JSC-23309

307 pages

A Shuttle Chronology 1964 --- 1973 Abstract Concepts to Letter Contracts

VOLUME I

Abstract Concepts to Engineering Data; Defining the Operational Potential of the Shuttle

Management Analysis Office
Administration Directorate

December 1988

NASA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

<u>Final Vehicle Lines and Flight Mechanics</u> (CONFIDENTIAL, downgraded 1 June 1972), <u>Vol. IV - Final Configurations Thermostructural Design, Sub-Systems, & Weights</u>, 12 July 1968.

1968 July 17 In response to a 17 June RFP (request for proposal) McDonnell Douglas Astronautics Company (MDAC) submitted a proposal to develop a derivative of the Gemini spacecraft for logistic support of a space station. MDAC proposed to examine the design, development and use of various Gemini derivatives in conjunction with Titan and Saturn launch vehicles. The proposal assumed that NASA would "supply the current launch vehicle data" on "the vehicles to be utilized for this study."

The initial design requirements were to "provide the capability to transport a nominal 9 man crew and cargo to low earth orbit." The crew size and cargo requirements were to be "further defined from considerations of the requirements of the space stations which will be supported by this vehicle." Both 7 day and 90 day missions were envisioned as was extended "orbital quiesent" storage in orbit for "at least 180 days."

The proposal addressed two primary spacecraft concepts. These were ~~a~~ baseline Big G design, based on a crew module which differed ~~little from the~~ existing Gemini capsule, and an Advanced Logistic Spacecraft System (ALSS) which was designed around a 60° cone. In either case, the study was to "concentrate on the definition of a minimum cost logistic spacecraft based largely on the existing Gemini B configuration."

McDonnell Douglas Astronautics Company, Big G: Proposal for a Logistic Spacecraft Evolging From Gemini, Part 1 - Technical, and Part 2 - Cost, 17 July 1968.

1968 August 1 — NASA initiated study on a logistic spacecraft development of the Gemini capsule in conjunction with McDonnell Douglas Astronautics Company (MDAC). This was the beginning of the Big G (for Big Gemini) Program, pursued by MDAC under contract NAS9-8851 (see the 17 July entry, above, and the 11 October 1968 entry, below).

McDonnell Douglas Astronautics Company Briefing, "Logistics Spacecraft System Evolving from Gemini, "Big G," atch to memo with encl, W. S. Beckham, MSC, to distr, "Mid-term briefing, Contract NAS 9-8851, Logistic Spacecraft Evolving From Gemini (Big 'G')," 6 January 1969,

1968 August 10 — George E. Mueller, Associate Administrator for Manned Space Flight, gave a speech to the British Interplanetary Society (BIS) of London, England outlining NASA's aspirations for future space programs in a way that stressed the importance of reducing the cost of space operations. In his speech, Mueller made the first public reference to the Space Shuttle as a name for a specific vehicle concept; before this Space Shuttle had only been used as a generic term for a reusable earth orbit spacecraft. Stressing economy in space operations, Mueller gave this explanation of why he saw the Space Shuttle as being crucial to NASA's future operations:

to the issuance of the Integral Launch and Reentry Vehicle (ILRV) study contracts.

"Foreword and Background," Atch to Contract No. NAS9-9205, 31 January 1969.

1968 October 7 — As originally announced at a press conference with President Lyndon B. Johnson on 16 September 1968, Administrator James E. Webb resigned from NASA.

Astronautics and Aeronautics, 1968: Chronology on Science, Technology, and Policy (Washington, D.C., 1969), 212-13.

1968 October 7 — Thomas O. Paine, formerly Deputy Administrator, became Acting Administrator.

Astronautics and Aeronautics, 1968: Chronology on Science, Technology, and Policy (Washington, D.C., 1969), 212.

1968 October 11 — NASA signed a $436,000.00 study contract with McDonnell Douglas Company for examination of a logistic spacecraft Gemini derivative, the "Big G" program, Contract NAS9-8851 managed by MSC. Northrop Corporation was awarded a subcontract worth $75,000.00.

The study was to run for 45 weeks. It addressed a minimum cost approach to the logistic support of a space station or space base (see the 17 July 1968 entry, above).

McDonnell Douglas Astronautics Company Briefing, "Logistics Spacecraft System Evolving from Gemini, "Big G," atch to memo with encl, W. S. Beckham, MSC, to distr, "Mid-term briefing, Contract NAS 9-8851, Logistic Spacecraft Evolving From Gemini (Big 'G')," 6 January 1969.

