~~Hx SECRET~~
SPECIAL HANDLING

PRO A6e(3)

BYE-71092-66

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF SPECIAL PROJECTS (OSAF)
AF UNIT POST OFFICE, LOS ANGELES, CALIFORNIA 90045

REPLY TO ATTN OF: SP-7

SUBJECT: Re-entry Vehicle Source Selection for HEXAGON

13 DEC 1966

TO: Director, National Reconnaissance Office

1. In response to your direction in WHIG 5850, the System Program Office has completed the evaluation of the Re-entry Vehicle supplementary information submitted by McDonnell Aircraft Corporation and General Electric Company. The technical evaluations of the two supplements are included as Attachments 1 and 2, and the revised costs for both contractors are found in Attachment 3. Copies of the letters which requested the revisions are also included as Attachments 4 and 5.

2. Both contractors responded in a satisfactory manner to our requests for revisions to the Statement of Work and to the other managerial and cost comments. Their schedules have been compressed, and both contractors propose to still meet a 1 March 1969 launch date with a 1 January 1967 go-ahead.

3. In the technical area, there are still deficiencies in General Electric's supplementary information:

a. An unsupported (free-foam) ESM heat shield. There is insufficient test data to warrant the analytical predicted performance of the unsupported ESM. On the other hand, there does exist sufficient ground and flight test data on similar unsupported and supported ESM to conclude that GE's proposed design is marginal for the predicted high heating rates and shear forces of Hexagon re-entry conditions. This conclusion also applies to the re-entry conditions of Program 846, so that GE's proposed flight test of their design on an 846 vehicle could cost half a mission, which would eliminate the $5 million cost differential between MAC and GE. As noted in the evaluation of the original proposal, the phenolic nylon - phenolic glass heat shield is unacceptable because of the limited shelf life. Therefore, a satisfactory solution of this problem by GE is doubtful and would be at a considerable cost and schedule risk at best.

b. The location of the ignitor in the retro-rocket for the medium RV. The ignitor, which is in the head-end of the rocket, is not accessible after installation of the rocket in the RV, and would have to be installed at the RV factory. This is not acceptable for safety reasons; the correction of this problem would require either a redesign of the proposed rocket or the selection of a different rocket. Either of these alternatives would impact on the overall RV design and costs.

~~Hx SECRET~~
SPECIAL HANDLING

EXCLUDED FROM AUTOMATIC REGRADING; DOD DIR 5200.10 DOES NOT APPLY.

PRO A-6-e(3)

c. The location of the flashing light. GE's revised design is still not acceptable, since most of the hemisphere below the RV is still not covered by the light.

d. Weight vs performance trade-off. Considering the overall design and performance, GE has chosen to provide a ΔV of 1300 fps in order to meet the dispersion requirements for the entire orbital envelope at the expense of exceeding the empty weight allocations. GE's medium RV weight results in an increased launch weight of over 300 pounds for the 4 - bucket configuration.

4. McDonnell responded in a satisfactory manner to all of the technical revisions except the structural analysis:

a. Structural analysis. MAC's structural design is considered to be basically sound, but their analysis is still weak and incomplete although improved over the analysis in the original proposal. Since this can be resolved through effective systems engineering and direction by the SPO, it is not considered a serious problem.

b. Weight vs performance trade-off. Considering the overall design and performance, McDonnell has chosen a ΔV of 1000 fps which meets the empty weight requirements at the expense of not meeting the dispersion requirements for approximately 1.5% of the orbital envelope as defined in the RFP; however, this small percentage represents orbital conditions which lie outside the system's routine operating orbits. Successful reentry would still be made from those conditions, but the recovery forces would have to be spread out for the higher predicted dispersions.

5. The revised costs including fee which were bid by the contractors are as follows:

	Large RV	Medium RV
McDonnell	$29,121,000	$31,256,000
General Electric	$24,002,900	$26,167,900

The breakdown by task and subtask and a discussion of the major cost differences are presented in Attachment 3.

6. After the evaluation of the original proposals, it was believed that the major technical deficiencies of the General Electric design could be corrected and that the estimated cost difference of $6 million warranted the award of the contract to GE in spite of the fact that McDonnell was superior in the technical and management areas.

~~Hx SECRET~~
SPECIAL HANDLING

BYE-71092-66

As noted above, GE's supplementary information fell far short of correcting the technical deficiencies. I recommend therefore that we be directed to enter into contract negotiations with McDonnell Aircraft Company for the development of the Hexagon Recovery Vehicle, and that upon successful completion of these negotiations within a specified period, McDonnell be awarded the contract.

Frank S. Buzard

FRANK S. BUZARD
Project Director

5 Atch a/s

~~Hx SECRET~~
SPECIAL HANDLING

~~HX SECRET~~
SPECIAL HANDLING

BYE-71092-66
Cy1, Attch 1

MCDONNELL AIRCRAFT CORPORATION

TECHNICAL EVALUATION

Attachment 1

~~HX SECRET~~
SPECIAL HANDLING

Batteries

The contractor was requested to examine the idea of utilizing automatically activated batteries.

The supplemental proposal submitted by McDonnell incorporates automatically activated silver-oxide-zinc batteries in place of manually activated batteries. The concept presented for the battery design is consistent with existing qualified hardware and employs redundant temperature controls and activation means.

The proposed design is very good and a very good capability is indicated to accomplish the design implementation.

Electrical Power and Distribution Subsystem

The contractor was requested to describe the design and test of the Electrical Power and Distribution Subsystem to survive water impact and immersion.

McDonnell describes harness design and electrical design techniques to be employed to assure RV survival in the event of water impact. Water-proofing of harness, connectors, and equipment which meet the standards developed for the Gemini and Asset Programs will be used in conjunction with a test program to validate their design.

The proposed design is adequate and a very good understanding and capability is indicated to resolve difficulties that may arise in their water immersion and impact test program.

Flashing Light

In the contractor's original proposal, the location of the flashing light, which is used for initial acquisition of the descending system for night aerial recovery, did not provide for coverage in the hemisphere below the RV.

The proposal supplement corrects the deficiency of the flashing acquisition light in an adequate and acceptable way.

a. A flashing light of 23 candlepower - seconds is added to the bottom of the canister providing complete coverage in the lower hemisphere.

b. The flashing light (previously 23 candlepower-seconds) mounted on the flotation bag was changed to an intensity of eight candle-power-seconds. This light will cover the upper hemisphere.

Sink Subsystem

The contractor's original proposal included a pyrotechnic sink subsystem. This was considered an undue hazard to the recovery forces. The contractor was directed to incorporate an electro-chemical sink plug into his design. The supplemental report shows the use of three plugs in the payload canister and two in the flotation bag. The location of the plugs are optimized based on the orientation of the vehicle with full and partial payloads and sea state. The design is now considered satisfactory.

Separation Concept

The original proposal did not show how the RV, which started spin-up inside the SBA, would separate from the film chute. The supplemental report shows a hinged film chute with a curved cross section. The concept is considered good, although it will have an impact on the SS contractors film chute design. The proposal is now considered adequate in this respect.

MAC

~~Hx SECRET~~
SPECIAL HANDLING

BYE-71092-66

Telemetry, Tracking and Beacon

The contractor was requested to add a swept audio tone to both the primary and back-up telemetry transmitters and to simplify the supplemental telemetry for the diagnostic RV's.

McDonnell has complied with the requests in a satisfactory manner. In the operational configuration, one swept audio oscillator is used to modulate (AM) both the primary and back-up transmitters. In the diagnostic configuration, one swept audio oscillator is used to modulate (AM) the primary transmitter and to modulate (AM) a sub-carrier (14.5 kc) which in turn modulates (FM) the back-up transmitter. A sub-carrier is required to separate the audio tone from the PCM spectrum in the back-up transmitter. The supplemental telemetry is simplified by deleting a multiplexer and eliminating 22 measurements; the remaining 20 measurements are satisfactory.

~~Hx SECRET~~
SPECIAL HANDLING

Structure Subsystem

The contractor was informed that the structural analysis presented in the original proposal is weak and incomplete, and specific areas which needed improvement were cited.

Strength Analysis of Heat Shield Substructure Under Flight Loads

McDonnell was requested to revise the analysis to include the effects of longitudinal bending in the aft end of the truncated conical shell, but he did not comply with this request. The longitudinal bending moments are induced by two forcing functions. The first contributing factor is that the titanium ring deflects less than does the conical shell when the latter is subjected to pressure loading. The second contributing factor is that the titanium ring expands at a different rate under heating than does the conical shell. This causes the shell to change its deformation pattern and induce longitudinal bending in the shell at the support. The only change in the analysis submitted by the contractor is the addition of thermal stresses caused by a gradient through the shell thickness. It had already been established that this was not a major effect. The strength analysis, as a result, is still weak and incomplete. Throughout the proposal, McDonnell alludes to a computer program which is capable of solving all of the torispherical cap and truncated cone structure problems. It appears that the contractor did not make good use of it for this effort.

Stability Analysis of Heat Shield Substructure Under Flight Loads

The contractor treated the problem of unsymmetrical pressures tending to elastically buckle the truncated conical shell by considering it to be unsymmetrical pressure acting on a pin-ended arch. This precluded any consideration of combined longitudinal edge conditions, and is therefore incorrect. In analyzing the torispherical nose cap, the contractor assumed that he can distribute the actual assymetric loading as an idealized uniform loading over the entire surface of the shell and still be conservative. This is incorrect. Shallow spherical shells, even under uniform loading, are more succeptable to assymetric buckling than to symmetric buckling. Consequently, the effect of the asymmetric loading causing the shallow spherical shell to buckle in an unsymmetric mode is much more severe than a uniform load over the entire shell. The contractor's analysis is not adequate in this area.

