell, Northrop, and Republic Aviation, set this idea aside as a stunt and consequently these contractors stressed the more elaborate recoverable hypersonic glider vehicle as the practical approach to the problems of flight in space. In the following paragraphs the no-lift minimum weight vehicles are reviewed first without regard for order of presentation and the hypersonic glider vehicles follow. An effort is made to summarize the pertinent gross features of each proposed vehicle at the head of each review and some of the details are discussed thereafter.

3. The proposal configurations were patterned directly after concepts developed by Allen, Eggers, et al of NACA-Ames and the background of data obtained through NACA research was impressively apparent throughout the proposals. Therefore, before going into the individual proposals it seems worthwhile to review briefly the suggestions made by NACA people. This review is covered in the next three paragraphs.

4. Mr. John Becker of NACA-Langley discussed two separate minimum man-in-space proposals. The first of these was a no-lift configuration

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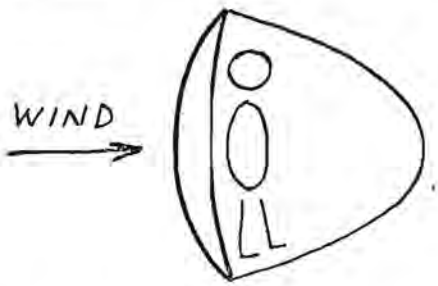
as diagrammed.



$W_g < 3000$ pounds

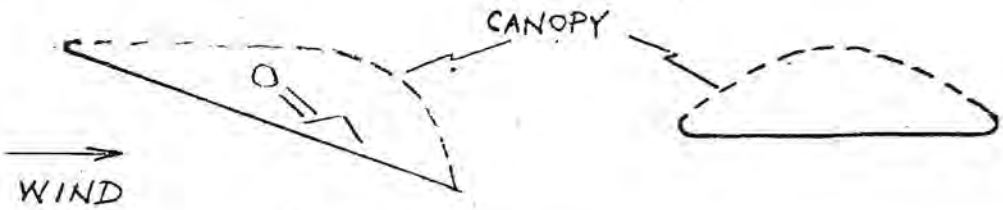
$W/S = 35$ pounds per square foot

This discussion considered only vehicles which fly within the atmosphere at perigee so that a small impulse applied anywhere along the flight path will initiate reentry. With zero-lift the drag deceleration will reach a maximum of about 8.5 g's with greater than 5 g's for 20 seconds. Small controls (flaps like air brakes) at the edge of the dish can be used to change angle of attack and thereby produce lift; this will reduce maximum g's to 4.5. The heating rate will approach a maximum of 100-150 Btu per square foot per second. This heat can best be absorbed in a Berylium heat sink between $\frac{1}{2}$ and 1-inch thick. The vehicle ultimately requires descent by parachute - this rules out landing in predesignated pin-point areas.

Boost with the ballistic-nose-cone-type vehicle can be accomplished with Atlas. During boost the heat shield is behind the pilot (passenger). Upon injection into orbit the vehicle must be reversed. This requires attitude controls that work in space. Reentry also requires a well-controlled gimballed retrorocket of nominal impulse and weight (<100 pounds).

Langley is presently making a structural analysis and investigating aerodynamic behavior in hypersonic tunnel.

5. The second proposal was a lift flat-bottomed wing device to enter the atmosphere at an angle of 25° ($C_L = 0.6$).

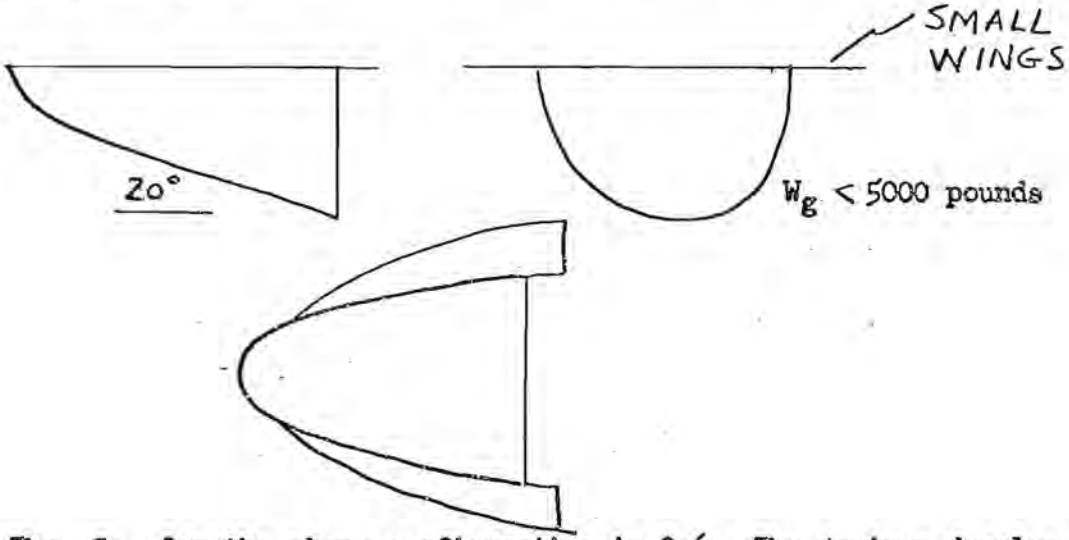


Blunt leading edge radius was given as 3 inches with W/S = 20 pounds per square foot. The heat transfer rate on the bottom was estimated at less than 12 Btu per square foot per second and the airframe can radiate all heat. Temperature of the skin would reach a maximum of 2000° F at the leading edge. This device would have less than 1 g deceleration at all times during reentry (except possibly at the earth's surface). Range can be controlled somewhat by varying angle of attack (L/D = 3.5 to 1.0).