1968 October 23 Douglas Lord of NASA Headquarters and John Hodge of MSC exchanged letters about information that Hodge had provided concerning MSC's plans for a Phase B Space Station study and for studies of the Big Gemini and the Integral Launch and Reentry Logistics System (ILRV). About the ILRV Lord observed:

> Your charts indicate a plan to constrain this study to concepts available in time for the 1975 space station. I consider this an unreasonable constraint, particularly in view of Dr. Mueller's desire to examine the stage-and-a-half concepts. If you attempt to relate this study too closely to the 1975 availability, no one is going to be satisfied with the output. It also appears the timing for this study is one of the forcing factors which is delaying your space station study.

Hodge replied to Lord's concerns by explaining that an effort was being made to expedite the ILRV study, and that a contract was scheduled to be awarded by 31 December 1968. Hodge further stated: "I also accept your comment relative to constraining the ILRV study to concepts within the 1975 time period and will look at concepts such as the stage-and-a-half which are beyond the 1975 time period."

Ltr, Douglas R. Lord, Hq., to John D. Hodge, MSC, 23 October 1968; ltr, John D. Hodge, MSC, to Douglas R. Lord, Hq., 25 October 1968.

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ILRV Results and the Space Design Division

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office that was then responsible for advanced mission planning and the types of programs being considered:

> The Advanced Manned Missions program office is responsible for overall systems engineering, planning, and definition of all advanced manned space flight mission studies and projects beyond those encompassed by AAP. It is also responsible for technical feasibility studies of major alternatives or additions to this office continued to study all aspects of potential future manned space flight systems and missions. Major attention was focused on space station and space shuttle concepts.

Concerning the shuttle the Report noted that "proposals for several promising space shuttle concepts were submitted to NASA as a result of the search for a low-cost transportation system."

NASA, Twentieth Semiannual Report to Congress July 1-December 31, 1968 (Washington, 1969), 46-47.

1969 January 24 George E. Mueller, Associate Administrator for Manned Space Flight authorized MSC to negotiate the Integral Launch and Reentry Vehicle (ILRV) study contracts. Mueller approved the letting of four, instead of two as previously planned, ILRV contracts. Mueller directed that MSC manage the North American Rockwell contract, that MSFC manage the General Dynamics and Lockheed contracts, and that LaRC manage the McDonnell Douglas contract.

These contractors were provided with what NASA called "ILRV Mission Requirements." The ILRV vehicles were to be "capable of varying passenger/cargo mixes" that would include a "total of 12-man capability for crew and passengers" and a single pilot operation. The ILRV was to have "a nominal discretionary lofted cargo of 25,000 lbs. to a 270 n.m. 55° orbit," but NASA advised the ILRV contractors that "the range of 5,000 to 50,000 lbs. [payload] will be investigated parametrically." The minimum "return discretionary cargo" was 2,500 lbs, with the maximum "being limited by the particular concept under investigation." NASA left the number of flights per year for the ILRV open but stated that "for baseline comparison purposes nominal launch rates of 8 and 12 per year will be used."

"Foreword and Background," atch to Contract No. NAS9-9205, 31 January 1969. See also: Dan Schnyer interview, Hq., 20 October 1984.

1969 January 31 NASA awarded four contracts, to North American Rockwell, General Dynamics, Lockheed, and McDonnell Douglas, for Integral Launch and Reentry Vehicle (ILRV) studies (see 24 December 1968 entry).

"Foreword and Background," atch to Contract No. NAS9-9205, 31 January 1969. See also: Dan Schnyer interview, Hq., 20 October 1984.

1969 February 10 Andre J. Meyer, Manager of the Lunar Exploration Project Office of the MSC Advanced Missions Program Office (AMPO), made handwritten notes of discussions held in a staff meeting of the AMPO. Some of the comments made in this, and other staff meetings of the AMPO, concerned the status of advanced planning at MSC and NASA:

> [John] Hodge [manager of AMPO] feels press misinterpreted Nixon's instructions to DuBridge [the President's Science Advisor]. Look into means of doing space fl[igh]t cheaper....
>
> Everything is confused, maybe by design until Nixon direction is provided.

> doesn't like the MSFC concept. Favors LaRC concept and Paine concurs. Paine wants an advanced logistics system, not an Apollo derivative, but rather the Gemini B (MOL config.) cabin and add on passenger cabin & supply section.
>
> Aim is to get the President to commit to a continuing Manned Space Program.
>
> Paine opposes "National Prestige" & "etc." Don't use them.
>
> Manned space flight is still and will continue to predominate with unmanned at a low level. They are not even in most of these planning mtg's.
>
> MSFC is really building up to handle the advanced program.