Heat Shield Substructure for the Large RV

In the original proposal McDonnell presented a very narrow choice of structural configurations and materials. He was informed that the large RV's heat shield substructure weight was excessively high and that he should perform a more comprehensive weight-strength analysis using internal stiffening rings, etc. in order to lower the weight. Instead of complying with this request, he has presented the same selection of structural configurations and materials and shows the design of the large RV. What was really desired was a study showing that the chosen material and configuration are significantly better than the other candidate materials. The contractor did not include a sensitivity analysis to demonstrate the impact of a variation of system parameters on the design.

Design of Corregated Skin of Cassette Subjected to Water Impact Loads

The loads for this analysis were developed for 28.5 fps ultimate velocity. This is low because it neglects the effects of surface winds. This low loading combined with the fact that the side wall strength analysis shows a margin of safety of zero indicates poor engineering judgement in proposing this design for water impact.

Modal Survey

This study was performed in an acceptable manner. However, the results that are presented are quite meager, since the contractor has included the circumferential waves and their associated natural frequencies that are compatible with only the first longitudinal half wave.

Panel Flutter

The panel flutter analysis utilizes the mode shapes obtained from the modal survey to construct an equivalent curved panel. This is then evaluated for flutter sensitivity. Using this technique, the contractor obtains large margins against panel flutter. This effort meets the minimum requirement. However, the study should have been made on the full truncated conical frustrum. It was impossible to check the results by the traditionally accepted work of Schulman because of the lack of information on modes other than the first longitudinal mode which is presented.

Shuttlecock Vehicle Dynamics

The mathematical model, consisting of two lumped masses with coupled translatory and rotational motion, is adequate for a preliminary analysis. From the material presented, it appears that the contractor has grasped the principles involved and could do a flexible body study during the design phase.

In conclusion, McDonnell showed some improvement in his structural analysis, but it is still weak and incomplete in several areas. The proposed structural design is basically a clean, intuitively good design, but the poor analysis fails to back up the good design. This is not considered to be a serious problem, and the contractor should be able to overcome the deficiencies in the proposal and its supplement by effective systems engineering and direction.

MAC

Parachute Subsystem

The contractor's original proposal included the use of the conical extension parachute. This system is not considered optimum. The contractor was requested to propose the annular parachute and he was provided a specific development test program to use as a basis for cost. In addition, he was requested to include in his cost proposal the procurement of one hundred (100) parachutes for use in initial training by the aerial recovery forces.

The proposal supplement submitted by MAC is in agreement with the AF requirements except for the deployment conditions for the series of systems tests. MAC states that the system tests will be conducted under the maximum condidions attainable with release from aircraft. The actual conditions as specified by the Air Force would require release from balloons at high altitude instead of release from aircraft.

MAC also recommended additional tests of both first and final stage systems, but did not include them in the effort that was priced. It is felt that additional tests of the first stage are not warranted since parachute operation at velocities up to Mach 1.3 to 1.5 has been within state-of-the-art for more than 10 years, and adequate data are available on wake characteristics for a similarly shaped vehicle (Discoverer). An exception is the proposed wind tunnel test of the first stage behind a streamlined bomb to permit comparison with free flight tests. The required tests should be considered as a verification of design rather than an extensive development effort. Similarly, the number of

tests specified by the AF for the final stage (annular system) should be adequate if Phase III of the Universal Aerial Recovery System program is successfully conducted by Northrop Ventura (contract is about to enter negotiation).

MAC presents little discussion of how the tests will be conducted (aircraft type, aircraft limitations and possible problem areas), leaving some question as to a complete understanding of the effort required, although similar programs were conducted by MAC on Mercury and Gemini.

MAC's original proposal used a thruster to eject the drogue chute. He stated that a mortar would have been proposed except for the RFP requirements that pyros emit no gases or particles. He was informed that their requirement did not apply to the drogue chute eject mechanism.

MAC responded by proposing a mortar concept that is the same design as Gemini for both the Medium and Large RV's, except for overall length.

ACE Deficiencies

The contractor had two shortcomings in mechanical ACE and handling equipment. No handling equipment was called out for RV installations in the MST or for film chute alignment after RV installation.

The contractor has proposed two configurations for RV installation for the two and four-RV case. For the two-RV case, the contractor has proposed a portable floor internal to the SV for personnel and two sets of installation rails and carriages for removing and replacing the RV in the SV. The RV that has been removed from the SV will then be removed from the MST by a hoist. For the four-RV case, the contractor has proposed two work stands and one ladder on each of two MST levels in addition to [illegible] portable internal floors. The workstands are capable of being elevated by means of a pneumatic motor and scissors mechanism to allow a MST floor level installation of an RV and installation of another RV, five feet above MST floor levels. The ladder is used to allow personnel access to the RV positioned five feet above MST floor level. The contractor's proposal for RV installation is acceptable. The contractor has proposed a method of film chute alignment which is similar to his proposal for RV installation bolt hole alignment. The installation carriage utilizes rails which provide alignment into the approximate position desired. Vernier positioning is attained by the following procedures. A threaded lever arm provides positive rotation of the entire RV. Threaded brass wedges provide verticle adjustment. Horizontal adjustment is provided by rotation of a threaded shaft. Chute Alignment Templates and an

~~TOP SECRET~~
SPECIAL HANDLING

RV Mirror Mounting Bracket are proposed as minor alignment AGE. The templates are used with standard feeler gages to establish deviation from reference alignment surfaces on the outside of the film chute. The mirror mounting bracket mounts on the RV optical reference surface and will be used by the SBA contractor in his integrated alignment set up. The film chute alignment AGE proposed by the contractor is acceptable.

~~TOP SECRET~~
SPECIAL HANDLING

Venting During Re-entry

The original proposal provided an active (nitrogen) pressurization system for use during re-entry. This design was considered unnecessarily complex because passive devices have served the purpose in all previous Discoverer series flights. In his supplemental report, the contractor proposes a passive design which incorporates a simple vent tube. At 1000 ± 300 ft, the vent tube is sealed by means of redundant pyro valves initiated by redundant baro switches. The design is now considered adequate to meet the venting requirement.

ACE Excess Requirements

The contractor was requested to propose a reduced quantity of displays and a reduction in the complexity of the Re-entry Vehicle Control and Monitor Equipment (RVCME). McDonnell proposes to reduce analog display meters from 12 to 8, discrete function displays from 96 to 35 and to delete all binary count readouts and analog-to-digital converters. He also proposes to reduce the number of recording equipment racks from three to two, by combining the Test Control and RV Control and Monitor Consoles.

The contractor was requested to eliminate the Fault Location Test Set (FLTS) at the launch base and the portable air conditioners for the recovery forces. He has proposed to eliminate the FLTS and to use RV Command and Telemetry links to provide for fault location. The air conditioners have been deleted as requested.

He was also requested to eliminate hard wire connections between the RVCMC and the SBA with the exception of emergency RV shut down command lines. The contractor proposes to eliminate umbilical checkout hard wires between the RVCMC and each RV and instead use the SGLS link to send checkout commands to the RV's. Four hardlines will be retained for emergency RV shut down.

Retro-rocket and Dispersion Analyses

The contractor was requested to propose a Retro-rocket Subsystem that did not include thrust termination. A 3 sigma total impulse tolerance of ±3% was to be used unless he could substantiate a lesser variation. It was also requested to re-accomplish the dispersion analyses to match the selected rocket and determine the orbital envelope from which the dispersion requirements could be met.

McDonnell presented adequate evidence that a 3 sigma total impulse tolerance of less than ±.75% can be achieved by reasonable manufacturing controls and by a knowledge of the motor temperature immediately prior to firing. This tolerance has been demonstrated by the Surveyor, Burner II, and Gemini motors. Therefore, McDonnell proposes to use the same rocket motor as originally proposed with the thrust termination capability removed. The necessary production controls to achieve the ±.75% figure will be maintained and a temperature sensor will be added to the rocket. This is a good approach.

The proposed retro-rocket will provide a ΔV of 1000 ft/sec ±.1% to the heaviest payload. Based on this ΔV, MAC provided very detailed dispersion analyses for both in-track and cross-track dispersions. The analysis shows that the MAC RV would meet 98.5% of the RFP in-track dispersion requirements and 100% of the cross-track requirements. The dispersion requirements which MAC will exceed occur on orbits that have little operational use. MAC further states that meeting all the RFP dispersion requirements would require a ΔV of 1375 ft/sec and result in a weight increase of 62 pounds in the Medium RV and 120 pounds in the Large RV.

Mass Properties and Dimensions

Since the previous changes affect mass properties and dimensions, the contractor was requested to re-determine these parameters. In addition, a change in mass properties reporting was requested and the large RV heat shield weight was questioned.

The effect on mass properties of the requested changes is relatively minor, amounting to minus five pounds for the medium RV and minus seven pounds for the large RV. The empty weights are now 606 lb and 964 lb. All changes were considered, and the weight differences are logical and in the correct order of magnitude. MAC's weight estimates as originally proposed were slightly under the allowed weights, so that the reductions enhance the probability of meeting the allowed weights of 615 lb and 975 lb. MAC explains the weight difference in the large RV heat shield substructure as due to an erroneous listing of wetted area (62.4 rather than 69.8), although the correct area was used in the weight calculation.

The suggested substitution of one mass properties report for one of another type was incorporated in the supplement, with the notation that the now deleted report was included by error.