The weight of this aerodynamic-ski would be less than 5000 pounds, possibly considerably less.

One of the problems of both the NACA devices will be control of velocity and angle at injection into orbit. Present ICBM quality guidance is not good enough. A retrorocket to slow ski down by 200 feet per second at 300,000 feet perigee altitude will lower perigee by 50,000 feet. This will initiate re-entry.

6. Mr. Clarence Syvertson of Ames outlined certain configurations that are being studied there. These assume an initial circular orbit at 500,000 feet. If at this altitude the velocity is reduced by 2 percent the altitude will be lowered by 220,000 feet.



The C_L for the above configuration is 0.6. The maximum deceleration is always less than 1 g. Hypersonic wind tunnel studies of this configuration have shown a serious aerodynamic center shift at transonic speeds. This A.C. shift

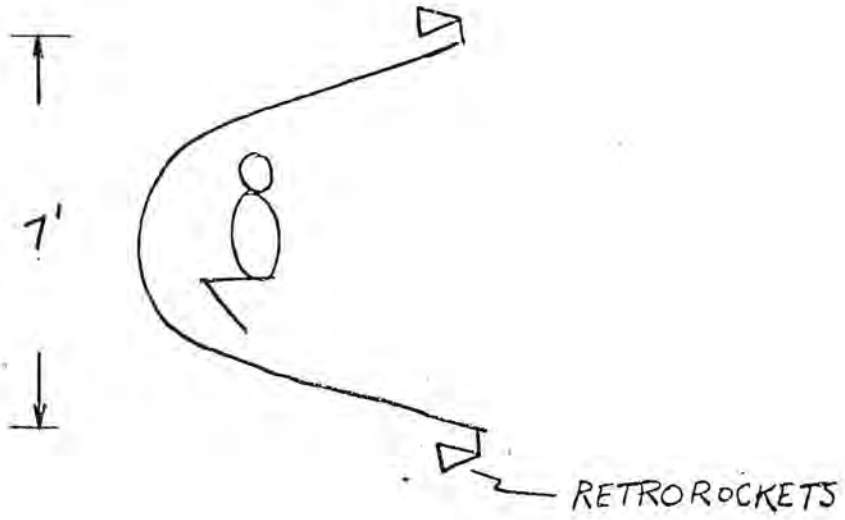
amounts to about 30 percent of the body length. Two suggested solutions are to use thicker wings or no wings at all. Drag-brake-like controls surfaces (about 5 in number) around the periphery of the configuration are being studied.

Essentially this device is one half of an ICBM reentry body. The controllable lift provides control over range. A former idea for parachute landing is being abandoned.

AUTONEUTRONICS

Initial presentation by Mr. Krause who discussed an elaborate scheme of experiments to be accomplished with rocket-propelled vehicles along with an extended series of engine-vehicle assemblies to carry out the program. Even the manned satellite concept was regarded as the end experiment of a series starting with protozoa and bacteria and building up through invertebrates, vertebrates, and finally, man. Only the manned space vehicle is outlined below. The space program discussed is reviewed in the discussion section.

Vehicle: One man zero-lift nose-cone.



Weight: Payload 855 pounds:

Man	175 pounds
Oxygen and purifier	85 pounds
Water	20 pounds
Food	10 pounds
Clothing	110 pounds
Temperature controls	130 pounds
Attitude controls	85 pounds
Communication	85 pounds
Navigation	45 pounds
Experiments	65 pounds
Telemetering	--
Total payload	855 pounds
Berylium ablation shield	850 pounds
Parachute	100 pounds
Recovery (?) system	50 pounds
Retrorocket	250 pounds
Structure	300 pounds
Instruments	70 pounds
Capsule	70 pounds
Total weight	2545 pounds

Boosters: Atlas and Rustler ($F_2 - NH_3$)

Schedule: Manned earth satellite late in 1963 (with 3300 pound payload and Atlas-Rustler booster.)

Cost: $\$80 \times 10^6$.

Discussion

Concerning the high lift/drag glider configurations as opposed to the high drag zero-lift ballistic reentry concepts Mr. Krause presented the following arguments:

The high L/D configuration entail:

(a) Unsolved aerodynamic and structural problems
(b) Development of new test methods
(c) Major test facilities
(d) Material development
(e) Long development schedule
(f) Structural fabrication problems

The high drag configurations entail:

(a) Nominal test facilities
(b) Development of heat sink materials
(c) Short development schedule
(d) Simple fabrication
(e) Aerodynamic data available

A high altitude research program involves:

(a) Procuring scientific data
(b) Studying environmental effects
(c) Testing components
(d) Developing recovery techniques
(e) Biomedical experiments
(f) Manned flight

The high altitude research and test work can be accomplished with: Thor, Polaris, Atlas, Titan, or special vehicles.

Satellite program must include:

(a) Study of physical environment
(b) Precision experiments
(c) Reconnaissance

Satellite flights can be accomplished with the Thor-Hustler, Thor-Rustler, Atlas-Hustler, and Fitan-Rustler. Both the Fitan and the Rustler will use fluorine as oxidant.

Lunar flight program might include:

(a) Navigation in precision orbit
(b) Lunar impact
(c) Instrument landing

For lunar flight, vehicles might be the Thor-Rustler-Vanguard 3rd stage, Atlas-Rustler, and Fitan-Rustler.

The vehicle development chart for these programs proceeds: (a) Thor-Hustler, (b) Thor-Rustler, (3) Atlas-Rustler, and (4) Fitan-Rustler.

For the earth satellite program estimated payload weights for several configurations were calculated:

Configuration	Payload, pounds	Initial W_o, pounds
Th-6V	201	
Th-6V-V	335	
Th-H	377	112,499
Th-R	858	113,169
A-H	3272	
A-R	3848	
F-R	5459	

The schedule was for four earth-satellite flights in twelve months, first recovery 18-20 months, biomedical experiments 22-25 months. Rustler (F_2 - N_2H_4) was predicted to be ready in the twenty-first month (extremely optimistic). This would raise payload over 500 pounds within two years.