Andre J. Meyer, MSC, handwritten notes, notebook VII, 7 March 1969 [Meyer notes].

1969 March 14 — In testimony given to the House Subcommittee on Manned Spaceflight, North American Rockwell provided an explanation of the value of the Big G (Fig. II-1) program at a time that NASA and industry were preparing for a reusable Space Shuttle:

> If, however, budget constraints prohibit the simultaneous development of a new logistics vehicle, a new launch vehicle to launch it, and a space station, we feel that the system which is based on Apollo-type hardware and derivatives of the current Saturn launch vehicle provides an excellent interim logistic system for the first year or 18 months of space station operation while the new shuttle is being developed (Fig. II-2).

House Committee on Science and Astronautics, 1970 NASA Authorization, Hearings before the Subcommittee on Manned Space Flight, 91st Cong., 2d sess., pt. 3, Feb. 23, Mar. 14, 1969.

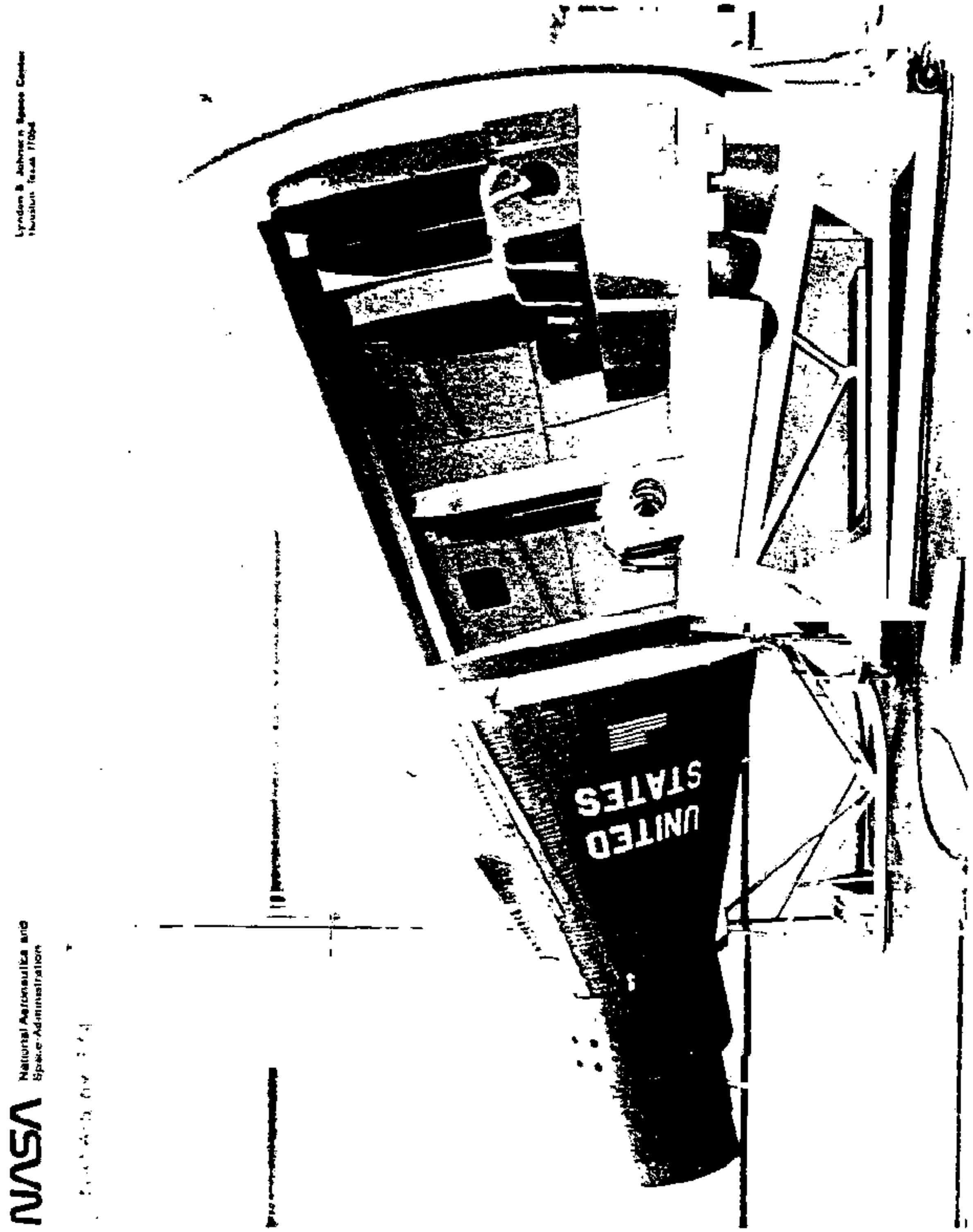

Figure II-1.- "Big G" (Date of entry, 3-14-69).