~~SECRET~~
SPECIAL HANDLING

March 2, 1941

GENERAL ELECTRIC COMPANY

TECHNICAL EVALUATION

Attachment 2

~~SECRET~~
SPECIAL HANDLING

Spin Subsystem

The contractor was requested to propose a cold gas spin subsystem in lieu of solid rocket motors. The design he proposed consists of a toroidal tank for storage of the cold gas, mounted around the retro rocket.

The GE approach for the cold gas spin subsystem is considered acceptable. Redundancy is provided on the most critical item, which is the initiation valve. No mention is made of the type of fitting and joints that would be used for the pneumatic system. For the lifetime of this vehicle, brazed welded joints are most desireable. This omission, therefore, detracts from their proposal.

The trade-off studies were apparently all made at one pressure level. On this basis the toroidal tanks was adopted over a spherial tanks, even though there was a substantial weight penalty. They state that the ease of installation and elimination of c.g. lateral shift outweighs the lighter spherial tank installation. However, it would have been interesting to trade off increased tank pressure to approximately 5000 psi to determine whether the smaller volume would allow a more reasonable spherical tank installation.

The contractor has proposed canted spin nozzles which would serve to back up a partial leak in the pneumatic system used to eject the RV from the SBA. This is considered a desirable feature, because it builds in inherent redundancy.

The overall design adopted by GE would result in a very satisfactory spin subsystem.

~~TOP SECRET~~
SPECIAL HANDLING

Retro-rocket

The contractor was requested to provide additional information on the initiator installation for the Medium RV and to change the stated 3 sigma total impulse tolerance from ± 1% to ± 3%, unless the lower figure could be substantiated. In addition, he was directed to provide for firing of the retro-rockets at temperature extremes in the test program.

The Retro-rocket proposed by GE for the Medium RV uses a head-end mounted ignitor with redundant squibs and circuits. This requires the ignitor to be installed in the motor prior to shipping the RV to VAFB. This procedure is not considered acceptable. G.E. states that on-pad ignitor accessibility can be obtained by increasing the height of the thrust cone by approximately six inches, or by repositioning the ignitor to the nozzle end, but neither alternative was proposed to correct the deficiency. Repositioning the ignitor would require some rocket redesign and extra testing; however, G.E. did not estimate what the added cost might be. The increased weight, mass properties changes and associated costs which would result from the thrust cone change was not presented.

G.E. presented adequate evidence that a 3 sigma total impulse tolerance of less than ±1% can be achieved by reasonable manufacturing controls. This tolerance has been demonstrated by the Surveyor, Burner II, ALCOR, Minuteman second stage Wing 6, and the SVM-1 motors.

The proposed test program now provides for firing of the retro-rockets at temperature extremes as directed.

~~TOP SECRET~~
SPECIAL HANDLING

Dispersion Analyses

The contractor was requested to re-accomplish the dispersion analyses and determine the orbital envelope from which the dispersion requirements could be met. In addition, the contractor was requested to include cross-track dispersions, and the operational modes of unbalance, use of BRAC, and the combination of unbalance and use of BRAC, which were not included in the original proposal.

G.E. has proposed a retro-rocket which will provide a ΔV of approximately 1300 ft/sec $\pm$ 1% to the heaviest payload. Since G.E. presented in-track dispersions for this case in original proposal, the new analyses was based on a $\pm$ 3% variation in ΔV. The cross-track dispersions are based on $\pm$ 3% variation in ΔV only; the cross-track dispersions for $\pm$ 1% were not presented in either the original or supplemental proposal. The data that is presented by G.E. in the supplemental proposal is not as detailed as that presented by MAC; however, it is adequate. These analyses show that the 1300 ft/sec ΔV with a $\pm$ 1% variation meets all the dispersion requirements but a $\pm$ 3% variation does not.

Heat Shield

In his original proposal, the contractor proposed a phenolic nylon ablator. Since this material did not meet the two-year shelf life requirement, the contractor was requested to propose an alternate design.

In the supplemental proposal, GE proposes ESM 1004 AP as the heat shield ablation material. This material is the latest in the GE 1000 series of silicone elastomeric shield materials. The base elastomer is phenyl methyl silicone and the formulation is filled with 12% aluminum silicate fibers. The primary problem apparent from review of the proposal and the available literature concerns the fact that this material is a free foam and is not supported in a honeycomb matrix.

Since the GE ESM materials were originally developed for lifting re-entry vehicles(3), some limited data is available for heat fluxes over 90 to 100 BTU/FT^2-SEC. It is generally apparent that at heat fluxes greater than about 150 BTU/FT^2-SEC, surface recession becomes limiting and the effectiveness of the silicone elastomeric materials degrade considerably(4). With these ablation materials it is imperative that a stable char layer be maintained and recession be limited to vaporization at the heated surface. The primary inherent weakness of silicone elastomeric materials is the weakness of the char layer(5).

At the present time, the only proven method of strengthening the char layer is through the use of a phenolic glass honeycomb supporting matrix. The honeycomb provides maximum char support by providing a structural matrix continuous to the bondline. The supporting data presented in the proposal is completely inadequate to establish with any reasonable degree of confidence that the unsupported ESM will survive in the stagnation region ($q_{max} \approx$ 300 BTU/FT^2-SEC; $\tau_{max} \approx$ 6 to 7 LBS/FT^2) of the RV.

In the original proposal the contractor indicated that ground tests "indicate accelerated ablation rates for unsupported free-ESM foams".

In the supplemental proposal, GE proposes a completely unsupported heat shield and indicates, on the basis of a very limited test data, that the performance of the shield material is independent of both aerodynamic shear level and whether or not the material is supported in a honeycomb matrix. This is an apparent contradiction with GE's own previously published data (2) where performance of the unsupported 1004 AP at 120 BTU/FT^2-SEC fell off drastically when the shear level was increased from 1.5 to 4.5 LBS/FT^2, while the performance of the supported formulation did not.

McDonnell data on the honeycomb supported Gemini material (ρ = 53 LBS/FT^3) indicate a pronounced effect of shear level on surface recession at heat rates over 100 BTU/FT^2-SEC.

Experience of the Martin Company with a similar ESM, indicated that separation will occur at the char virgin plastic interface and that the shear carrying capability is a function of ablator thickness; i.e., 1/8 inch will support high shear forces, while 1/2 inch will not support more than a few PSF. In this case the inclusion of random fibers did not increase char strength.

The contractor indicates that no additional design data on ESM 1004 AP are required for the 612 Program. At the same time GE does not exude confidence in their own material by recommending a safety factor of 2 be used for design purposes. No correlation of ESM ground test data has been made for heat rates over 93 BTU/FT^2-SEC to verify analytical prediction methods. The test program is not adequate to prove the shield material.

In summary it can be said that:

At this time the choice of 36 LBM/FT^3 unsupported ESM in the stagnation region is not acceptable as it represents a high risk design selection. This material has no re-entry experience and very limited applicable ground test data.

One of the primary advantages of the elastomeric heat shield is the ability to formulate them in controlled densities to meet changing station requirements. For example, GE's 1000 series ESM can be made with densities from 20 to 80 LBM/FT^3. Higher density material could be used for the nose of the RV where surface recession is controlling and a lower density grade used on the conical frustrum where thickness is controlled by insulation requirements. This is the approach taken on the PRIME vehicle. GE did not attempt to tailor the ESM density to 612 re-entry requirements.

Weight saving with the ESM material over phenolic nylon is not a large factor (3 or 4% of re-entry weight on the large RV).

The resistance of ESM materials to low temperature and temperature cycle appear to be a proven property. The extremely low modulus of elasticity prevents differential stresses from arising over a wide range of temperatures. This attribute becomes important only in the case of a nose-mounted RV. If the RV's are mounted internal to the SBA the heat shields can be effectively shielded from the orbital environment.

GE mentions outgassing of ESM has little effect on RV static and dynamic stability during re-entry. If shift of cg is high enough, additional nose ballast may be required.

Flight tests of the 241 heat shield as proposed by GE could be an expensive method to prove a risky heat shield material.

REFERENCES

1. "Low Density Materials Study," TDR 669-(6240-10)-5, January 1966.

2. "Study for Development of Elastomeric Thermal Shield Materials," NASA CR-186, March 1965

3. "Elastomeric Thermal Shield Systems for Lifting Re-Entry Vehicles," GE TIS Report No. 65SD244, April 1965

4. "Analysis of the Effects of Environmental Conditions on the Performance of Charring Ablators," AIAA Paper Entry Technology Conference, 1965

5. "Elastomeric Shield Materials," 7th Symposium on Ballistic Missile and Space Technology, 1962.

Parachute Subsystem

The contractor was requested to revise his proposal in this area to include the cost of accomplishing a specific test program. The program was provided to him in detail. In addition, he was requested to include in his cost proposal the procurement of one hundred (100) parachutes to be used in initial training by the aerial recovery forces.

The supplementary report submitted by G.E. is in agreement with the requirements. The contractor proposes three additional system tests from high altitude balloons to obtain the maximum and minimum conditions specified. Similar system tests using a B-52 are also proposed, but these tests are considered excessive to the requirements. The costs for these additional system tests were not included in GE's revised cost proposal.

The wind tunnel test program for the first stage is described in much greater detail than was supplied and includes the addition of a test with a streamlined forebody for comparison with free flight test data. The cost of the additional effort will be negligible.

GE presents a good discussion of aircraft type and limitations, what test condition will be required as maximum and minimum values, and what problem areas are likely to arise, indicating that a rather complete study of the test effort was conducted.

Flashing Light

In the contractor's original proposal, the location of the flashing light, which is used for initial acquisition of the descending system for night aerial recovery, did not provide for coverage in the hemisphere below the RV.

