Informal Working Papers: Technical History of Saturn
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D R A F T

Authorization by the Advanced Research Projects Agency (ARPA) of the Department of Defense, to construct a 1,500,000 pound thrust booster, in 1958 came as a result of several years' concerted effort by Development Operations Division, Army Ballistic Missile Agency. While preliminary theoretical studies of earth satellites had taken place as early as 1947, the first detailed engineering study was a publication issued September 15, 1954, "The Minimum Satellite Vehicle Based Upon Components Available From Missile Developments of the Army Ordnance Corps," by Dr. von Braun. This study laid the basis for a program in which the Air Force and Navy were invited to participate. The Air Force declined since their interest lay in orbiting much heavier satellites, but the Navy accepted. The Army-Navy cooperative effort culminated in the submission of a proposal, Project Orbiter, in August 1954.

Active interest in space projects continued at ABMA, and during the period ending with approval of the Juno V program, five discrete launch vehicle design studies were completed.

In addition, concrete plans for an integrated space program were developed which materially aided later in identifying a National space program.

Influence of the International Geophysical Year (I.G.Y.). The International Geophysical Year (July 1, 1958, to December 31, 1958) had a profound influence on the U. S. space activity. Ideas and proposals for space exploration, heretofore confined to elements of the Department of Defense, received broad support of the international scientific community. Fred Singer, an American delegate to the Fourth Congress of the International Astronautical Federation meeting in Zurich, Switzerland, in August 1953 had proposed orbiting a small earth satellite. Another proposal was made at the Third Symposium on Space Travel in May 1954 meeting at the Hayden Planetarium, by a representative of the U. S. Weather Bureau, Harry Wexler. The following October at a meeting of the International Council of scientific unions in Rome, discussions of the possibility of launching an earth satellite as a scientific experiment of the I.G.Y. took place. These discussions led to the adoption of a resolution recommending the project.

In the United States, the National Committee for the I.G.Y. endorsed the satellite project and on July 29, 1955, the President approved the endorsement. Scientific responsibility for the program was assigned the National Academy of Sciences and fiscal responsibility assigned the National Science Foundation. The Department of Defense was required to furnish logistic and technical support as well as launching rockets.

The Department of Defense, at the time, had under consideration several proposals from the military services for the development of satellites and satellite launch vehicles including Project Orbiter. The Department of Defense Advisory Group on Special Capabilities (Stewart Committee) and the Department's Policy Council recommended approval of a Navy proposed project. Approval was granted in September 1955. The Navy proposal drew heavily upon experience gained in their Upper Atmosphere Research Program which began with the V-2 launches at White Sands, New Mexico and led to the development of the ~~used~~ the Viking and Aerobee-Hi Launch rockets. The new program was designated Vanguard.

With the apparent loss of the opportunity to participate in the U. S. satellite program, ABMA concentrated upon development of the Jupiter ballistic missile. As a part of that development, a test program to verify design of the warhead reentry body was undertaken. The test program required test conditions that could best be duplicated by actual reentry. The Redstone missile, modified to serve as the required reentry test vehicle, was designated Jupiter C. In response to an ABMA request to use the Jupiter C as a back-up to Vanguard, a Department of Defense Directive was issued on June 21, 1957, citing a May 1956 memorandum from Mr. Holaday, directing ABMA to dissest from satellite activity.

The Russians, however, succeeded in orbiting Sputnik I on October 4, 1957. Their achievement prompted an announcement that Vanguard would orbit a four-pound satellite during December 1957, to be followed by a scientific satellite in March 1958. The question of ABMA's participation on a back-up basis was then reopened. Authorization to proceed was received on November 8, 1957, and executed on January 31, 1958, just 84 days later. by Explorer I.

Nation Impact of Operating Satellites. Just as the I.G.Y had exerted a deciding influence by sponsoring adoption of earth orbiting satellites for collection of scientific data, the actual launchings by the Russians impressed the American public with the potential of satellites and space exploration. Congress or the President moved to reexamine the National posture relative to the new field of space. From these examinations there emerged an organized space activity armed with extensive plans detailing a logical and orderly progressive long term space exploration program.

Organization.

In the month following launch of Explorer I, the President directed Dr. J. R. Killian, Jr., to head a committee to study and recommend on Government organization of a national space program. Concurrently with the President's action, the Department of Defense announced activation of the

Advanced Research Projects Agency (ARPA) to provide leadership and coordination of the various space and anti-missile projects conducted by elements of the Department. Congress placed a one year time limitation on ARPA (ending February 1, 1959) for the initiation of non-military space projects.

This organization was instrumental in planning the technical programs to be conducted and in initiating development of the rocket launch vehicles by which the programs could be carried through. Among the many projects initiated by the agency was that of a booster in the 1.5 million pound thrust class. This booster program was later to grow into the Saturn Vehicle Development Program.