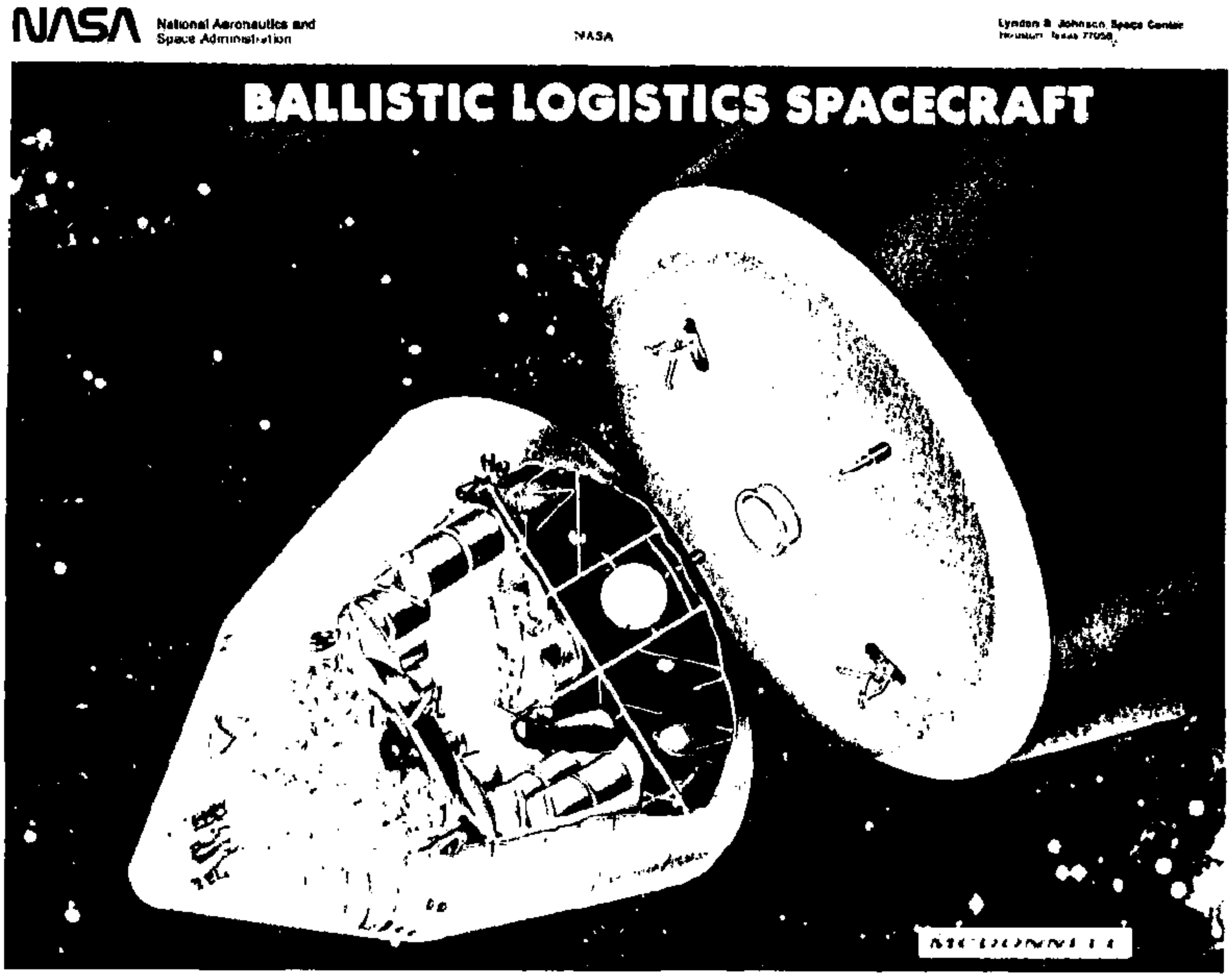

Figure II-2 - Ballistic Logistic Spacecraft (Date of entry 2-10-70)