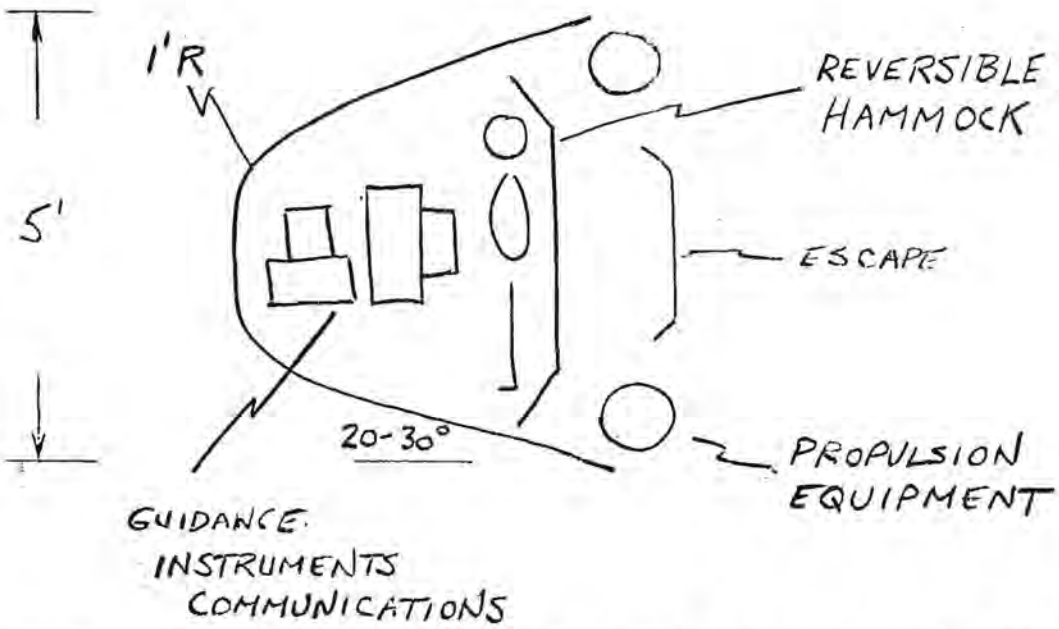
The purpose of the series of biomedical experiments is to establish survival limits and determine nervous system behavior. Protozoa-bacteria experiments were to be done with Thor-Hustler, Rhesus monkey experiments with Thor-Rustler, chimpanzee experiments with Atlas-Rustler, and manned flight also with the Atlas-Rustler. The Thor-Hustler program is expected to cost $\$50 \times 10^6$, boosters and range free, the Thor-Rustler program an additional $\$30 \times 10^6$.

MARTIN

Introductions by Mr. Bunker, President, and Mr. Merrill, Vice President at the Denver facility. Outline of proposal by Mr. George Trimble, Vice-President of engineering. Details by Mr. Demeret, head of the astronautics section(?), Denver.

Pertinent Features

Vehicle: One-man zero-lift body illustrated below. Later vehicles planned to have lift and controls. Later vehicle weights up to 40,000 - 60,000 pounds.



Weight: 3500 pounds total; ablation shield (phenolic resin), 650 pounds; instruments, 150 pounds.

Boosters: Titan.

Time and altitude: 24-hour trip; 150 - 200 miles at perigee.

Reentry method: Retrorocket (-500 feet per second) applied at apogee; ballistic reentry, W/C_DA = 100 - 150, maximum g's = 7.5 at 3° reentry angle; maximum temperature = not stated; maximum heat transfer = 5 - 6 Btu per square inch per second; ablation cooling.

Recovery and landing: Parachute within ±50 miles.

Tracking: ICBM inertial. Minitrack to provide altitude and position data.

Safety feature: Retrorocket used to separate vehicle from booster if booster fails.

Schedule: Manned flight by mid-1960.

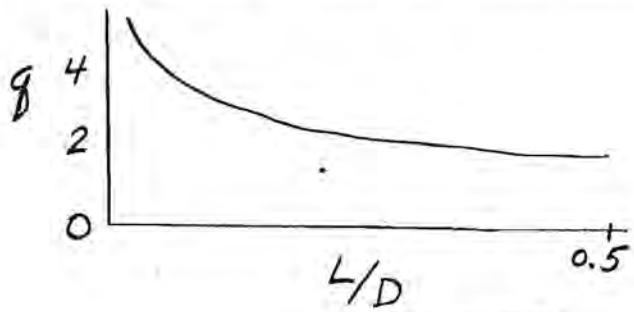
Cost: Not stated.

Discussion

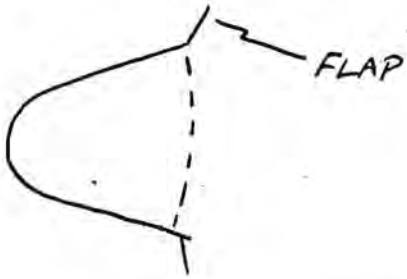
Present ICBM guidance okay for attitude reference for ten days. Integrating accelerometer will gage retrorocket within ±10 feet per second. Propose H_2O_2 retrorocket with hot-gas vernier control system for attitude stabilization. Present Titan system fails to lift 3500 pound payload into orbit by 500 feet per second. (Can carry about 2900 pounds into orbit.) Twenty percent additional payload capacity is foreseeable growth by 1960.

No specific design proposed for controlled flight. A second proposal to carry 16,000 pound third stage with a -5000 feet per second retrorocket (weighing 10,000 pounds) was suggested - but not detailed - to avoid heating problem.