The proposal supplement does not substantially improve the efficiency of the flashing acquisition light. The location of the light was changed from the RV base to the tip of an 8-inch long stem extending from the RV base. Thus, the coverage in the lower hemisphere was slightly improved. (The light now covers the entire upper hemisphere plus 10° of the lower hemisphere). A cone with a semi-vortex angle of 80° below the RV is not covered at all by the acquisition light. This is not acceptable.

It appears that GE fully understands the problem but they seem to be unable to provide a satisfactory solution. Based on the results of the Sirocco (Night Recovery Feasibility) Program, the coverage of the hemisphere below the RV provided by the flashing acquisition light(s) is considered mandatory.

~~Hx SECRET~~
SPECIAL HANDLING

L-71092-66

EMI

The contractor was told his proposal for Electromagnetic Compatibility was unacceptable and to resubmit a plan as directed by the RFP.

In the supplemental proposal, GE has retracted all of the exceptions (except for four items of clarification which were allowed) originally taken to SAFSP Exhibit 65-27, Electromagnetic Compatibility Requirement Specification. The contractor now satisfies the program EMI requirements.

~~Hx SECRET~~
SPECIAL HANDLING

HX SECRET
SPECIAL HANDLING

BYE-71092-66

Destruct Subsystem

The contractor's original proposal did not provide for redundancy is the destruct subsystem. He was requested to propose a redundant design. The supplemental report described a redundant design in adequate detail. The design of this subsystem is now considered satisfactory.

HX SECRET
SPECIAL HANDLING

Separation from the SBA

The contractor's original proposal did not show how redundancy would be achieved in the initiation of the explosive valve in the pneumatic collet mechanism used to separate the RV from the SBA. He satisfied the request for detailed explanation in this area by showing the use of a single valve with dual squibs and dual bridge wires in each squib.

The trade-off studies presented were good. He rejected the use of redundant valves in parallel because the probability of leakage would be increased. However, he did not consider the use of redundant sealing of the single valve. Such a consideration would add more assurance against leakage and would have strengthened the proposal.

Water Seal & Film Cutter

The contractor's original proposal did not adequately describe the film cutter he was proposing. In addition the water seal was inadequately described and no data was shown on the tip-off errors induced by the water seal door scraping against the film chute during RV separation.

A description and drawing of the film cutter has now been provided. Conceptually, the mechanism could prove satisfactory in practice, although usual redundancy provisions for this type of mechanism (e.g. for the torsion springs, dual squibs for the yoke actuating pin puller, etc.) are not noted or discussed.

The water/light seal is adequately described and a schematic drawing is presented. Although the kinematics of the trap door mechanism can only be assumed from the drawing enclosed, the seal concept is entirely feasible and could be designed to be highly reliable. A detent feature which preserves the integrity of the film chute water/light seal is described. The question of degradation of RV orientation at separation is satisfied by the tip-off rate anslysis presented.

~~SECRET~~
SPECIAL HANDLING

BYE-7102-66

Venting Devices

The contractor's original proposal inadequately described the ascent and re-entry venting devices. The supplemental report shows these devices as spring-loaded relief valves. The devices are adequately described and their design requirements are presented. The proposal is now considered adequate in this aspect.

~~SECRET~~
SPECIAL HANDLING

RF Beacon

The contractor was requested to delete the capability to transmit altitude information and water impact time in his beacon design.

He has complied with the requested deletions in a satisfactory manner.

~~SECRET~~
SPECIAL HANDLING

Mass Properties and Dimensions

Since the previous changes affect mass properties and dimensions, the contractor was requested to re-determine these parameters. In addition, a change in mass properties reporting was requested.

The net effect of the two major design revisions, the heat shield and the cold gas spin subsystem, was a decrease in the empty weight of both the medium and large RV's. However, the weights still exceed the RFP requirements by 73 lb and 66 lb respectively. The weight changes and empty weights are summarized as follows:

Large RV	WAS	IS	Difference
Heat Shield	258	199	-59
Spin Subsystem	11	47	+36
Misc.		2	+2
Empty Wt	1062	1041	-21
RFP Empty Wt	975	975	
Medium RV			
Heat Shield	177	146	-31
Spin Subsystem	7	23	+16
Misc.		2	+2
Empty Wt	701	688	-13
RFP Empty Wt	615	615	

These changes had minor effects on the center of gravity and inertias.

The requested mass properties reports have been included in the revised CDRL (Form 1423).

~~SECRET~~
SPECIAL HANDLING

~~HX SECRET~~
SPECIAL HANDLING

E-7092-65

Attch 3 & 4

COST EVALUATION

Attachment 3

~~HX SECRET~~
SPECIAL HANDLING

BYE-71092-66

COSTS

The costs which were bid by the contractors in their supplementary report are as follows:

	GE	MAC
Large RV		
Total Cost	$ 20,872,100	$ 25,323,000
Fee	3,130,800	3,798,000
	24,002,900	29,121,000
Medium RV		
Total Cost	$ 22,754,700	$ 27,179,000
Fee	3,413,200	4,077,000
	$ 26,167,900	$ 31,256,000

A detailed breakdown of costs by task and subtask is included in this attachment.

~~EX SECRET~~
SPECIAL HANDLING

GE-71C92-66

The following is a discussion of the major cost differences between MAC and G.E. for the medium RV. The figures shown are the revised proposed dollars as contained in the contractor's supplemental report.

Structure

G.E.	MAC	Difference
$3,611,900	$2,239,000	$1,372,900

Direct labor hours compare favorably between the two contractors. However, GE's higher labor and burden rates amount to approximately $.5M of the total difference. In addition, G.E. has a procurement expense of approximately $.5M higher than MAC.

Propulsion

G.E.	MAC	Difference
$1,097,700	$1,985,000	$ 887,300

The major difference in this area is the MAC procurement cost which is approximately $.6M higher than G.E. MAC proposed a retro rocket which requires development. G.E. proposed an off the shelf retro rocket.

Electrical Power and Distribution

G.E.	MAC	Difference
$1,103,000	$2,259,000	$1,156,000

MAC's proposal contained three times as many man hours as did GE's proposal. This alone amounts to nearly $.75M of the difference when labor rates and burden rates are applied. In addition, MAC's procurement expense is approximately $.5M higher than G.E. The lower G.E. cost can be attributed to their experience. They have proposed equipment and techniques which they have developed for the Discoverer series.

~~EX SECRET~~
SPECIAL HANDLING

~~TOP SECRET~~
SPECIAL HANDLING

BIF-1692-66

Tracking, Telemetry and Programming

G.E.	MAC	Difference
$2,211,500	$5,364,000	$3,152,500

MAC's proposal contained two and one-half times as many man hours as did G.E.'s proposal. This amounts to approximately $1.4M of the difference when labor rates and burden rates are applied. MAC has a subcontract cost of $2.7M. G.E. has no subcontract cost. The lower G.E. cost can be attributed to their experience. They have proposed equipment which they have developed for the Discoverer series.

Parachute

G.E.	MAC	Difference
$2,711,400	$3,109,000	$ 397,600

The higher MAC cost is attributed to their higher subcontract cost of approximately $.4M or 30%. The reason for the higher MAC cost is not apparent since both contractors costed the same test program on one hundred parachute procurement for initial training by the aerial recovery forces.

Instrumentation

G.E.	MAC	Difference
$ 637,600	$1,547,000	$ 909,400

MAC's proposed labor hours are nearly 2.5 times those proposed by G.E. This amounts to approximately $.5 M of the difference when labor rates and burden rates are included. In addition, MAC has a procurement expense nearly $.5M higher than G.E. The lower G.E. cost can be attributed to their experience. They have proposed equipment and techniques which they have developed in the Discoverer series.

~~TOP SECRET~~
SPECIAL HANDLING

Design, Integration, Assembly & Evaluation

G.E.	MAC	Difference
$2,534,000	$1,103,000	$1,431,000

In subtask 3.2 Integration the MAC and G.E. Costs are as follows:

G.E.	MAC	Difference
$ 285,200	$1,506,000	$1,220,800

If tasks 3.2 and 1.10 are added together the cost differential is negligible. It appears that the difference between the two contractors in their two areas is due to a difference in accounting definition.

AGE

G.E.	MAC	Difference
$1,643,700	$1,721,000	$ 77,300

The difference in this task is negligible. There are, however, large differences in the subtasks in this area. These large differences are attributed to accounting definition of the costs.

Special Studies

G.E.	MAC	Difference
$1,019,300	$ 783,000	$ 236,300

The direct labor hours proposed by the two contractors compare favorably. The higher G.E. cost, 30%, is due to their higher labor and burden rates.

~~Hx SECRET~~
SPECIAL HANDLING

BYE-71092-66

Integration

G.E.	MAC	Difference
$ 285,200	$1,506,000	$1,220,800

The difference in these costs was discussed in task, Design, Integration, Assembly and Evaluation.

Post Flight Analyses

G.E.	MAC	Difference
$ 364,400	$ 82,000	$ 282,400

The difference in cost in this area is attributed to G.E. proposing nearly 2½ times the number of labor hours proposed by MAC. The scope of work proposed by each contractor in the Work Statement and Program Plan is comparable. No reason can be found for the large cost differential.