1969 March 20	From discussions held in a staff meeting of the MSC Advanced Missions Program Office (AMPO), Andre J. Meyer, Manager of the Lunar Exploration Project Office of AMPO, noted some of the activities that MSC was currently engaged in that related to the development of the Space Shuttle. Meyer recorded the creation of the MSC "Skunk Works" that played a central role in the Center's early research and development work on the shuttle with this observation: "[James] Chamberlin [manager of the Design and Analysis Office of the Engineering and Development Directorate at MSC] assigned to work on Logistics Vehicles for RRG [Robert R. Gilruth Director of MSC]. Lockheed brief'g Kim on stage & half."

Another notation by Meyer gave Rene Berglund's (manager of the Advanced Projects Office of AMPO) assessment of MSC's advanced planning "distribution of effort" -- "10% space base, 5% art[ificial] 'G' cluster 55% Space Station, 10% Big G, 10% CSM, & 10% for Adv[anced] Log[istic] Systems."

Andre J. Meyer, MSC, handwritten notes, notebook VII, 20 March 1969 [Meyer notes]. See also: ibid., notebook VIII, 21 April 1969 [Meyer notes].

1969 March 27	Andre J. Meyer, Manager of the Lunar Exploration Project Office of the MSC Advanced Missions Program Office (AMPO), indicated in his notes of an AMPO staff meeting the growing interest of the Manager of AMPO, John D. Hodge, in what was to become known as Phase A of the Space Shuttle, the Integral Launch and Recovery Vehicle (ILRV).

Andre J. Meyer, MSC, handwritten notes, notebook VII, 27 March 1969 [Meyer notes].

comparative analysis of the five heat shield concepts mentioned above, the proposal argued "that passive reradiative cooling using LI-15, supplemented by ground cooling after landing," is the "most reliable and economical system."

Lockheed Missiles and Space Company, Proposal for Study of Integral Launch and Reentry System, Vol I, Technical Proposal, 29 November 1968, with atch coverletter, C.F. Hagenmaier, Lockheed, to Thomas Mancuso, MSC, "Solicited Proposal: 'Study of Integral Launch and Reentry System,'" 27 November 85 [Lockheed documents].

1968 December 11 — MSC requested authorization from NASA Hq. to initiate a contract to study logistic spacecraft. The Request to Negotiate (RTN) was titled "Study of Integral Launch and Reentry Vehicle;" it was the first formal step in the MSC shuttle design effort.

Ltr to distr, Carl B. Peterson, MSC, "Integral Launch and Reentry Vehicle Study Information Data Package," 28 February 1969, cvr ltr to NASA Contract No. NAS9-9205, 31 January 1969.

1969 January 9 — McDonnell Douglas Astronautics Company (MDAC), Eastern Division, conducted ~~a mid-term briefing~~ on Contract NAS9-8851, the "Big G" Program, a Gemini applications program, in the Building 30 Auditorium at MSC. MDAC envisioned the "Big G" spacecraft as a scaled-up Gemini vehicle with a crew of from three to nine. The posited mission was space station logistic support, typically entailing low earth orbits of 100-300 nm at 28-30° inclination and a system availability date of 1973 to 1975.

The program objective was a logistic capability at minimum cost. Land landing in the continental U.S. was the preferred recovery option, with water recovery capability to be retained. MDAC proposed two basic crew modules: a so-called "min-mod" vehicle and an "Advanced Big G." Typical effective spacecraft launch weights varied from 13,538 lbs to 13,678 lbs. Launch vehicles considered included the Titan IIIM, the Saturn IB, and the Saturn S-IC/S-IVB. Orbital cargo delivery capability (cargo plus containers) ranged from 3,180 lbs with the Titan IIIM booster at 90° orbital inclination, to 11,800 lbs with the Saturn IB at 28.5° inclination, and 65,375 lbs at 90° inclination using a Saturn S-IC/SIVB booster with launch steering. The design return cargo capability was 2,000 lbs. MDAC suggested several recovery options; notable among these were an externally deployed parawing and bicycle landing gear supplemented by outriggers.

McDonnell Douglas Astronautics Company, Eastern Division, Report G894, BIG G, Logistics Spacecraft System Evolving from Gemini, Mid-Term Oral Briefing Presented to NASA Manned Spacecraft Center, Contract No. NAS9-8851 (Saint Louis, Missouri), 9 January 1969.