Maximum heat transfer can be reduced by some lift.



Martin suggested use of control flaps on reentry vehicle to produce angle of attack and lift.



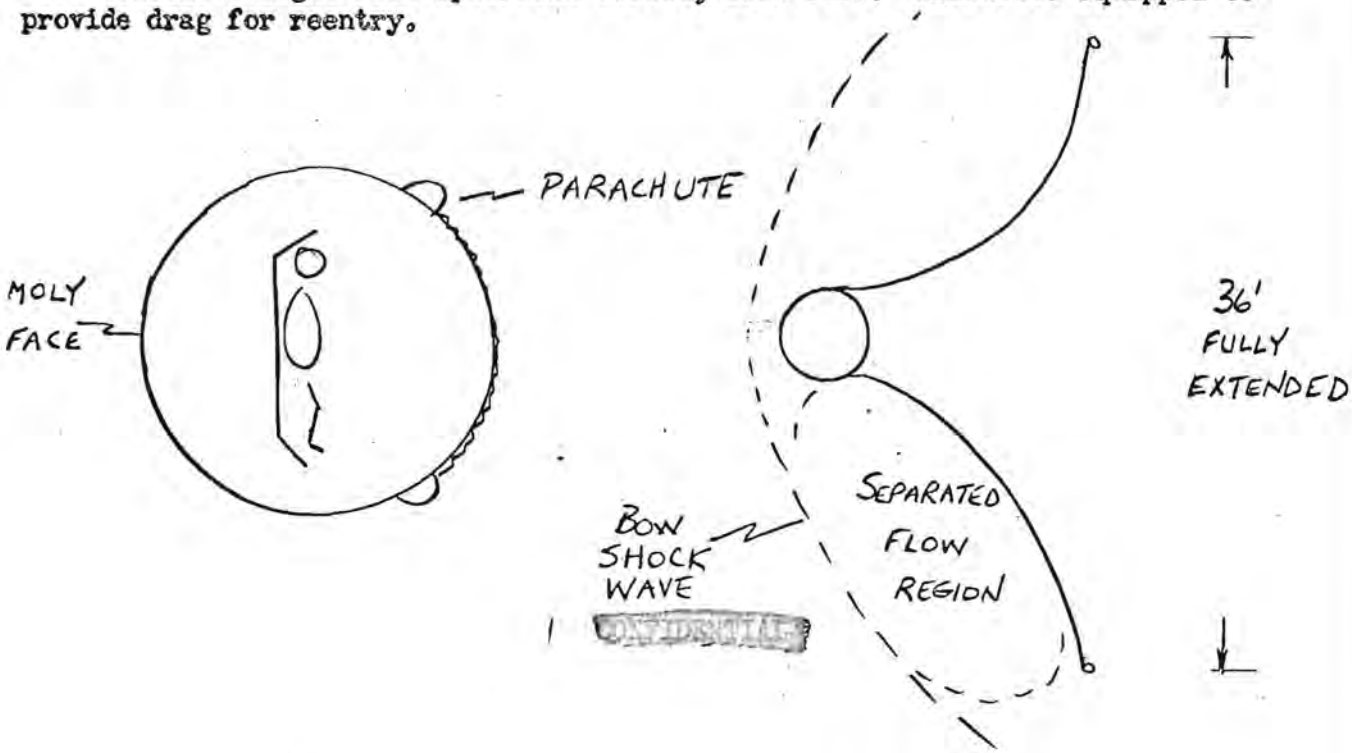
The Martin proposal impressed me as the most thoroughly worked out proposal.

AVCO

Presentation principally by Dr. Arthur Kantrowitz, Director of Research. AVCO has twice previously proposed the following. (The last time in November, 1957.)

Pertinent Features

Vehicle: Eight-foot spherical vessel, zero lift. Parachute equipped to provide drag for reentry.



Weight: 1500 pounds

Capsule	220 pounds
Internal structure	114 pounds
Survival equipment	126 pounds
Parachute	330 pounds
Other	85 pounds
Escape rocket	240 pounds
Man and clothing	150 pounds
	1265 pounds
Contingency	235 pounds
Total weight	1500 pounds

Boosters: Titan (or Atlas) as is. Maximum g's = 11 (second stage).

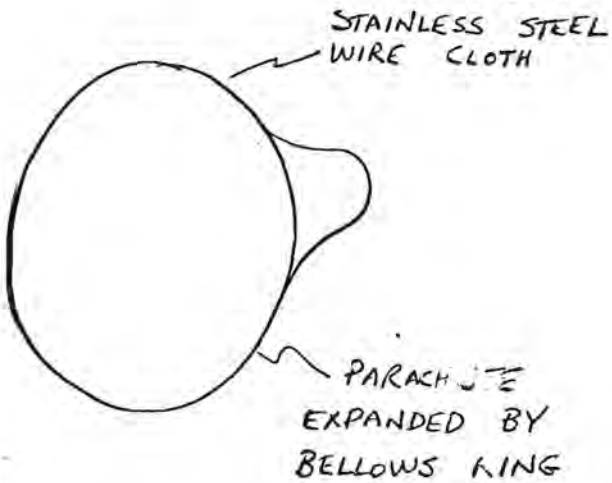
Time and altitude: Orbit at 110 - 120 miles (circular). Time arbitrarily variable. With parachute furled as many as 40 orbits are possible. Propose a three-day flight.