~~Hx SECRET~~
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

COSTS BY TASK AND SUBTASK

TASK I

MEDIUM

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
1.1	Structure	3.6119	3.6119	2.317	2.239
1.2	Propulsion	1.0977	1.0977	2.600	1.985
1.3	EP & D	1.1030	1.1030	2.372	2.259
1.4	TT & P	2.2673	2.2115	5.606	5.364
1.5	Heat Shield	1.1637	1.1611	1.007	1.007
1.6	Parachute	1.1685	2.7114	1.749	3.109
1.7	Rec. Aids	.7379	.7379	.575	.716
1.8	Instr	.6376	.6376	1.831	1.547
1.9	Spin Stab S/S	.3642	.5742	.546	.536
1.10	Des. Int. Assy. Eval	2.5340	2.5340	1.082	1.103
	Total	14.6858	16.3803	19.685	19.865

~~Hx SECRET~~
SPECIAL HANDLING

BYE-7109-66

~~SECRET~~
SPECIAL HANDLING

TASK II

MEDIUM

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
2.1	Handling Transp.	.6538	.5651	.748	.743
2.2	Inplant Elec.	.4842	.4842		
2.3	Field Elec.	.5154	.5154		
2.4	Gas Serv Eq				
2.5	Launch Control	.0790	.0790	.715	.421
2.6	Ground Power			.106	0
2.7	Special Purpose			.557	.557
	Total	1.7324	1.6437	2.126	1.721

CVE-71092-66

~~SECRET~~
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

TASK III

MEDIUM

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
3.1	Special Studies	.0357	1.0193	.352	.783
3.2	Integration	.2852	.2852	1.618	1.506
3.3	Post Flt Anal	.3644	.3644	.082	.082
	Total	.6853	1.6689	2.052	2.371

~~Hx SECRET~~
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

TASK IV

MEDIUM

TASK		O. E. Original	O. E. Revised	MAC Original	MAC Revised
4.1	Test Planning	.3608	.3608	.048	.048
4.2	SV Sys Test Supt		.2531	.885	.399
4.3	Launch Base Supt		.0378	.542	.133
4.4	STC Support		.0188	.078	.018
4.5	Remote Site Supt		.0410	.076	.040
4.6	Logistics		.3846	.109	.109
4.7	Software		.1061	.327	.327
4.8	Training		.0327	.123	.123
	Total	.3608	1.2549	2.188	1.197

~~Hx SECRET~~
SPECIAL HANDLING

Hx SECRET
SPECIAL HANDLING

TASK V

TASK		G. E. Original	G. E. Revised	NAC Original	NAC Revised
5.1	Program Control	.4158	.4158	.035	.035
5.2	Prog Mgmt	.6133	.6133	.531	.499
5.3	Config Mgmt	.1610	.1610	.274	.274
5.4	Production Mgmt	.4502	.4502	.264	.259
5.5	Documentation	.1666	.1666	.958	.958
5.6	Special Security	———	———	———	———
	Total	1.8069	1.8069	2.062	2.025

Hx SECRET
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

SUMMARY

NERVA

TASK	G. E. Original	G. E. Revised	MAC Original	MAC Revised
I	14.6858	16.3803	19.685	19.865
II	1.7324	1.6437	2.126	1.721
III	.6853	1.6689	2.052	2.371
IV	.3608	1.2549	2.188	1.197
V	1.8069	1.8069	2.062	2.025
Total Cost	19.2712	22.7547	28.113	27.179
Fee	2.8907	3.4132	4.217	4.077
Total Proposed	$22.1619	$26.1679	$32.330	$31.256

~~Hx SECRET~~
SPECIAL HANDLING

Hx SECRET
SPECIAL HANDLING

COST BY TASK AND SUBTASK

TASK I

LARGE

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
1.1	Structure	3.2308	3.2308	2.348	2.295
1.2	Propulsion	.9902	.9902	2.767	2.165
1.3	EP & D	.8574	.8574	1.938	1.880
1.4	TT & P	1.7630	1.7025	4.852	4.680
1.5	Heat Shield	1.1292	1.1126	.884	.884
1.6	Parachute	1.0665	2.8773	1.633	3.201
1.7	Rec Aids	.6729	.6729	.480	.584
1.8	Instr	.4597	.4597	1.628	1.339
1.9	Spin Stab S/S	.3240	.4914	.493	.488
1.10	Des Int Assy Eval	2.2344	2.2344	1.040	1.070
	Total	12.7281	14.6292	18.063	18.586

BYE-7092-66

Hx SECRET
SPECIAL HANDLING

TASK II

LARGE

TASK	G. E. Original	G. E. Revised	MAC Original	MAC Revised
2.1 Handling Transp	.4729	.4729	.572	.573
2.2 Inplant Elec	.4842	.4842		
2.3 Field Elec	.5154	.5154		
2.4 Gas Serv Eq				
2.5 Launch Control	.0790	.0790	.707	.412
2.6 Ground Power			.099	0
2.7 Special Purpose	____	____	.527	.527
Total	1.5515	1.5515	1.935	1.542

BIF 7/09/69

~~Hx~~ SECRET
SPECIAL HANDLING

TASK III

LARGE

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
3.1	Special Studies	.0357	1.0193	.364	.783
3.2	Integration	.2852	.2852	1.243	1.185
3.3	Post Flt Anal	.3644	.3644	.054	.054
	Total	.6853	1.6689	1.1661	2.022

BYE-4709-66

~~Hx~~ SECRET
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

TASK IV

LARGE

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
4.1	Test Planning	.3608	.3608	.048	.048
4.2	SV Sys Test Supt		.2531	.885	.399
4.3	Launch Base Supt		.0578	.542	.133
4.4	STC Support		.0188	.078	.018
4.5	Remote Site Supt		.0410	.076	.040
4.6	Logistics		.3452	.109	.109
4.7	Software		.1061	.327	.327
4.8	Training		.0328	.123	.123
	Total	.3608	1.2156	2.188	1.197

~~Hx SECRET~~
SPECIAL HANDLING

~~Hx SECRET~~
SPECIAL HANDLING

TASK V

LARGE

TASK		G. E. Original	G. E. Revised	MAC Original	MAC Revised
5.1	Prog Control	.4158	.4158	.035	.035
5.2	Prog Mgmt	.6133	.6133	.531	.499
5.3	Config Mgmt	.1610	.1610	.274	.274
5.4	Production Mgmt	.4502	.4502	.211	.209
5.5	Documentation	.1666	.1666	.959	.959
5.6	Special Security	———	———	———	———
	Total	1.8069	1.8069	2.010	1.976

BYE-7109-66

~~Hx SECRET~~
SPECIAL HANDLING

SECRET

SUMMARY

LANGE

TASK	G. E. Original	G. E. Revised	NAC Original	NAC Revised
I	12.7281	14.6292	18.063	18.586
II	1.5515	1.5515	1.935	1.542
III	.6853	1.6689	1.661	2.022
IV	.3608	1.2156	2.188	1.197
V	1.8069	1.8069	2.010	1.976
Total Cost	17.1326	20.8721	25.857	25.323
Fee	2.5699	3.1308	3.879	3.798
Total Proposed	$19.7025	$24.0029	$29.736	$29.121

SECRET

SPECIAL HANDLING

~~Ex SECRET~~
SPECIAL HANDLING

Attch 4, pg 1

LETTER TO MCDONNELL

AIRCRAFT CORPORATION

Attachment 4

~~Ex SECRET~~
SPECIAL HANDLING

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF SPECIAL PROJECTS (OSAF)
AF UNIT POST OFFICE, LOS ANGELES, CALIFORNIA 90045

BYE-71092-66

REPLY TO ATTN OF: SP-7

SUBJECT: Re-entry Vehicles Proposal for the HEXAGON System

TO: MAC (R. Rapp)

1. As a result of our Source Selection activity, you are requested to provide by 1 December additional cost, technical and managerial data for revisions to your proposal to:

a. Correct significant technical and operational deficiencies as identified in Attachment 1.

b. Improve system compatibility as identified in Attachment 2.

c. Meet revised requirements as identified in Attachment 3.

These revisions and the costs associated with them should be made only for the 558 lb and 1120 lb - payload RVs; the 270 lb - payload RV should be disregarded.

2. The changes to your cost proposal should be limited to those required by the revisions we have requested and must be firm quotes for future negotiation of a contract to be awarded as a result of this competition.

FRANK S. BUZARD
Colonel, USAF
Hexagon System Program Office

3 Attachs
1. Sig Tech & Oper Def
2. Sys Compat Improvement
3. Revised Requirements

SYE-71092-66

SIGNIFICANT TECHNICAL & OPERATIONAL DEFICIENCIES

1. Batteries: Manually activated batteries present a reliability risk for the long wet stand requirement. If such batteries can be developed, installing them at the launch pad and the associated handling and AGE equipment degrades the factory-to-pad concept. Automatically activated batteries are available, flight proven, and can be installed at the RV factory. In addition, it could not be determined how the Electrical Power and Distribution Subsystem will be designed or built to survive the salt water environment in the event of water impact. An underwater test program should be provided if required.

2. Flashing Light: The location of the flashing light prevents it from being an effective aid for night recovery until the RV has descended to an altitude near that of the recovery aircraft. The location of the light on the RV should be changed to provide more coverage in the hemisphere below the RV.

3. Sink Subsystem: The use of pyros in the sink subsystem is an unacceptable risk to recovery force personnel, especially after the RV has been in the water. If you cannot find an alternate design that meets the RFP sink requirements, propose your best choice along with its expected performance. (Electrochemical plugs have been used satisfactorily in the past).

4. Separation Concept: From the information presented in the proposal we cannot determine how the separation can be accomplished without binding on the film chute since it appears that the RV begins to spin simultaneously with the lateral movement. Clarification or modification of the separation sequence is required.

5. RF Beacon: The system should be designed so that the beacon begins to transmit at RV separation from the SRA in order to serve as an acquisition aid for the tracking station(s), the recovery aircraft, and the other recovery forces during the entire re-entry sequence.