1969 January 10 John D. Hodge, MSC Manager, Advanced Missions Program, circulated an internal memorandum announcing a series of contractor briefings, to be given at MSC in response to interest expressed by NASA "in recent months" in "low cost earth orbit transportation such as the 'stage-and-one-half' or 'Space Shuttle' type of systems." The purpose of the briefings was "to inform MSC personnel of the industry efforts undertaken to date, the major trade-offs involved in a system selection, the development required, and the cost and schedules involved...."

The memorandum was circulated on a Friday; the briefings were to be conducted beginning the second Tuesday following. Each briefing was to begin at 9:00 o'clock and run until noon; however, contractor personnel were to be available for detailed discussions in the afternoon. The contractors, scheduled dates, and security classifications of the briefings were:

Lockheed	21 January	Unclassified
Martin Marietta	22 January	Unclassified
North American Rockwell	23 January	Unclassified
McDonnell Douglas	28 January	Unclassified
General Dynamics	29 January	Secret

Hodge predicted that MSC would become "increasingly involved" in "the general area of high L/D [lift to drag ratio] spacecraft" and urged attendance at the briefings.

Memo to distr, John D. Hodge, MSC, "Presentations on state of development of low cost earth orbit transportations systems," 10 January 1969.

1969 January 16 Maxime A. Faget, Director of Engineering and Development at the MSC, responded to a memorandum from Caldwell C. Johnson, Chief of the Spacecraft Design Office, arising from discussion of the "Big G" Study. Johnson's memo had stated that "Pressure garments will surely be carried [on logistic space station support missions], if for no other reason than to have them available at the station" and went on to suggest that if pressure garments "are carried, it might be argued that they might as well be worn and the cabin ECS [environmental control system] done away with. In reply, Faget stated his convictions on the subject:

> "We made a mistake when we did not design the Apollo Command Module for shirtsleeve crew operation. Objections to this approach were voiced by FCOD [Flight Crew Operations Directorate], FOD [Flight Operations Directorate], and the Medical people and their views prevailed over the designers who pointed out that greater safety could be obtained by applying the same weight and financial resources into a safer cabin, etc. These same factions have changed their views and not only have confidence in the basic cabin structure, but see virtue in the additional freedom afforded the astronaut by removal of the bulky suit. I therefore see no basis at all for further consideration of the use of pressurized garments within the logistic spacecraft (including launch and reentry flight plans). The many benefits in simplification and cost savings accrued by not encumbering the spacecraft with those many complicating features required to support pressure-suited occupants overwhelm any argument that such features should be maintained to cater to archaic requirements on a contingency basis or for other traditional considerations.

Memo C[aldwell] C. Johnson to Maxime A. Faget, MSC, "Use of pressure garments in logistic missions." 13 January 1969; Maxime A. Faget Memo to C. C. Johnson, "Use of pressure garments in logistic spacecraft," 16 January 1969

1969 January 22

A Martin Marietta Corporation briefing team headed by R. B. Demoret, Manager, Advanced Concepts and Marketing, presented an overview assessment of future space transportation system options to NASA officials at MSC, followed by a similar presentation at MSFC the following day. The presentation focused on lifting reentry and "stage and one-half" systems, presuming a spacecraft with a crew of nine. It included a historical summation, tracing applicable lifting systems

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which indicated significant advantages for the 1½ stage vehicle in RDT&E (research, development, test and evaluation) first vehicle and recurring costs.

Lockheed indicated a preference for passive, as opposed to active, TPS. The preferred heat shield options were, in the order stated: rigid LI-1500 insulation, a metallic heat shield with fibrous insulation, and full or partial depth ablator.

Metallic heat shield materials considered included René 41, Haynes 25, TD NiCr, Cb 752 columbium alloy and 90 Ta-10W tantalum alloy; the last two of these were coated to avoid oxidation. Lockheed considered TD NiCr (thorium-dispersed nickel chromium alloy) an "attractive" heat shield option which "introduces design risk" and felt that "rigid insulators offer potential low cost" and "multiple reuse" potential.

> Lockheed Missiles and Space Company, <u>ILRV Interim Technical Review</u>, 21 August 1969 [Lockheed Files].

1969 August 21 — McDonnell Douglas Astronautics Company submitted the final report of its study of the Big G logistics spacecraft, conducted under Contract NAS9-8851, managed by MSC. The study was based on a vehicle derived from the Gemini spacecraft which "would be used to resupply an orbiting space station" and had been ongoing since July of 1968 (see the 17 July 1968 entry, Chapter I).