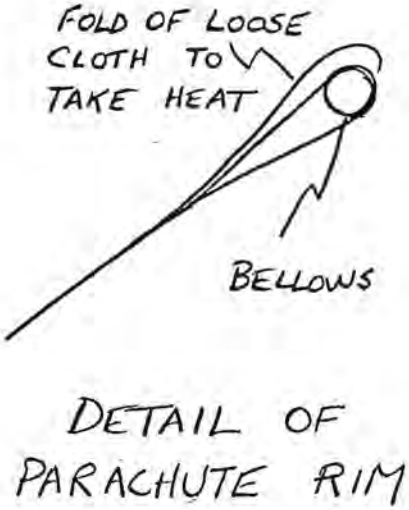
Reentry method: Thirty-six foot diameter stainless steel parachute creates drag to cause descent in one half orbit. Control of parachute used both to adjust orbit and to control landing point. Grazing angle (1/4°) reentry; maximum g's 9 @ 250,000 feet; maximum temperature, 1800° F; maximum temperature of parachute, 1140° F; maximum heat transfer (?) @ 270,000 feet.

Recovery and landing: Parachute also used to land capsule; landing area about size of Kansas. Landing velocity, 35 feet per second. Fall requires one half hour.

Tracking: Existing minitrack systems. Man is strictly passenger - no control.

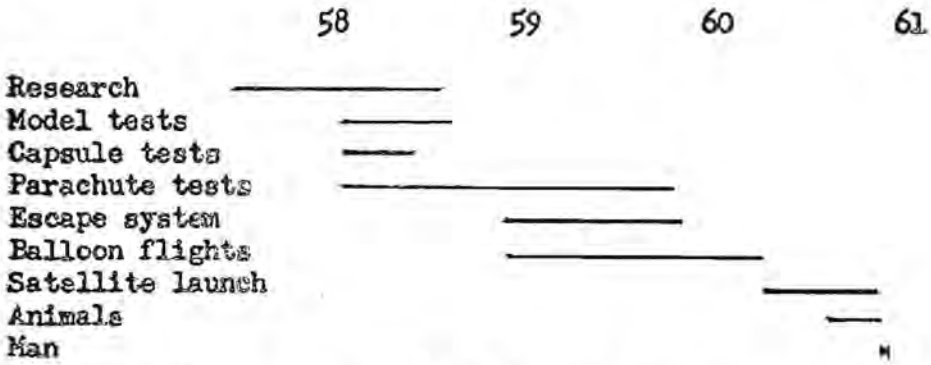
Controls: Air-jets to kill angular momentum (attitude). Liquid paddles to maintain attitude. Parachute extension controllable by expansion of bellows ring at rim; changes drag by 50 x. Used to correct orbit. ICBM-quality guidance good for 0.8°, want 0.25°.





Safety features: Solid rocket provided for safety escape if boosters fail; otherwise fires along with second stage. Safety rocket separates from capsule after firing.

Schedule:



Cost: $40 x 10^6 plus $12 x 10^6 for flight vehicles excluding launchers.

Discussion

Dr. Kantrowitz looks at this proposal as the quickest way to manned satellite. This he regards as no stunt. A permanent orbit at 110 - 120 miles can be established with a solar propulsion device capable of overcoming the 5 grams drag force. The vehicle described may also offer a means for escape from a disabled large-scale vehicle.

The g factors and capsule atmosphere (60 percent oxygen, remainder N_2, He at ½ atmosphere pressure) are based on WADC Aeromedical group data. Certain upper atmosphere data on which the calculations are based are in doubt but better data will certainly be available before manned flight schedule.

The stainless steel parachute lies in a region of secondary flow (this is the reason for the shuttlecock shape) and will be subjected to peak temperatures of 1140° F, in contrast to the 1800° F peak at the sphere nose. The capsule will be above 200° F skin temperature for about 20 minutes. With the planned insulated wall construction the amount of heat transferred into the sphere will amount to about 1500 Btu (heat of fusion of a 10 pound block of ice) and is nearly negligible. Construction of the pressure vessel capsule is 0.020-inch stainless steel, insulation thermoflex with 0.001-inch stainless steel radiation shield; the nose is coated with 0.010-inch molybdenum skin.

The parachute has inflatable stainless steel bellows around the rim (about 3-inch diameter) and is made of 400 mesh stainless fabric covered with shim-stock stainless "shingles"; total fabric weight about 60 pounds. Unfurling this chute increases the drag of the vehicle about 50 times. The chute can be opened and collapsed several times provided the bellows expansion doesn't exceed two times its length.

There was some discussion of magneto-hydrodynamic propulsion and means of projecting the shock location away from the vehicle using magnetic fields. This was not part of the proposal.

This presentation impressed me as having the most thorough correlation with available scientific and aerodynamic data.

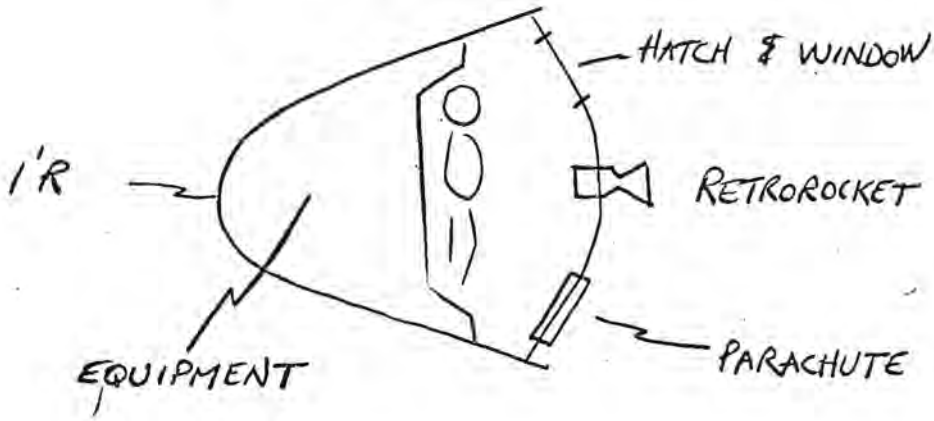
LOCKHEED

Proposal presented by Dr. Perkins, Development Planning.