The results of findings of the Killian Committee were forwarded to the congress who in turn conducted a series of committee hearings. The resulat of Congressional hearings were embodied in House Resolution 12575 calling for the establishment of a National Aeronautics and Space Administration, modeled after it's predessessor, the National Advisory Committee for Aeronautics. Signed into law by the President, the resolution became the National Aeronautics and Space Act of 1958 (Public Law 85-568). Refining and expanding the agency led to the addition of the Army's Ballistic Missile Development group in October 1959 by Executive Order.

The Technical Plan. As early December 1957, ABMA published the first technical plan for an integrated missile and space vehicle program (9). This plan was followed in April 1958 by a similiar plan published by the Working Group on Vehicular Program (1) conveined by NACA. The program evisioned by ABMA consisted of two principle parts: Instrumented and Manned satellites and Moon flight vehicles. The program suggested development and/or modification of existing hardware into seven basic carriers, designated consecutively Mark I through Makr VII. The carriers were Vanguard, June series, Atlas, Super Titan, Super Jupiter and Suber Atlas. Operational payloads suggested ranged from 21 pounds in 1958 upward to 50,000 pounds in 1970. Interestingly enough, the total Research and development costs for this plan was estimated at 2.6 billion dollars (9). It is also interesting to notice that a scientific exploration was evisioned through 1965 with suitable satellites for communication, reconnaissance, followed by permanent space stations becoming operational in 1965 through 1968. This proposal was of some significance to the Nation Space Effort since it correlated all exciting ballistic missile developments into a single comprehensive space exploration and explortation program. Use of existing long rang rockets was emphasized so as to realize maximum capability at minimum cost. In the tangible sense the proposal suggested the necessity of achieving high payload capability (50,000 pounds) during 1970. The proposal also carried the seeds of the Saturn Program. It proposed a mark VI; Super-Jupiter comfiguration for orbital carrier (9) table XV. Payload capabilities of 20,000 to 30,000 pounds were evisioned for operations over a sever year perios of 1963 to 1970.

By April 1958 an ad hoc Working Group instigated by NACA issued a similiar report (1). The number of vehicles were increased to thirteen disignated mark I through mark XI, see Table 4.

In this report (1) it appears that the so-called Super Jupiter is designated mark X (judging by the fact that 4, E-1 engines are used for booster power), it should also be noted that claimed payload capability has increased to the range of 25,000 to 35,000 pounds.

Sequential events to be expected from a long term space exploration program are shown on tables 1, 2, and 3. These tables reflect the accessment of ABMA, Air Force, and the NACA ad-hoc Working Group as to the time frame during which accomplishment of projects could be expected. An examination of the tables disclose a surprising similarity of the basic philosophical approach: thorough scientific exploration followed by man in space. The purpose of the payloads listed reflect the primary role of the group advancing the plan; Table 3 lays great stress on military - scientific facets, Table 2 follows the same pattern, while Table 1 emphasizes the scientific approach. Commercial applications were also considered in Tables 2 and 3 but are lacking in Table 1. Thus it is seen that ABMA and the Air Force considered a broad base of scientific, military, and commercial benefits to be acquired by the National Space Effort. Thus the sizeable outlay of public funds would reap concrete returns in terms of national defense and in terms of commercial ventures - especially in the communications field. Add to these concrete advantages, the intangables, that could possibly be accured through scientific investigations. Thus the entire package of purposes of satellites and probes gains a proper prospective that cuts across the national objectives of producing an advancing economy in a militarily strong country. This necessary duality of purpose was appreciated by ABMA and exploited to its fullest in their initial plans.

The large orbital payloads estimated as desirable by ABMA in their initial plan (9) is incorporated in the NACA estimate, Table 1. Unfortunately the estimated payload weights were unavailable in the Air Force plan, Table 3. The general missions however, would tend to reflect

~~while the "B" was the final three stage version. This approach permitted an early launch availability of the interium vehicle.~~

which would take advantage of the probabile early availability of the JPL 6K stage earmarked for the third stage of the final configuration; the Juno IV B.

The Juno IV A was found to be incapable of meeting the ~~test~~ requirements shown in Table 8 without a 240 pound reduction in the second stage could be achieved. ~~[illegible]~~ Performance it was concluded as marginal [8]. The Juno IV B was found ~~suit~~. compatable ~~of~~ ~~to~~ with the requirements shown in Table 8.