The study defined two baseline spacecraft. The first was a minimally modified version of the Gemini B designed to carry a total of nine passengers and crew called the Min-Mod Big G. The second was an advanced concept twelve man design with the same external geometry, but with "new, state of the art subsystems" called Advanced Big G (Fig. III-4). Three booster systems were considered during the study: Saturn S-IB, Titan IIIM and the INT-20. The INT-20 (for Intermediate 20) booster was a Boeing design based on a modified Saturn S-V/S-IVB stack. The Saturn S-V stage was modified by the removal of the center F-1 engine, reducing the number of engines to four. The S-IVB upper stage was essentially unmodified.

The basic spacecraft design consisted of a crew module designed by extending the Gemini B 40° exterior cone to back a 165 in. (13 ft) diameter heat shield. A cargo propulsion module was attached to the crew module for up cargo and orbital operations. Orbital transfer, rendezvous and docking, attitude control and deorbit propulsion functions were all performed by a single liquid propellant system. Recovery of the crew module was by parawing and a three skid landing gear extended from the bottom of the crew module. Design and analysis of the parawing and landing mode were accomplished by Northrup-Ventura under a subcontract. Launch escape was provided by an Apollo-type solid rocket escape tower mounted on the spacecraft nose.

The Min Mod spacecraft was 18 ft long and 13 ft in diameter at the base of the heat shield. The cargo module added 20 ft 7 in. to this for a total length of 38 ft 7 in. exclusive of the escape tower. Total length with escape tower attached was 77 ft 9 in. It was designed to be launched by a Titan IIIM booster (the Saturn S-IB was discarded late in the study). Total height in launch configuration was 173 ft.

Launch weight of the spacecraft with the Titan IIIM was 13,721 lbs, of which 1,620 lbs was personnel. The cargo and propulsion module had a launch weight of 21,760 lbs, of