Pertinent Features

Weight:	Capsule	600 pounds, includes 150 pound man
	Ablating material	600 pounds
	Retrorocket	100 pounds
	Parachute	200 pounds
	Total weight	1500 pounds

Vehicle: One-man nose-cone shape.



Boosters: Atlas and Bell Hustler. Hustler fires for 80 seconds between 620 - 700 seconds flight time to inject into orbit. Maximum g's 6.6 (first stage). Specific impulse = 280 pounds per second per pound required of Hustler.

Time and Altitude: Six hours; perigee 150 miles; apogee 300 miles.

Reentry method: Retrorocket (-225 feet per second. One mile altitude at perigee roughly equals 1.5 feet per second. Retrorocket weighs less than 5 percent of vehicle.)

$W/C_o A = 0.01$

Maximum g's, 7.5 at 1° reentry angle

Maximum temperature, not stated

Maximum heat transfer, not stated

Vehicle subsonic at 60,000 feet; 600 feet per second at 40,000 feet. Cooling by ablation material.

Recovery and landings: Cloth parachute to recover entire capsule. Landing area 20 miles by 400 miles along path. Errors of 150 miles due to lack of knowledge of air density between 125,000 and 250,000 feet. Lockheed proposes water recovery.

Tracking: 108 mc minitrack plus two-way voice. Flywheel attitude control. Either gimbal or jet-vanes on retrorocket.

Safety features: Overrides on man's limited control functions. Hustler is fired to escape if Atlas booster fails. If Hustler fails man has had it.

Schedule: Preliminary experimental flights (Thor with 300 pound payload) in late 1958. Experimental centrifuge and vacuum chamber testing in mid-1958. Manned flight in late 1959.

Cost: $\$10 \times 10^6 < \text{cost} < \$100 \times 10^6$.

Discussion

X-17 tests (28 out of 38 successful) have confirmed hot shot and shock tube high speed data. Lockheed Missile Systems Division (MSD) has three-inch shock tube which uses 1-inch model.

Berylium is better than copper for ablation cooling material. Vehicle has no cosmic or meteor protection.

Lockheed feels lift reentry is best in long run.

CONVAIR

Introduction by Mr. William H. Patterson, of Convair Astronautics. Extended discussion by Mr. Krafft A. Ehricke. Much of Ehricke's discussion was concerned with an extensive program of populating the solar system with reconnaisance, radio relay, etc., systems. Pulling that part of the presentation which applies to the minimum man-in-space concept from my notes is difficult. The program reviewed by Mr. Ehricke is contained in the Convair Astronautics report entitled: "A Satellite and Space Development Program", December, 1957 (Copy No. 185 is charged to the Lewis Laboratory Library.).

Some notes on the minimum man-in-space device are outlined in the following.

Pertinent Features

Vehicle: 60-inch sphere.

Weight: Man plus 1000 pounds, 500 pound heat-sink.

Boosters: Atlas Series D plus third stage. It is conceivable that the third stage need not be used - will require 5 specific impulse units improvement in present rocket performance.

Time and altitude: Time not noted. Altitude - 300 miles.

Reentry method: Retrorocket. Reentry angle, 2° maximum, $C_oA/W = 0.05$ to 0.08. Maximum g's = 8, greater than 6 g for 60 seconds.

Schedule: First flight (unmanned), February, 1959. Man in satellite orbit, April, 1961. Vehicle production schedule, one per month. Atlas D vehicle will not be fired before May, 1959.

McDONNELL

Introduction by Dr. Wokansky, coordinator of research. Presentation by Mr. Michael Weeks, Chief, preliminary design. McDonnell Aircraft presentation was an obvious bid for the "payload package" without the propulsion problem. Details were given in the McDonnell report to WADC.

Pertinent Features

Vehicle: One-man capsule. Data below are for a nose-cone device. Winged vehicle was considered possible in 30 months.

Weights:

Crew	270 pounds
Seat	50 pounds
Oxygen (3 hours)	70 pounds
Pressurization	134 pounds
Canopy	135 pounds
Structure	345 pounds

(Weight - continued.)

Stabilization	202 pounds
Retrorocket	90 pounds
Electronic	400 pounds
	1693 pounds
Landing chute	135 pounds
Heat problem	450 pounds
Incidentals	122 pounds
	2400 ± 25 percent

Boosters: Atlas and Polaris. Peak g's (Polaris) about 7.

Time and Attitude: One orbit ($1\frac{1}{2}$ hours); apogee not noted; reentry initiated at 300,000+ feet.

Reentry method: Retrorocket (-143 feet per second). Ballistic reentry $WC_D/M = \frac{1}{2}$ to 1; maximum g's 10 (1°) to 13 (4°), above 7 g's for 50 seconds, above 5 g's for 100 seconds; maximum temperature, 1200° F one foot behind leading edge (?); heat sink (not ablative) cooling.

Recovery and landing: Ejection seat with parachute.

Safety features: Polaris fired if Atlas fails. Ejection seat throws pilot clear.

Tracking: Ground control system for control of vehicle.

Schedule: Manned capsule flight 20-25 months.

Cost: Not stated.

GOODYEAR

After introduction by Mr. Baldwin, Mr. Darrell Romick described Phase 1 of a long-range (six to eight years) program to provide an operational satellite platform. The initial program was to conduct reentry tests (30 pound payload)

with Jupiter launcher; with primate (150 - 300 pound payload) with a Thor or Jupiter; manned spherical ball (1500 - 2000 pound payload) with Atlas or Titan. Only the features of the minimum man proposal are given here.

Pertinent Features

Vehicle: One-man 7-foot spherical vessel.

Weight: 1700 pounds; structure, 1050 pounds.