6. Telemetry: In order for our recovery forces to use the telemetry signal as a backup recovery aid, some distinctive audio tone (usually a periodically swept tone) is required.

7. Structure Subsystem: The structural analysis presented in the proposal is weak and incomplete. Few analytical techniques are shown in your structural analysis. For example, there is no presentation of a buckling analysis for either the torispherical nose cap or the truncated conical frustrum, although it is stated that this design condition has been

Attach 1

BYE 71092-66

studied for the spherical shell. Although it may not be a problem with the LSM heat shield, no panel flutter analysis is provided. There is no analysis to establish that the inner capsule or its externally mounted equipment will not contact and interact with the heat shield substructure in the "shuttlecock" mode. There are no stress or structural dynamics analyses to establish the structural integrity of the corrugated skins of the film canister and its externally mounted equipment under loads during parachute opening, descent, air snatch, and water impact.

In the evaluation of those analyses which are provided in the proposal, there appears to be some lack of understanding of the basic problem. An example is the strength analysis of the heat shield sub-structure, which treats the truncated conical frustrum as a ring and not as a shell. It is correctly recognized that loads on the aft end of the truncated conical shell are extremely important to the selection of the honeycomb substructure, and the titanium ring stiffener configuration is selected on this basis to best distribute the loads into the internal capsule. This is good for the capsule, but very poor for the substructure. In treating the shell as a ring and only designing for loads in the plane of the ring, your analysis neglects the longitudinal shell bending stresses in the honeycomb substructure near the titanium attachment ring. In addition, the thermal stresses are neglected, although the material properties are modified to take the thermal environment into consideration.

For the large RV only, it appears that a numerical error was made in the calculated weight of the heat shield substructure (approximately fifteen pounds too much). However, even after this error is subtracted, the selected configuration still has a weight per unit area that is excessively high. This indicates that you should probably deviate from the proposed substructure design and perform a more comprehensive weight - strength analysis using internal stiffening rings, etc. in order to lower the weight.

Considering the amount of analyses and development testing that will have to be accomplished on the Structure Subsystem should you be awarded the contract, it appears that your bid cost for this subtask is low.

8. Special Studies and Analyses: In addition to your proposed effort under subtask 3.1, you should (1) conduct studies and analyses on parachute illumination to insure compatibility and operability with the Recovery Force and (2) conduct studies and analyses of the RV in the water mode to insure compatibility and operability with the Recovery Force. The costs for the efforts of 3.1 plus the additional efforts stated above are to be based on a ten (10) equivalent man month per month level of effort for the period of performance of the entire contract.

BYE-71092-66

9. Parachute Subsystem: Your proposed conical extension parachute is not considered optimum to meet the requirements. The reduced-weight parachute will place an unnecessary maintenance burden on the JC-130 recovery equipment. In addition, there is doubt that the conical extension will function properly over the required large variation in suspended weight. Therefore, you are requested to propose the annular parachute and to rely on subcontractor capabilities for this development. The Air Force expects to solve the existing problems associated with the annular parachute in the very near future. In the selection of the device for deploying the drogue chute, the restriction of emitting no gases or residues does not apply. Your proposal should include the parachute test program that is presented in Appendix 1 and the procurement of one hundred (100) parachutes for initial training of the JC-130 crews at Hickam AFB.

10. AGE: There are two shortcomings in mechanical AGE and handling equipment. No AGE or handling equipment was called out for assisting in the film chute alignment procedure, whereby the entire RV must repositioned. All of the illustrations depicting RV replacement, equipment replacement, and film alignment show the necessity for some sort of floor just below the level of the RV roll axis. No information was presented as to how these work levels are to be provided. This might be a fairly complicated problem with the four-RV, in-line configuration.

BYE-71092-66

SYSTEM COMPATIBILITY IMPROVEMENTS

The following comments concern those portions of your proposal which the System Program Office considers to be an unnecessary complexity and excessive to our requirements. Request that you simplify the designs, delete excessive equipment, or reduce your proposed effort as appropriate.

a. Venting During Re-entry: The proposal to pressurize the film canister with N_2 during re-entry appears unnecessarily complex. Similar problems have been solved in the past by using a properly designed and located ball/poppet valve to permit passive venting. The additional feature of providing tumbling of the RV for destruct is not considered necessary.

b. Supplemental Telemetry: Your supplemental telemetry system is considerably more complex than is required and should be simplified. One of the multiplexers can be made to serve both the RV transmitter and the SBA telemetry subsystem since these functions are not required simultaneously. A second and more serious problem is the excessive amount of data proposed - the number of accelerometers, redundant temperature sensing, digital clock words with an accuracy of 5 milliseconds, etc.

c. AGE and Special Support Equipment: You have proposed an excessive amount and overly complex AGE and support equipment at the launch pad. The RV Control and Monitor Equipment (RVCME) display system is grossly overdesigned. There are three analog displays, each of which contains four meters. Each group of four meters are in turn connected to a three-digit "decimal" display with an Analog-to-Digital converter associated with each "decimal" display. If the meters are not accurate enough to display the data inputs they carry, they should be deleted entirely. If the meters are accurate to a sufficient degree, then the "decimal" display and the A-to-D converters should be deleted. In addition, there are four panels of discrete displays of twenty-four parameters each. There is no list of discretes to be monitored that would justify a display of this size. There are three racks of recording equipment, including four eight-channel analog recorders and a 100-channel discrete function recorder. Since all the data inputs to the RVCME come from the main PCM/FM ground stations, where they have already been recorded with the rest of the telemetry data, the RVCME recorders seem to be an extravagant duplication of equipment. The telemetry checkout system, via the RV Control and Monitor Console (RVCMC), is designed to "isolate problems to the subsystem, and even component level without external wiring connections." Therefore, the proposed portable Fault Location Test Set, which is also designed to do fault isolation to the replaceable module level, is completely redundant to the RVCMC and considered unnecessary. The RVCMC is hardwired to the SBA command system at all times and outputs from the RVCMC go directly to the "control logic in the SBA." This should be changed so that normal commands go through the SBA ground system used to send commands to the vehicle command system. The only

Attach 2

hardwire commands should be those necessary to shut down the RV in the event of malfunction.

The proposed portable air conditioners for the recovery aircraft and ships should be deleted. Our past experience has shown that such a device is not required. Keeping the capsule shielded from the direct rays of the sun has proven to be adequate.

d. Operational Support: You have proposed a much greater role and many more men than is required in accomplishing Sub-tasks 4.2 through 4.5. The costs for these efforts should be based on the following guidelines:

(1) Assign a total of ten (10) men to the SBA contractor's facility and Vandenberg AFB from three months before the first RV delivery until the end of the contract period. Two of these can be permanently assigned to VAFB. Some of the individuals will travel to the base with the Satellite Vehicle, remain there until it is launched, and then return to the SBA contractor's facility. Most of the testing and monitoring that you have proposed will be accomplished by the SBA contractor in his role as Satellite Vehicle Integrating Contractor.

(2) Assign one (1) man to the STC during a mission only (30 days every other month for six flights).

(3) Assign one (1) man to Hickam AFB from six months before the first flight until the end of the contract period. After the RV capsule is recovered, the Government accomplishes all of the tasks associated with handling and transporting the capsule to the film processing facility where the film is removed. The capsule will then be sent to the RV contractor.

e. The System Program Office does not approve of the plan to refurbish the DTV's and use them as the sixth set of flight vehicles.

f. In Sec. 2.4 of Appendix B of your Cost Proposal, you state objections to paragraphs (c) and (g) of the ASPR 1-1905 FACI provisions. The Air Force agrees that paragraph (g) can be deleted; however, at the time of FACI, the hardware must conform to the appropriate specifications. If it does not conform to the specifications, you will be required, within the scope of the contract, to accomplish whatever is necessary to make the hardware meet the specifications. It is not clear that your proposed change to paragraph (c) will accomplish this. As a consequence, your proposal in this area should be revised. A related guideline is that FACI will not be conducted until after the completion of Qualification Tests and the DTV cycle through the launch pad.

BYE-71092-66

REVISED REQUIREMENTS

The following comments concern those portions of your proposal which should be changed as a result of changes to our stated requirements.

a. Retro-rocket and Dispersion Analysis: You are requested to propose a Retro-rocket Subsystem that does not include thrust termination. A 3 sigma total impulse tolerance of ± 3% should be used in your analyses unless you can fully substantiate that a lesser variation is attainable under the environmental conditions of the 612 Program.

You are also requested to re-accomplish the dispersion analyses and determine the orbital envelope from which the dispersion requirements can be met. When considering the Back-up Recovery Attitude Control (BRAC) mode, the analyses shall be based on the restriction that the SBA is able to orient the RV to only one optimum spatial attitude (determined and specified by the RV contractor).

b. Since the precceding changes will result in new dimensions and mass properties, it is requested that you re-determine these parameters.

c. Since it is not absolutely clear from your proposed Work Statement that the results of your System Analyses and test programs will be incorporated into the system design, the following statement is to be included in Section 1.1 Scope of the Statement of Work:

"This contract covers both the System Definition and Acquisition Phases of the 612 Re-entry Vehicle System development. As a consequence, it is expected that the RV System design, including all AVE, AGE and special equipment, will evolve through design analysis and testing from the initially proposed design to a fully qualified design which meets all the requirements of the RV Performance/Design Requirements General Specification. If System Analyses and the test programs uncover design deficiencies, the initially proposed design must be modified to correct these deficiencies. This evolutionary process by which the initially proposed design is modified as necessary to meet the requirements of the RV Performance/Design Requirements General Specifications is within the scope of this Statement of Work."

d. In your proposed documentation of Mass Properties data, you should substitute a Post-flight Report, data item subnumber 2.5 of Form 9 No. S-66-14.0, in lieu of the Plan-Operational Support-Orbital, data item subnumber 3.1. The latter report is item No. 108 on your proposed DD Form 1423.