LOGISTIC SPACECRAFT CONFIGURATIONS

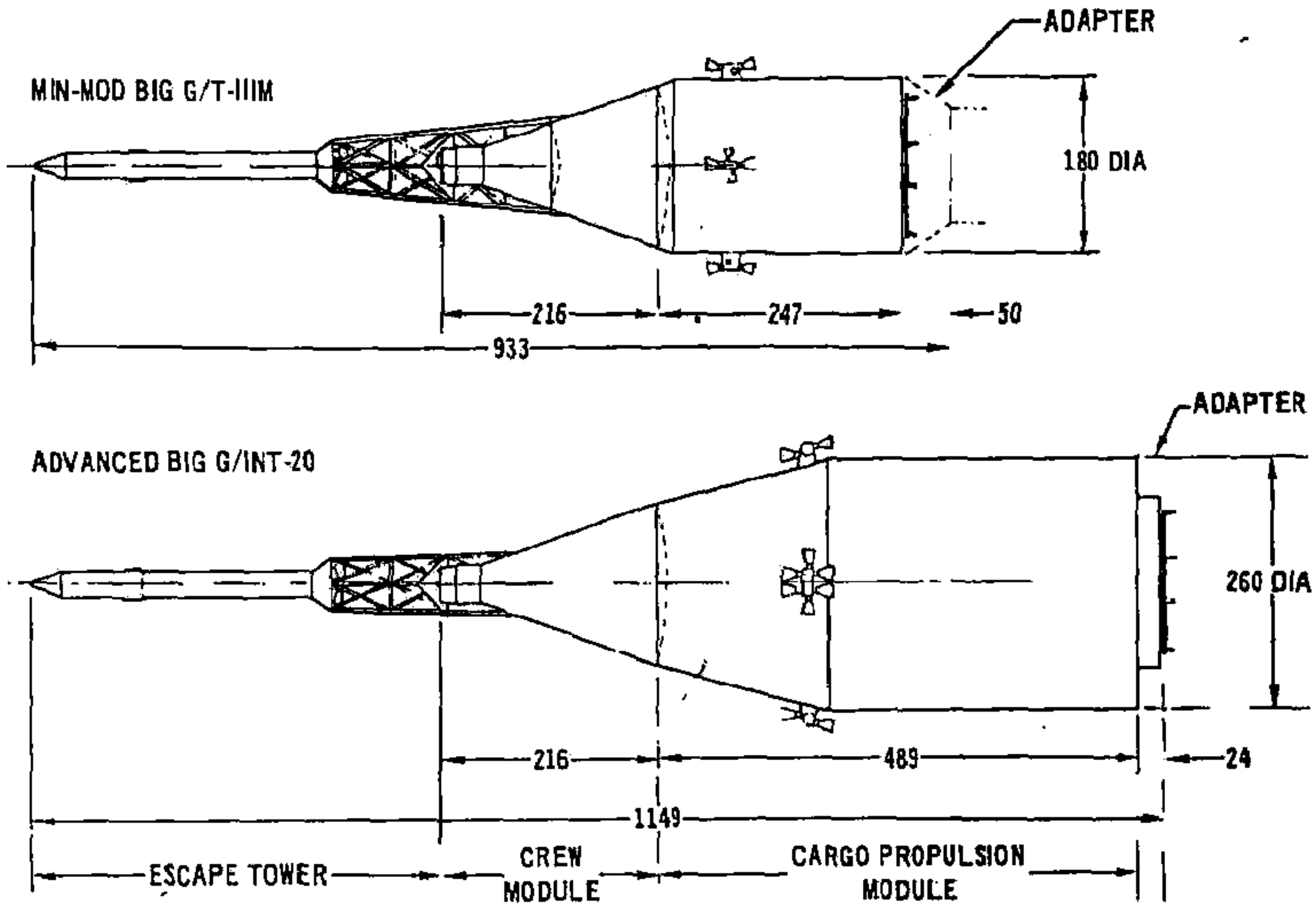

Figure III-4.- Mini Mod/Advanced Big G spacecraft configurations (Date of entry, 8-21-69).

which 6,630 lbs was cargo. The launch escape system added 4,266 lbs to the total of 36,100 lbs.

The Advanced Big G spacecraft was 18 ft long and 13 ft in diameter at the base of the heat shield. The cargo module added 40 ft 9 in to this for a total length of 58 ft 9 in. exclusive of the escape tower. Total length including escape tower and the adapter ring at the base of the cargo module was 95 ft 9 in. The Advanced Big G was designed to use either the Saturn S-IB or the INT-20 booster.

Launch weight of the spacecraft with the INT-20 booster was 14,136 lbs, of which 2,160 lbs was personnel. The cargo and propulsion module had a launch weight of 104,778 lbs, of which 68,964 lbs was cargo. The launch escape system added 4,266 lbs to the total of 120,200 lbs.

Return cargos of up to 4,000 lbs were envisioned.

MDAC estimated that a flight test Min-Mod vehicle could be launched 37 months from go-ahead and that the first operational vehicle could be launched 43 months from go-ahead. The Advanced Big G schedule added three months to these figures. Parawing technology was considered "the pacing item in the development program." Parawings had not been demonstrated with payloads above 6,000 lbs at this point, well below the 18,000 lbs required for Big G though MDAC was "reasonably certain" that the required capability could be achieved.

Big G system cost estimates for ten units were as follows:

	Min-Mod/T IIIM	Advanced Int/20
Development	\$518M	\$777M
Spacecraft (New)	\$44M	\$55M
Spacecraft (Refurbished)	\$22M	\$28M

McDonnell Douglas Astronautics Company, Big G Final Report, Vol. I, Condensed Summary, Vol. II, Spacecraft Design and Performance Summary, Vol. III, Mission and Spacecraft Performance Analyses, Vol. IV, Launch Escape, Landing and Recovery System Analyses, Vol. V, Spacecraft Design and Weight Analyses, Vol. VI, Subsystems Analyses, Vol. VII, Refurbishment and Reuse, Reliability and Operational Support Analyses, and Vol. VIII, Program Development, Costs and Study Results, 21 August 1969.

1969 September 11 — George E. Mueller, Associate Administrator for Manned Space Flight, issued instructions that MSFC be given responsibility for shuttle auxiliary propulsion development. He did so in line with recommendations contained in a presentation by Jerry Thomson, MSFC, that MSC and MSFC were to share in the expenditure of \$1.8 million for this purpose. Thomson's presentation was given at a special session on shuttle technology following the Management Council meeting.

Ltr, Robert R. Gilruth, MSC, to George E. Mueller, Hq., 26 September 1969, atch to ltr, George E. Mueller, Hq., to Robert R. Gilruth, MSC, 20 October 1969.

1969 September 14 — Robert R. Gilruth, Director of MSC, and Wernher von Braun, Director of MSFC, agreed that MSC should be responsible for orbiter development and MSFC for booster development. This