Projected Long Range Mission Planning
Brig. Gen. H. A. Boushey, Dir. Adv. Technology
U.S. Air Force 1959

Mission	Achieved	Purpose
Unmanned space probes (and lunar probes)	1959	Scientific and military
Unmanned communication satellites	1960	Military and commercial
Unmanned geodetic survey, reconnaissance, and attack-warning satellites.	1961	Military and scientific
Unmanned weather reporting satellites	1961	Military, commercial, and scientific
Unmanned navigation satellites	1961	Military and commercial
Unmanned lunar and planetary satellites	1963	Scientific and military
Manned maintenance, repair, and resupply space vehicles	1965	Military, Commercial, and scientific
Unmanned lunar surface vehicles (soft landing capability)	1965	Scientific and military.
Manned lunar circumnavigation (and return to Earth)	1966	Do.
Manned defensive offensive space vehicles	1967	Military
Manned "all purpose" space station (astronautical observatory, Earth surveillance, weather reporting, and communication relay).	1968	Military, scientific, and commerical
Manned lunar vehicle (landing and return to Earth)	1968	Scientific and military
Manned lunar base (start construction)	1969	Military and scientific

TABLE 1

LONG RANGE MISSION PLANNING Oct. 1958.

Interim Rpt. To the NACA: A National Integrated Missile and Space Vehicle Dev.

EVENT	YEAR	PAYLOAD ROUGH	MISSION
Earth Unmanned Satellites	1958	20/300	Scientific Investigation
Planned Suborbital Flight, Mach7, X-15 Flight, Earth Orbital, hard and soft lunar landing	1959	500/1,500 orbital 500/100 lunar	Scientific
Manned Orbital Flight, Soft Lunar landing, Cis-Martian Probe, Venus Probe	1960	2,800/8,800 orbital 2,500/2,400 probes	Scientific
Solar Probe	1961	600	Scientific
Manned Exp. Space Station, Winged Manned Orbital	1962		Scientific/Military
Lunar Circumnavigation	1963	20,000/30,000 orbital 5,000 lunar	Scientific
Manned Lunar Circumnavigation	1964	5,000 pounds	Scientific
20-Man Interim Space Station	1966		Scientific
Martian Probes, Manned Lunar Landing, Venus Probe	1967	5,000 pounds	Scientific
Establish 50-man Permanent Space Station	1968		Scientific
Orbital	1970	50,000/100,000	Scientific/Military
Large Lunar Expedition	1972		Scientific
Establish Permanent Lunar Base	1973/1974		Scientific
Landing on a Planet	1977		Scientific
Second Expedition to Planet	1978		Scientific

NACA Rpt.

Table 2

LONG RANGE MISSION PLANNING

ABMA Presentation to NASA Dec. 15, 1958

MISSION	PAYLOAD WT. RANGE	DATE	APPLICATION
Unmanned Earth Satellites & Cislunar Probe	20-lb. Orbital 35-lb. Probe	1958	Scientific
Lunar Probe, March 7, X-15 Flight, Manned Rocket Flight	2,000-lb. Orbital 15-lb. Probe	1959	
Static Test Juno V, Orbital, Interplanetary Probe, Manned Orbital	10,000-lb. Orbital 2,000-lb. Probe	1960	
Venusian Probe, Communication Satellite (24-hours Orbit)	1,000-lb. Comm. Satellite	1961	Scientific/ Military
Orbital Satellites, Interplanetary Probes, Venusian Satellite, Martian Probe, Manned Orbital (2 men)	20,000/30,000 Orbital 5,000/7,000 Inter-planetary; 5,000 Martian	1962	Scientific
4-man Space Station, Circumlunar Navigation, Operational Comm. Satellite, Lunar Soft Landing, Solar Probe	5,000/10,000 Lunar Soft Landing	1963	Scientific/ Military/ Commercial
16-man Orbital Flight, Martian Satellite, 20-man equitorial space station		1964	Scientific/ Military
Manned Circumlunar Navigation, Venusian Soft Landing		1965	Scientific
Orbital, Martian Soft Landing	50,000 lbs. Orbital	1966	Scientific
Lunar Landing and Return, 50-man Permanent Space Station		1967	Scientific/ Military

payload weights of similiar missions described in Tables 1 and 2.

These basic plans formed the bases of the initial NASA long range plan which was provisioned by the National Aeronautics and Space Act of 1958. The formal NASA plan was keyed for a progression of space science research and exploration activities for a ten year period, from 1960 to 1970, and indicated important areas for work in the post 1970 period. Four major fields of activity were delineated: scientific satellites, lunar and planetary exploration, application satellites, and manned space flight. Some key milestone events of the plan are shown on the following table (17):

TABLE 4

SELECTED MILESTONE EVENTS OF THE INITIAL NASA 10-YEAR PLAN

YEAR	EVENT
1961	Manned orbital & Auborbital flights Lunar Impact
1962	Prolotype Communications satellite O.A.O Satellite
1963	Soft Lunar Landing (Instruments) Launch Saturn C-1
1964	O.A.O. and Planetary Probe
1965	Prolotype Apollo Test (C-1)
1966	Launch Saturn C-2 (3 stages) Launch RIFT, Unmanned Spacecraft in Planetary
1970	Orbit, Manned Apollo earth orbits, Circum lunar Manned Apollo Flight
Post 1970	Manned Lunar Landing

While the plan shown above is not as detailed as those shown on Tables 1, 2, and 3 it does show that the manned lunar landing was to take place in the post 1970 era which is in substantial agreement with the NACA Working Group report (Table 1) but not with ABMA (Table 2) or the Air Force plans (Table 3).