Attach 3

BYE-71092-66

RECOVERY AND RETRIEVAL TEST PROGRAM

This test program described on the following pages is the minimum program that will provide confidence in successful recovery and retrieval of the payload.

The following factors prevent a reduction in the number of tests specified:

a) Deceleration and aerial retrieval are required by a single recovery system for a much wider range of payload weights than has been attempted previously.

b) Night retrieval is required.

c) A new (not previously operational) recovery parachute concept is to be employed.

d) An ambitious parachute system weight reduction (from feasibility demonstration hardware) is considered.

e) Since the desired reliability of 0.99 plus at an acceptable confidence level cannot be demonstrated without an overly extensive test program, the approach of derating all components is used instead. This approach, as described in the following test program, requires proof testing (demonstration of adequate safety factor) of all portions of the system (main canopy as well as pickup canopy, etc.) and operations at extremes of all variables (payload weight, etc.).

Appendix D

TEST MATRIX (FIRST STAGE)

Type of Test	Number of Tests	Payload	Altitude	Velocity	Dynamic Pressure	Purpose
Wind Tunnel	1	(a)	Nominal	Nominal	Nominal	Establish aerodynamic characteristics and wake effects
	1	(a)	3σ Max	Nominal	< Nominal	
	1	(a)	3σ Min	Nominal	> Nominal	
	1	(a)	3σ Max	3σ Min	3σ Min	
	1	(a)	3σ Min	3σ Max	3σ Max	
Drop	1	max	nominal	nominal	nominal	Establish aerodynamic characteristics and deployment system adequacy
	1	min	nominal	nominal	nominal	
	1	max	3σ max	3σ min	3σ min	
Drop (Proof)	1	max	nominal	1.225 nominal	1.5 nominal	Demonstrate safety factor
	1	max	< nominal	nominal	1.5 nominal	

(a) Wind tunnel tests should be conducted at full scale with a simulated vehicle.

TEST MATRIX ([illegible] STAGE)

Type of Test	Number of Tests	Payload Weight	Altitude	Velocity	Dynamic Pressure	Purpose
Drop [illegible]	7 (a)	max	~ nominal	~ nominal	~ nominal	Establish aerodynamic characteristics and deployment system
	3	min				
Drop (proof)	1	max	nominal	1.225 nominal	1.5 nominal	Demonstrate safety factor on pickup canopy
	1		< nominal	nominal	1.5 nominal	
	1	max	nominal	nominal	nominal (b)	Demonstrate safety factor on Main Canopy
	1	min	< nominal	nominal	1.5 nominal	Demonstrate safety factor on pickup canopy (c)
	1	min	nominal	nominal	nominal (b)	Demonstrate safety factor on main canopy (c)
Tow	3	Tow and boarding tests to establish stability of reentry vehicle during JC-130 boarding and suitability of capsule carriage				
JC-130 Aerial Retrieval	2	max	20000'	-	-	Establish suitability of pickup configuration
	1	min				
	2	max	(d)	(d)	(d)	Demonstrate safety factor on pickup webbings

BYE-71092-66

Test Matrix (First Stage) continued

Notes

(a) At least two of these tests should be conducted at T-1 to establish adequacy of [illegible] (by photometric measurement and pilot assessment during fly-by) early in the program.

(b) Time duration of zero reefing should be shortened as required to 1.3 times nominal dynamic pressure at time of main canopy inflation.

(c) These tests will also demonstrate behavior of the system at off-nominal Q and velocity conditions with a light payload.

(d) Pickup altitude or pickup aircraft velocity should be varied to develop engagement forces 1.5 times nominal value.

TEST MATRIX (SYSTEMS TESTS)

Type Test	Number of Tests	Payload Weight	Test Description	Purpose
Systems Drop Test	1	max	These tests should be conducted at altitude and velocity conditions closely approximating the nominal values. Vehicle mass and shape properties shall be closely simulated	Demonstrate stabilized recovery system operation (no aerial retrieval)
	1	inter-mediate		
	1	min		
Packed Parachute Life	3	max	After successful completion of the three systems tests, three new parachute systems (first and final stages) shall be packed in the operational configuration and be stored under the same conditions that are expected for storage of operational systems. At the end of 180 days of storage the parachute systems shall be tested under nominal deployment conditions (separate tests for first and final stages if desired) with aerial retrieval of final stage	Demonstrate parachute operation after storage in packed condition
	3	max	As above except that storage interval shall be 210 days	

BYE-7109-66

Type Tests	Number of Tests	Payload	Time	Purpose
[c] JC-130 Aerial Retrieval	10	max	day	Demonstrate overall retrieval system compatibility
	5	max	night	
	5	min	day	
	5	min	night	

[a] These tests are to be conducted at OI-1 and off shore Pt Mugu with final stage only.

[b] One hundred additional final stage systems are to be supplied for training.

[c] Deployment conditions will be established later.

BTE-7109-66

TOP SECRET
EYES ONLY
SPECIAL HANDLING

BYE-71092-66

Hosk 5, 41

[redacted]

[redacted]

TOP SECRET
EYES ONLY
SPECIAL HANDLING

[redacted]

[redacted]
SPECIAL HANDLING

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF SPECIAL PROJECTS (IGSAF)
AF UNIT POST OFFICE, LOS ANGELES, CALIFORNIA 90045

DE-71092-68

REPLY TO ATTN OF: SP-7

SUBJECT: Re-entry Vehicle Proposal for the HEXAGON System

TO: GE (T. Handley)

1. As a result of our Source Selection activity, you are requested to provide by 2 December additional cost, technical and managerial data for revisions to your proposal to:

a. Correct significant technical and operational deficiencies as identified in Attachment 1.

b. Delete excess requirements as identified in Attachment 2.

c. Provide cost information for tasks that were previously omitted as identified in Attachment 3.

d. Meet revised requirements as identified in Attachment 4.

These revisions and the costs associated with them should be made only for the 555 lb and 1120 lb - payload RVs; the 270 lb - payload RV should be disregarded.

2. The changes to your cost proposal should be limited to those required by the revisions we have requested and must be firm quotes for future negotiation of a contract to be awarded as a result of this competition.

Frank S. Buzard

FRANK S. BUZARD
Colonel, USAF
Hexagon System Program Office

4 Attachs
1. Sig Tech & Oper Def
2. Excess Requirements
3. Cost Omissions
4. Revised Requirements

P-26282
ep 3

[redacted]
SPECIAL HANDLING

[redacted]

BTE-71592-66

SIGNIFICANT TECHNICAL & OPERATIONAL DEFICIENCIES

1. Spin Subsystem: Your choice of solid rocket motors for performing the spin function is considered risky from the viewpoint of ignition characteristics, thrust level tolerance, and temperature sensitivity. Therefore, you are requested to propose cold gas for the Spin Subsystem in lieu of the solid rocket motors. The System Program Office will accept the increased weight in order to obtain the proven reliability and performance of cold gas.

2. Retro-rocket: From the information presented in the proposal for the medium RV, we cannot determine the location of the initiator(s), the degree of accessibility, or if redundant initiation is provided. Request you clarify these details.

Your test program should provide for firing of the retro-rockets at temperature extremes in addition to the proposed firing at 70°F.

Your stated 3 sigma total impulse tolerance of ± 1% for the chosen retro-rockets is considered very doubtful in the light of no substantiating data. Therefore, a 3 sigma total impulse tolerance of ±3% should be used in your analyses unless you can fully substantiate that a lesser variation is attainable under the environmental conditions of the 612 Program.

3. Heat Shield: Your proposal to use phenolic nylon as an ablator is unacceptable because of high risk in meeting shelf life requirements. Request you propose an alternate design.

4. Parachute Subsystem: Your proposed parachute test program is considered inadequate. Your proposal should include the parachute test program that is presented in Appendix 1 and the procurement of one hundred (100) parachutes for initial training of the JC-130 crews at Hickam AFB.

5. Flashing Light: The location of the flashing light prevents it from being an effective aid for night recovery until the RV has descended to an altitude near that of the recovery aircraft. The location of the light on the RV should be changed to provide more coverage in the hemisphere below the RV.

6. EMI: Volume III, Section 4.2.5.1 of your proposal states that SAPSP 65-27 will be "implemented as applicable." This approach is not considered satisfactory.

Volume I, Section 5.3.6.1 of your proposal is not in accordance with the intent of SAPSP 65-27 or the RFP. The frequency ranges, signal levels, and number of points to be measured within each frequency band were not specified. You referenced a 12 db interference level

[redacted]

Attach 1

BYE-71092-66

"In excess of reported pad environment or measured radiated vehicle interference, whichever is higher." However, on any given day the levels can vary significantly. The values given in SAFSP 65-27, on Pages 28, 29, 30 and 44 are directly applicable for this test and should be used by you for this test without deviation.

Volume I, Section 5.4.3 fails to define test limits criteria, etc. Request you provide additional information in this area.

From Volume III, Section 2.1, SAFSP 65-27, exception b, it appears that you have proposed no testing of components or sets of integrated components. This is not consistent with SAFSP 65-27 and is unacceptable to the SPO since it would not be until system level testing that component EMI deficiencies would be discovered.