Boosters: Atlas or Titan first stage. Five third stage Vanguards or eight Irises (made by Goodyear Aircraft Corporation) for second stage. Maximum g's 5 to 7.

Time and Altitude:

Perigee = 110-115 miles; and Apogee = 600 - 800 miles.

Reentry method: External retrorocket (H_2O_2-polyethylene, -800 feet per second, with tankage jettisoned before reentry.) $W/C_D A = 0.028$; maximum g's 7.5, greater than 4 for five minutes; maximum temperature, 3200° R, temperature greater than 2000° F for five minutes; maximum heat transfer not stated. Ablative cooling using Goodyear Aircraft Corporation-developed material.

Recovery and landing: Parachute for entire capsule deployed at 15,000 feet, with velocity 300 feet per second. Water landing in Western Pacific Ocean. Velocity at impact - 28 feet per second.

Control features: Extendable skirt for attitude control. Peripheral jet nozzles for attitude stabilization with retrorocket.

Tracking: Minitrack and defense radar.

Schedule: First firing - 23 months; manned flight - 26 months.

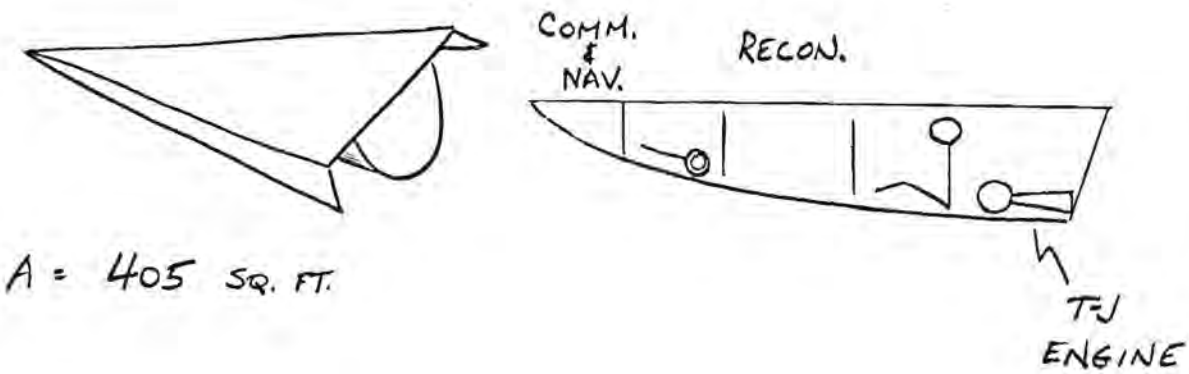
Cost: $\$100 \times 10^6$.

NORTHRUP

Northrup's presentation stressed the previously presented Dyna-soar proposal along with the military advantages and capabilities of the reconnaisance-bomber glider vehicle. Their man-in-space proposal is essentially an adaptation of this vehicle.

Pertinent Features

Vehicle: A glider as outlined below:



Weight: 10,500 pounds including 400 pounds fuel and a J-83 turbojet engine for final maneuver and landing.

Boosters: Three stages not detailed. The boost requirements vary in carrying out the separate steps in the development program. For the satellite flight the three stages of boost would each require a mass ratio of 3.6 with oxygen - JP-4. Initial gross weight, about 600,000 pounds. Maximum g's - 3.

Range and Altitude: 22,000 miles. Total time 70 minutes, attitude and speed variable with time, maximum altitude 200,000 feet.

Reentry: By increasing drag as glider descends. Maximum temperatures 3450° F at leading edge; 2150° F on lower surface, 1000° F on upper surface. 100 pounds liquid coolant and radiation cooling.

Recovery and landing: Conventional glide landing.

Tracking: Self-contained navigational system claimed to have 2 miles C.E.P.

Schedule: First glider vehicle 1960, boost flight tests at 4000 - 5000 mile range - 1961, near-orbital manned flight - 1964.

Cost: 22 test vehicles.

Year	Megadollars	Year	Megadollars
1958	0.5	1962	92
1959	26.5	1963	59
1960	57	1964	29
1961	116		
		Total	380

Discussion

The test sequence for the various stages of vehicle development would be: (1) air launch from a carrier aircraft, (2) unmanned version for boost development testing, and (3) manned tests. Several technologies are needed, particularly the development of reliable boost rockets. Results of the X-15 high-speed flights and development of stellar-sight guidance equipment are also required.

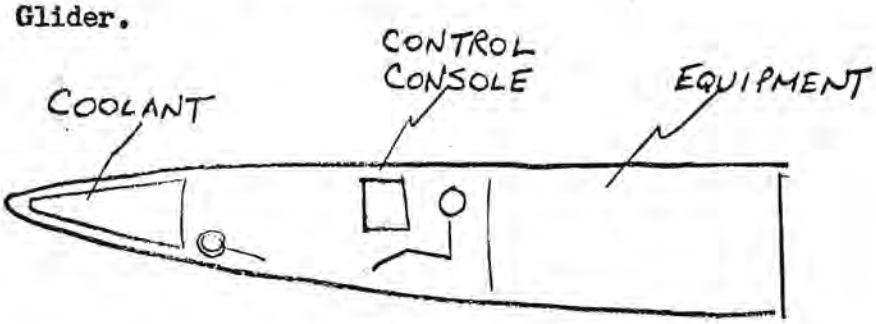
Development of this vehicle brings with it the possibility of bombing or reconnaisance missions. These Northrup has detailed in the "Dyna-soar" proposals. Much of the allotted discussion time was spent in reviewing these weapon system capabilities.