In viewing these plans it must be remembered that they were keyed to launch vehicle availability. The availability was directly relateable to the timely approval and allocation of funds for development.

With the submission of budget requests for Fy 62 the National Administration refused approval funds requested for large booster developments. This precluded the possibility of manned lunar landings until mid 1970's. (17). The lack of timely fiscal action therefore invalidated the plans shown in Tables 2 and 3 in so for as manned lunar landing events were concerned. All three of the basic plans, (Tables 1, 2, and 3) in addition to the formal NASA plan (Table 4) emphasized the gradualism necessary when confronted with exploratory effort in an unknown field. The major differences in preliminary planning and the formal plan appears in the absence of operational space stations during the 1960 era and citation of specific manned programs as Apollo. This is explainable since Apollo evolved as a program after publication of the preliminary plans. Also the initial plans cited purposes for utilization a military, scientific, and commercial while the formal NASA plan made use of more specific uses i.e. scientific, lunar and planetary exploration, application satellites, and manned space flights. The three categories of purposes put forth in initial planning was aimed at a broad base of the american economy and national interests. In military applications the over all aspect of national defense was treated from communications, anti missile and anti satellite vehicles and surveillance satellites, the commercial aspects took into consideration communications and navigation, while the scientific satellites were aimed at investigations whose results were largely intangable. This broad approach initially planned inherently gained a broad supporting bases to justify the large expandatures necessary to carry out such a revolutionary venture.

THE ARMY BALLISTIC MISSILE AGNECY (ABMA)

If we examined the Working Group Plan (1) and the ABMA plan (9), we can immediately grasp the significance of the launch vehicle development programs that has been of particular importance at the Marshal Space Flight Center. The first consideration is of course the payload carrying capability of the existing vehicles; Vanguard, Redstone, Jupiter, Thor, Atlas, Titan, an Palaris in terms of the expected weights of the projected satellites, probes, etc. Watching these expected weight requirements with available vehicles or modifications to existing vehicles brought order and reason to the relatively complex planning exercises. Thus ABMA spotted deficiencies in payload capabilities of existing vehicles and suggested developments or modifications to fill these gaps, Tables 4 and 6, taken from reference 1 but generally compatible with reference 9. The composite NACA report suggested thirteen configurations as opposed to the configurations initially proposed by ABMA. These configurations (1) were serially numbered "mark I, Ia etc. through XI". in asending payload capability. It will be noted that the NACA report subscribed to the Super-Jupiter concept, designating it Mark X. This is important for it supported the subsquent ARPA decision to develop the static test article which led to Juno V and ultimately to the Saturn Program.

At ABMA therefore the plans and proposals for the Juno I, II, III, IV, and V are in consistant agreement with the plans submitted first by

ABMA (9) and later accepted, with minor adjustments by the NACA Working Gorup (1).

At this juncture, the technical plan and organizational place for the NASA has evolved. At this point, the ABMA contributions to the National Space Program can be viewed in proper prespective if we digress to follow their accomplishments during the 1956-1959 period, keeping in mind the master plans cited in references 1 and 9. The logic of the progressions from Juno I through Juno V will be evident as will be the fact that ABMA consistantly adhered to their portions of the National Vehicle scheme. Often heard charges of incroachment by ABMA into a dominate position of rocket vehicle development is thus seen to be unfounded. The ABMA effort functioned within the framework of a shared development program including all developed ballistic missiles through out the country. Of the total number of vehicle, ABMA projected effort was concerned with only 38% to possibly 45%.

The story of ABMA activity in the field of launch vehicle development for satellites actually begins with a seemingly unrelated decision. This decision was to conduct a flight test program in order to prove the ability of the war head to withstand the high temperature environment generated by its reentry into the dense atmosphere such a test was unnecessary during development of the Redstone Missile since its speed and altitude did not create a thermal environment necessitating development of special heat resistant materials. The Jupiter's speed and altitude however were such as to create a severe thermal environment around the reentry warhead. The concept of abalation cooling was evolved as a solution which necessitated in flight proof tests. Thus the Redstone was modified to act as a carrier for the reentry test body. Even under the stress of pressing development problems, the modifications to the Redstone were carried out in such a manner as to accomodate flexibility or multi-purpose thus reducing cost in dollars and effort by taking advantage of the fact that several jobs could be done with the basic vehicle (Fig 9). The decision of produce maximum flexibility in Redstone redesign produced dramatic payoffs for the United States Space Effort.