All the exceptions to SAFSP 65-27 taken in Vol III, Section 2.1 are unacceptable, except a, c, d, and q, because they reduce the required design criteria.

7. Destruct Subsystem: Your proposed destruct subsystem is not redundant. Request that redundancy be provided for this subsystem.

8. Separation from the SBA: Your proposal does not show how redundancy will be achieved in the electro-explosive initiator used to actuate the explosive valve (Volume II, Figure 3.2-17). Request your proposed redundancy application be detailed in this area.

9. Water Seal and Film Cutter: The location of the film cutter is not included in your proposal and the concept is inadequately described. Request you present more detail in these two areas.

The water/light seal you propose requires more description. How will sealing be assured? What disturbing effects will the spring loaded door have on the RV's orientation at separation?

10. Venting Devices: Your proposal contained an inadequnte description of how ascent venting would be achieved and there was no description of re-entry venting. Request you provide more technical detail on these aspects of your proposal describing the devices to be used, their design capabilities, and their location in the RV.

11. Special Studies and Analyses: Your proposed level of effort in this area is too low. Request your cost proposal be changed to include a ten (10) equivalent man month per month level of effort for the period of performance of the entire contract in order to adequately cover the efforts described in your work statement tasks 3.1.2, 3.1.3, and 3.1.4. Tasks 3.1.1 and 3.1.5 should be included separately from the ten man level of effort specified above.

REQUEST
SPECIAL HANDLING

BYE-71392-66

EXCESS REQUIREMENTS

Your proposed RF beacon includes a modulation to transmit the altitude of the descending RV and a change in modulation to transmit water impact time to the recovery aircraft crews. These features are an unnecessary complexity and not required, since predicted altitude and water impact time can be computed with sufficient accuracy from telemetered events. You are therefore requested to delete these features of the RF beacon design.

~~SECRET~~
SPECIAL HANDLING

Attach 2

BYE-71093-65

COST OMISSIONS

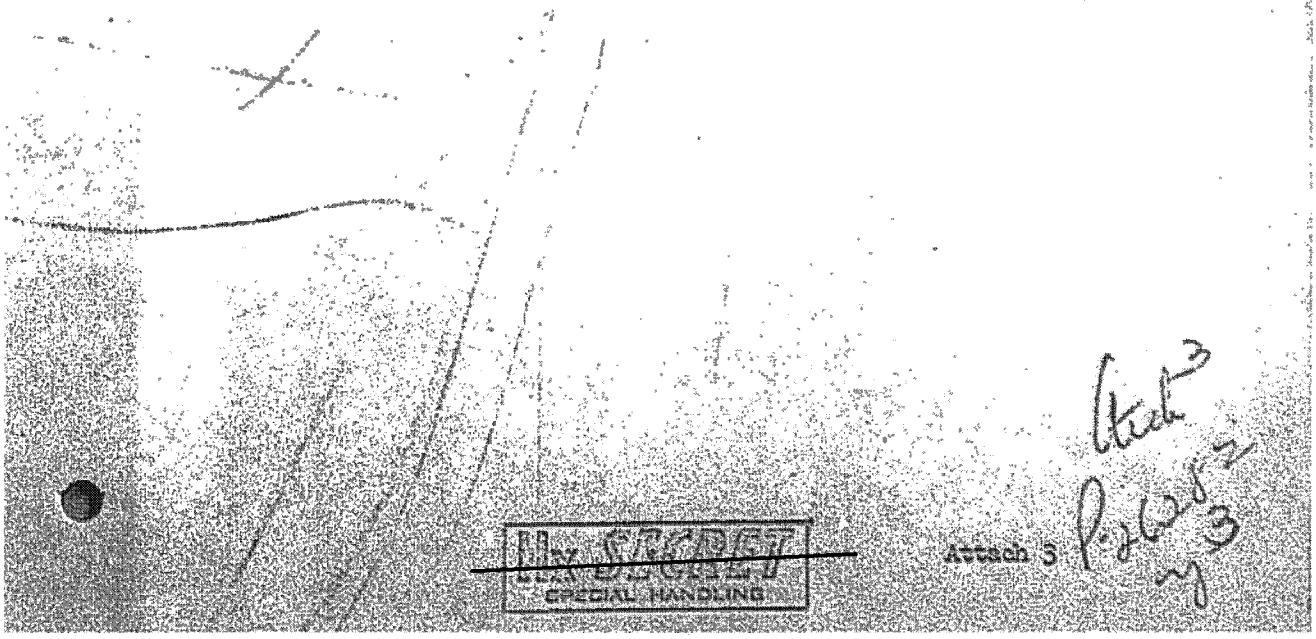
You are requested to submit costs for accomplishing subtasks 4.2 through 4.8 of the Work Statement which were omitted from your original Cost Proposal. Your plans and costs for accomplishing operational support, subtasks 4.2 through 4.5, shall be based on the following guidelines:

a. Assign a total of ten (10) men to the SEA contractor's facility and Vandenberg AFB from three months before the first RV delivery until the end of the contract period. Two of these can be permanently assigned to VAFB. Some of the individuals will travel to the base with the Satellite Vehicle, remain there until it is launched, and then return to the SEA contractor's facility.

b. Assign one (1) man to the SFC during a mission only (30 days every other month for six flights).

c. Assign one (1) man to Hickam AFB from six months before the first flight until the end of the contract period.

In the RFP you were requested to make a preliminary analysis of the support required under subtasks 4.2 through 4.8, and include your estimates and support plans as part of the Program Plan. You are again requested to submit your proposed effort for accomplishing subtasks 4.6 through 4.8 and the associated costs. It should be pointed out that subtask 4.8, Training, applies primarily to your own training requirements plus any requirements of SFC and Recovery Force personnel.



Attach 3

~~SECRET SPECIAL HANDLING~~

BYE-71092-66

REVISED REQUIREMENTS

The following comments concern those portions of your proposal which should be revised as a result of changes to our stated requirements.

a. You are requested to re-accomplish the dispersion analyses and determine the orbital envelope from which the dispersion requirements can be met. These analyses should include cross-track dispersions and the operational modes of unbalance, BRAC, and the combination thereof, which were not presented in your proposal. When considering the BRAC mode, the analyses shall be based on the restriction that the SBA is able to orient the RV to only one optimum spatial attitude (determined and specified by the RV contractor).

b. Since the preceding changes will result in new dimensions and mass properties, it is requested that you re-determine these parameters.

c. Since it is not absolutely clear from your proposed Work Statement that the results of your Systems Analysis and test programs will be incorporated into the system design, the following statement is to be included in Section 1.1 Scope of the Statement of Work:

"This contract covers both the System Definition and Acquisition Phases of the 612 Re-entry Vehicle System development. As a consequence, it is expected that the RV System design, including all AVE, AGE and special equipment, will evolve through design analysis and testing from the initially proposed design to a fully qualified design which meets all the requirements of the RV Performance/Design Requirements General Specification. If Systems Analysis and the test programs uncover design deficiencies, the initially proposed design must be modified to correct these deficiencies. This evolutionary process by which the initially proposed design is modified as necessary to meet the requirements of the RV Performance/Design Requirements General Specification is within the scope of this Statement of Work."

d. In your proposed documentation of Mass Properties data, you should delete the sequence numbers E4 and E5 of DD Form 1423 and list the following reports as listed in Form 9, No. S-66-14.0 (AFSCM 310-1):

Data Item Subnumber	Title
1.3	Detail M.P. Report for PDR
1.5	Detail M.P. Report for CDR
1.6	Detail M.P. Report for FACI
2.2	Status Report - Design for Acquisition Phase
2.4	Status Report - Preflight for results of Acceptance Weighing.

~~SECRET~~ SPECIAL HANDLING

Attach 4

Atch 4 f-26282 cy 3

BYE-71092-66

Data Item Subnumber	Title
2.5	Status Report - Post Flight
3.2	Plan-Verification
3.3	Plan-Operational Support

The noted reports shall be prepared, without exception, in accordance with the report content, where applicable, and the submittal schedule as noted in Figure 1 of Form 9.

e. The meaning of your statement of Sec. 1.1 Introduction of your Cost Proposal, Part I, regarding producing "all the RV's as a single lot and, therefore, requalification of components is not required" is not clear. This statement and the resulting program restriction is unacceptable if you mean that the costs for incorporating the results of development, qualification, DTV and flight tests into the system design and the flight hardware are not included in your proposal. The Air Force intends to contract for the development of an RV system that meets the requirements of the RV Performance/Design Requirements General Specification. Because of the tight system development and flight schedules, the possibility exists that some flight hardware will have been manufactured before all of the development, qualification and DTV tests are complete. If these tests show that the RV system does not satisfy the requirements of the RV Performance/Design Requirements General Specification, you will be required to correct and requalify, if necessary, any design deficiencies and include these corrections in all hardware. This includes retrofiting existing hardware, if necessary. The costs necessary to provide qualified flight hardware that meets the requirements of the RV Performance/Design Requirements General Specification must be in your proposal.

f. In Section 2.4.4 of your Cost Proposal, Part I, you state objections to paragraph (c) and (g) of the ASPR 1-1906 FACI procedures. The Air Force agrees that paragraph (g) can be deleted; however, at the time of FACI, the hardware must conform to the appropriate specifications. If the hardware does not conform to the specifications, you will be required, within the scope of the contract and without use of the changes clause, to accomplish whatever is necessary to make the hardware meet the specifications. As a consequence, your proposed change to paragraph (c) is unacceptable to the Air Force, and this part of your proposal should be revised. A related guideline is that FACI will not be conducted until after the completion of Qualification Tests and the DTV cycle through the launch pad.