BELL

Introduction by Dr. Dornberger. Presentation by Mr. Casey Forest. Dr. Dornberger discussed briefly a 3000 pound eight-foot sphere with retrorocket and maximum stagnation temperature of 3500° F; maximum deceleration - 8 g's. Although it could be accomplished one and one half years sooner, he dismissed the sphere as having no growth potential. Bell's proposal therefore hinged strongly on their ROBO concept. The glide vehicle is outlined in the following.

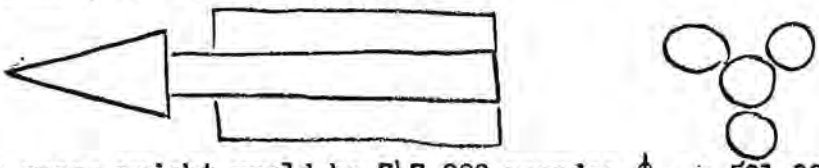
Pertinent Features

Vehicle: Glider.



Weight: 18,800 pounds.

Boosters: Several assembled configurations were discussed. The one favored was a three-stage clustered configuration with three Titans, one Titan, one F_2-NH_3 rocket, as diagrammed below:



Initial gross weight would be 747,000 pounds; ϕ_1 = 521,300 pounds, ϕ_2 = 175,300 pounds, ϕ_3 = 31,300 pounds, airplane - 18,800 pounds, research equipment 1500 pounds. Total propellants would be 669,500 pounds. Maximum acceleration - 4 g's.

Time and altitude: 127 minutes duration. Boost for seven minutes. Altitude at end of boost - 260,000 feet. Follow maximum L/D (Breguet) path.

Recovery and landing: Conventional man-controlled glider landing.

Navigation: Self-contained.

Schedule: Five years. Flight in 1963.

Cost: $889 x 10^6 including everything. Maximum cost in 1961 - $240 x 10^6.

Discussion

A short term (10 hour) satellite glider was also mentioned.

Bell has had a contract for development of a F_2-NH_3 rocket; they are willing to incorporate a $F_2N_2H_4$ rocket in the manned glider as the third stage of boost. In their ROBO studies and F_2NH_3 development work Bell claims to have a $2.5 x 10^6 effort, with the USAF also spending $2.5 x 10^6.

A system development team has been in existence for more than a year. This team is organized as follows:

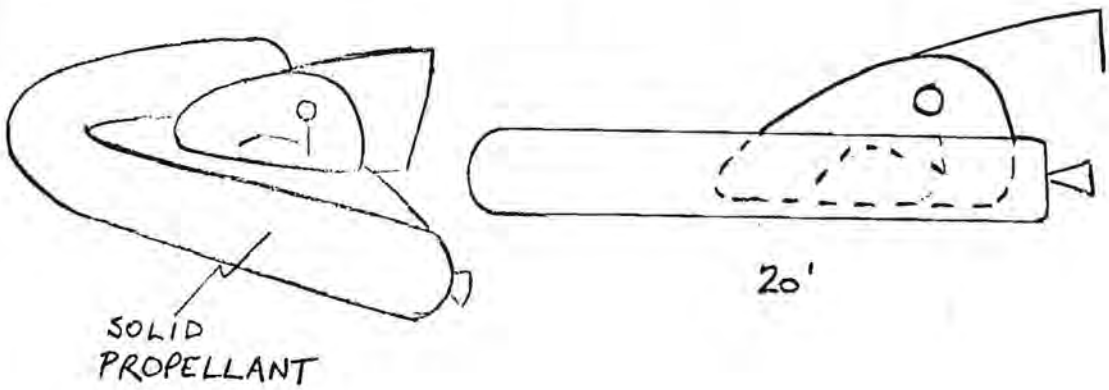
Airplane	Bell Aircraft
Electronics	Bendix Aviation
Navigation	Minneapolis-Honeywell
Boost	--------
Ground and Supplies	--------
Special Radar	Goodyear Aircraft

REPUBLIC

Introduction by Dr. Alexander Kartveli, Vice-President of Research and Development. The Republic proposal was based on the hypersonic glider concept of Dr. Antonio Ferri.

Pertinent Features

Vehicle: A blunt leading-edge sled with solid propellant rockets housed in the edges. Surface = 120 square feet. W/S = 25 pounds per square foot. $C_L = 0.7$.



Weight:

Propulsion	1000 pounds
Electrical	375 pounds
H_2O_2 control	175 pounds
Weight Total	3895 pounds (includes other factors)

Boosters: Atlas or Titan with modified propellants.

Time and altitude: 24 hours. Perigee 550,000 feet, reentry altitude - 300,000 feet.

Reentry method: Two retrorockets (-65 feet per second) applied at apogee. This reduces perigee to 300,000 feet. At this altitude produce negative lift (0.0005 g) by flying airplane inverted to prevent increasing altitude. Reaches M = 2 at 80,000 feet. Angle of attack on reentry about 40°. L/D = 1. Maximum temperature = 2500° F.

Recovery and landing: Ejection seat for pilot and survival kit. Vehicle destroyed.

Safety features: H_2-O_2 attitude controls. Three aerodynamic control surfaces.

Guidance and tracking: Inertial guidance with short term rate gyros, accurate within 20 - 25 miles in position. Also UHF communication and beacon transponder.

Schedule: 18 months. Lead item claimed to be inertial guidance system.

Cost: Not estimated.

Discussion

The performance estimates of the booster units are summarized in the following:

	Stage 1	Stage 2	Stage 3
Wo	198,700	74,000	15,000
W_{Bo}	78,600	16,890	4,000
F	304,000	72,200	16,000
I_s	230	250	265

CONCLUSION

This was the first round of proposals. Mr. Bell and WADC people expected to review these critically (they solicited comments from the NACA representatives before breakup of the group). A second round of the favored proposals was in the latter part of February and was planned to yield a proposal for WADC to submit to the Pentagon.

Adelbert O. Tischler

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Head, Rocket Combustion Section

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