The resulting test vehicle or reentry test vehicle (RTV) was designated Jupiter 6. From the first flight, so-called launch of missile No. 27, the success of the design approach was graphically portraied. The primary objective of this flight was to test the structure, staging, propulsion system, telemetry system, and predicted flight path (4). The vehicle exceeded its predicted range by 850 mi. rising to a peak altitude of 600 mi. All parts of the vehicle functioned satisfactorily. Later it was aboard Jupiter C that the Nose cone shown by President Eisenhower over television on Nov, 7, 1957 as a demonstration of United Sates technological achievements was carried. The stage was then set for the explortation of the flexibility previously incorporated in the Jupiter C design. Thus a reapproachment to the question of backing up the Vanguard Progarm. However, the previous May 1956, Mr. Holaday had sent a memorandum to General Gavin, Army Research and Development, which generally stated: Without indications of serious difficulties in the Vanguard program, no plans or presentations should be initiated for using any part of the Jupiter or Redstone programs for scientific satellites. Previous decisions to base all american space effort on the Vanguard launch vehicle were reappraised in view of the Russian launch of Sputnik I, October 4, 1957. The decision thus reached premitted the Army the opportunity of demonstrating the wisdom of its previous decision. Thus on January 31, 1958, 80 days after authorization to "go ahead", the modified Jupiter C - re Christened Juno I launched the first United States satellite. During the succeeding ten months period ending in October 1958, the Juno I was the principle United States space lunch vehicle, used in six launchings of earth satellites.

During the period of space orientated activity at ABMA with Juno I, events in Washington were taking place that would profoundly shape the future of the ABMA ballistic missile design group. As previously descussed, pages — , organizational activity evolved the ARPA within the Department of Defense. As the ARPA began planning and implementing development programs within the scope of their assigned mission, interest in ABMA planning (9) prompted discussions leading to the development of launch vehicles possessing higher orbital and even escape capability. Ever present budgetary and schedule considerations prompted the ARPA to incorporate requirements for use of existing hardware in their orders for launch vehicles to ABMA.

The second launch vehicle project instituted at ABMA was initiated by an ARPA order Nr. 1-58, issued on March 27, 1958, approximately two months after launch of Explorer I and almost two months after the announcement creating ARPA was issued on February 7, 1958.

The vehicle authorized by order Mr. 1-58 was designated Juno II, fulfilling the requirement cited in reference 1, for a Mark II vehicle, see Table 5.

It was a modification of the Jupiter IRBM to which upper stages were added, formed by clustering of solid propellant motors. The Juno II was first launched in Decmeber 1958 approximately 9 months after issuance of the ARPA order. Juno II was destined to serve a useful life of 17 months (December 1958 to May 1961) during which ten lift-offs were carried out. In addition to earth orbiting missions of higher payload weights, the Juno II was assigned escape missions carrying the Pioneer spacecrafts. Its first launch attempt in December 1958 was for air escape mission carrying Pioneer III, the first two unsuccessful launching of which had been attempted with the Thor-Able I vehicle in October and November 1958. The Juno II launched the Pioneer III to within 38,000 miles of the lunar surface which is quite remarkable achievement for the first launching of a new vehicle (5).

Prior to the approval of the Juno II program in October 1957, March 1958, ABAM had completed and submitted in the performance of the Jupiter based series of launch vehicles, using existing or available hardware. This configuration employed upper stages formed by clustering aolid propellant Meteor motors. It was designated Juno III, the Mark III vehicle of the Integrated Program (1) (see Table 5.)

The Army development Board acted upon the proposal with a ruling that due to the lag between submission and consideration, the configuration did not represent best capability. Thus Juno III was disapproved for development. The Jet Propulsion Laboratory concurred in the Development Board's action, stating that the Meteor Motor was not suitable for clustering

With the rejection of the Juno III proposal, the last attempt by ABMA was made to upgrade performacne of the Army ballistic missiles by using inexpensive clusters of solid propellant motors. Henceforth, to fulfill the demands of the United States space program by supplying vehicles possessing the power to loft heavier payloads (see Table 5)

ABMA found it necessary to resort to liquid propelled upper stages, in their response to an ARPA request forwarded in April 1958 for a study to define a vehicle based on esisting hardware and generally capable of performing advanced space missions. As almost an aside ARPA requested that advancements in the state-of-the-art inpropulsion and guidance.

As will be recalled ABMA sucessfully obtained authorization the previous month (March 1958) to proceed with the Juno II development. Thus within one month May 1958 ABMA had completed a proliminary design stüdy (6) geared to the ARPA request, yet adhereing to the basic National integrated plan (1) by complying to the requirements of a Mark VI vehicle.

The design submitted by ABMA was based on Jupiter type initial stages. The upper two stages were complete departures from previous ABMA space launch vehicles in that liquid propellant rocket engines were used for primary power. Thus ABMA proposed using the general Electric Companies (GE 405) engine adopted for use as Vanguard 1st stage power and initially developed by the Army in connection with the Hermes A-3B program as the X-400 engine. Modifications for Vanguard Application had also changed its designation to X-405. (7). For the third stage power ABMA proposed using a Jet Propulsion Laboratory engine then under development and rated at 10,000 pounds thrust. The three stage vehicle composed of the Jupiter and stage vehicle composed of the Jupiter and the two upper stages was designated Juno IV (Figure 2). The May 3, 1958 study very carefully considered the case of pump fed verses pressure fed liquid propellant engines. The latter type were vigorously propounded by the Jet Propulsion Laboratory who had at that time two pressure fed engines under development. In view of the general nature of space missions evisioned by ARPA the flexibility, especially multible restart of capabilities of pump fed engines, strongly supported the ABMA technical position. However ABMA left the door poen by stating that if performance and early availability were not overriding considerations, pressure fed upper stage rocket engines would be acceptable (6). The estimated performance characteristics of the ABMA, May 1958 version of Juno IV is shown in Table 6. It would appear that the upper stage engine combination proposed by ABMA was impressive since it was employed as the propulsion scheme for the short lived disign activity (May-Dec. 1958) for the Viga vehicle.

The Juno IV activity during the three months period from May through August 1958 concerned itself with a reassessment of the program and the acquisition of a new partner in the design activity the Jet Propulsion Laboratory.

The crux of the activity is found in the results of a ABMA/JPL conference held at Huntsville August 19-20, 1958 (8), four days after issuance of the formal ARPA order Nr. 15-59 and 16-59. This ARPA order was more specific than the general guidelines forwarded in April. The order specified a vehicle capable of injecting a 500 pound payload into a 300 N. mi. Polar Orbit.

The basis of the new approach ABMA/JPL approach (8) were formulated within the framework of the following ground rules:

In addition to being technically sound, the program synthesis must take available and forth coming vehicle components into consideration.

Optimum utilization of present facilities, development programs, and personnel should realize an economical program.

The greatest probability of achieving all Army and ARPA missions should be realized. (See Table 8).

Growth potential in payload capability for the period 1959 to 1965 should be provided together with an early payload capability.

Existing Army programs at AOMC could not be interferred with.

The resulting program plan described a two phase program characterized by two launch vehicle configurations; a two stage vehicle, Juno IV A and a final three stage vehicle, Juno IVB. Abandonment of the ABMA reservation, Page ___, were partially satisfied by the two phase approach. It was argued that the JPL 10,000 pound thrust engine could be ready at an early date thus permitting early launches. ABMA pointed out however that the Juno IVA configuration could not meet ARPA Polar Orbital requirements, (8).

The six vehicle program planned by ABMA and JPL was aimed at making available a launch vehicle suitable for all ARPA and Army launch requirements during the 1959 - 1960 period. During this interval five discrete missions were evisioned Table 7 as desirable and practicable: communications, meteorological observations, scientific investigations, space wxploration, and a general advance of technology (8). The first two missions fell within the perview of the Army while the remainder were of more scientific exploratory nature.

TABLE 7

Juno IV
Tentative Program
of
Missions and Vehicles

Range	Mission	Orbital Altitude Miles	Payload In Pounds	Maximum Latitude Covered	Launch Date	Vehicle
AMR	MET	250-300	300-250	57°	July 1959	IVA
AMR	COMM	300	300	33°	Oct. 1959	IVA
	Spare	300	300		Dec. 1959	IVA
PMR	MET	300	600	Polar	Feb. 1960	IVB
PMR	NAV	1,000-2,000	500	Polar	Apr. 1960	IVB*
AMR (Aft)				Equitorial		
AMR	COMM	1,000-2,000	500	33°	June 1960	IVB

AMR: Atlantic Missile Range
PMR: Pacific Missile Range
MET: Meteorological Mission
COMM: Communications Mission
NAV: Navigation
*Restart capability in the thirs stage propulsion to be available for transfer ellipse trajectory.

Advanced Research Projects Agency (ARPA) to provide leadership and coordination of the various space and anti-missile projects conducted by elements of the Department. Congress placed a one year time limitation on ARPA (ending February 1, 1959) for the initiation of non-military space projects.

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TABLE ~~4~~ 5

Vehicle Descriptions
Based On
Existing Military Hardware for an Integrated Space Program

Designation		Vehicle Description
Mark I	Vanguard	
Mark I.a.	Juno I	First Stage Redstone + (11+3+1) 6" Sergeant solid motors upper stages.
Mark II	Juno II	First Stage Jupiter + (11+3+1) 6" Sergeant solid motors upper stages.
Mark II.a.	Thor + 117	First Stage Thor + 15K Bell Thrust Stage
Mark III	Juno III	First Stage Jupiter + (12+3+1) Meteor Solid motors upper stages.
Mark IV	Atlas + 117	First Stage Atlas + 15K Bell Thrust Stage
Mark V		Carrier for the GLOBAL SURVEILLANCE SYSTEM could possibly consist of Atlas Booster + High Performance Upper Stage (LOX + LH_2).
Mark VI		Jupiter or Thor Boosters with Appropriate upper stages.
Mark VII	Titan	Unchanged two stage Titan missile.
Mark VIII	Titan + Polaris	Three stage orbital carrier consisting of first and second stage Titan and third stage Polaris.
Mark IX	High Energy Titan	Use LOX or LH_2 in upper stages
Mark X		Three stage orbital carrier: First stage 4x380K LOX/JP engines, second stage 1x380K LOX/JP engine, Atlas sustainer engine with high performance propellants.
Mark XI		Two Stage recoverable vehicle, possible 2 x 1.35K LOX/Hydrazine engines payload returnable after some stay time in orbit.

TABLE 5 6

Payload Capability
Of
Vehicles Described on Table

Designation	Single Payload Capability (lbs.)
Mark I	3.5 - 21.5
Mark I.a.	18. - 35.
Mark II	60. - 100.
Mark II.a.	200. - 300.
Mark III	300. - 700.
Mark IV	1,500. - 2,000.
Mark V	2,500. - 8,800.
Mark VI	500. - 1,000.
Mark VII	1,000. - 3,000.
Mark VIII	3,000. - 5,000.
Mark IX	5,000. - 10,000.
Mark X	25,000. - 35,000.
Mark XI	50,000

As a matter of interest the performance of the August version of Juno IV is shown on table 8 and the configuration on Fig 2.

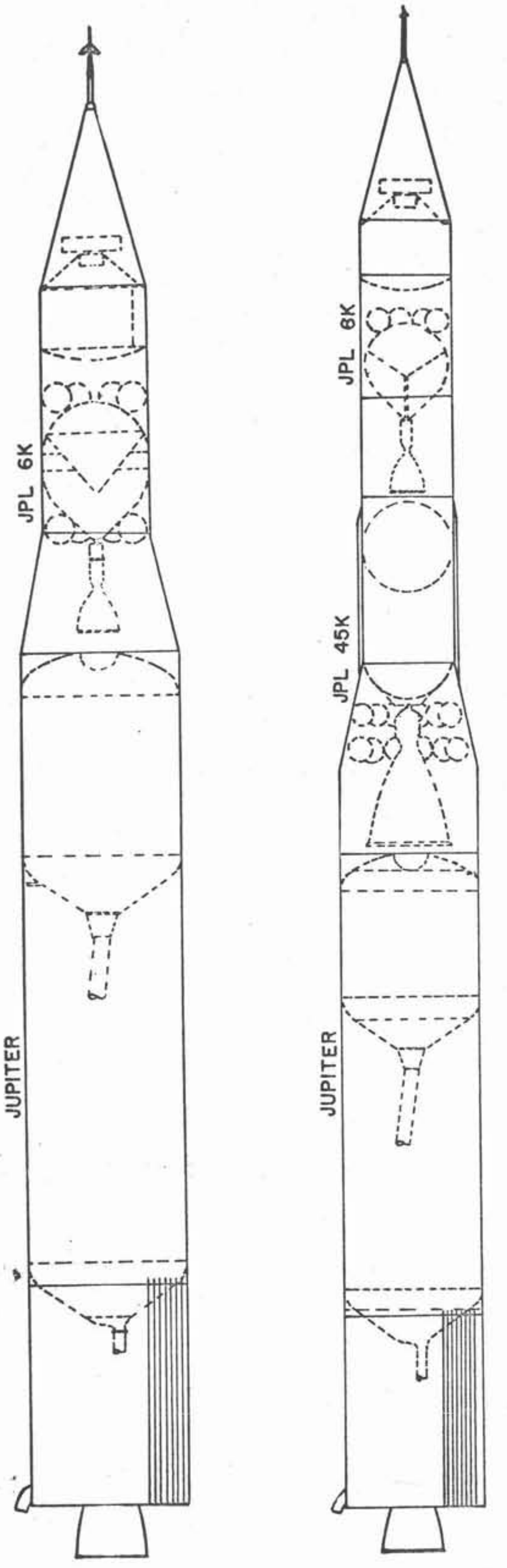
The six vehicle program as proposed was reduced to a four vehicle program and consequently terminated by a letter from the Secretary of Defense on October 16, 1958, two months after ARPA authorization. The letter of termination stated that existing launch vehicles could "best meet military requirements. ~~His~~ The military applications ~~were~~ composed two of the projected six missions or 33% of the mission capability envisioned for Juno IV. The polar orbit mission was subsequently carried out four months later (Feb. 28, 1959) using a Thor-Agena launch vehicle lofted from the Pacific Missile range head. (The Agena development program was initiated in Oct 1956 by the Air force with Lockheed Aircraft Co.) While the communications satellite mission was officially assigned to the Atlas-Centaur vehicle in Dec. 1958 by ARPA [14], two months after the Juno IV

TABLE ~~1~~ 8

Estimated Weight and Performance
Juno IV
Pressure Fed Upper Stage Engines

	Parameter	Juno IVA	Juno IVB
	Vehicle Lift-Off Weight	136,000	138,900
First Stage	Lift-Off Weight (lbs.)	124,025	106,696
	Diameter (inches)	105	105
	Engine	NAA 530	NAA 530
	Thrust (SL) (lbs.)	165,000	165,000
	Isp (SL) 16-sec./lb.	253	253
	Propellants	LOX-JP	LOX-JP
Second Stage	Lift-Off Weight (lbs.) (Power Unit Only)	10,250	23,990
	Diameter (inches)	70	70
	Engine (JPL)	JPL 6K	JPL 45K
	Vacuum Thrust (lbs.)	6,000	46,360
	Isp (Vac.)	296	304
	Propellants	N_2O_4/N_2H_4	N_2O_4/N_2H_4
Third Stage	Lift-Off Weight (lbs.) (Power Unit Only)		7,091
	Diameter (inches)		70
	Engine		JPL 6K
	Vacuum Thrust (lbs.)		6,000
	Isp (VAC.)		296
	Propellants		N_2O_4/N_2H_4
Guidance	Initial		ST-120
	Operational		Minit. ST-120

THE JUNO IV CONFIGURATIONS
USING PRESSURE-FED ENGINES
IN UPPER STAGES



JUNO IVA

JUNO IVB

Returning to the basic launch vehicle development plan [1], Table 5, it will be noted that for future developments only the Mark X and XI configurations remained to be defined. The proposal forwarded by ABMA [9] in 1957 was acted upon in this respect by ARPA on August 15, 1958, four day prior to the Juno IV meeting [8] with JPL, and — days prior to the ARPA Order authorizing the Juno IV program. The ARPA ~~than~~ interest in obtaining a high thrust booster, of a 1½ millions pounds thrust could only be obtained relatively early by clustering groups of existing rocket engines. The principle of clustering a number of high performance rocket engines, could most economically proved or disproved by construction and firing of a captive test model which was the requirements of the initial ARPA Orders Nr. 14-59. The initial order, it should be remembered did not authorize a flight test program - only a captive test program. Also, and this is very important to appreciate, existing engines must be used since no ~~engine~~ single engine possessing such a high thrust level existed. In addition a time limit was cited which precluded any approach other than the one pursued.

Initial ABMA studies [9] were developed around using a cluster of four E-1 engines then under development by North American Aviation's Rocketdyne Division. Discussions with ARPA, in light of fund limitations and early demonstration requirements led to the substitution of eight H-1 engines ~~for the~~ in lieu of the four E-1 engines. This decision thus saved an estimated 60 million dollars and 2 years development time [15].

The program thus initiated upon such a modest scale, ~~within~~ lying within the framework of the integrated plans [1] and [9] was designated the Juno V, ~~program~~ and later the Saturn.

We have thus traced the progress of ABMA in the launch vehicle development activity ~~that~~ during the 1956-1958 period. The compliance with the plans laid out first at ABMA [9] and later on a national scale [1] ~~E~~ lies in the vehicle design studies
[illegible]

~~Mark~~ III, IV, and X series which were redesignated Juno I, II, III, IV and V respectively. Maximum use of Air Force developments characterized by the Mark IV, V, VII VIII, and IX vehicle configurations give mute testimony of ~~[illegible]~~ unselfish planning for the National Interests in space above self interests. This attitude has consistently characterized planning of a national scope for a national program conducted by ABMA. It will be seen later that the same principles ~~[illegible]~~ are translated into the Saturn Program as it grows into a ~~major~~ launch vehicle development of considerable National importance