CENTRAL INTELLIGENCE AGENCY
WASHINGTON 25, D. C.

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BYE-2100-66
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23 FEB 1966

MEMORANDUM FOR : Director, National Reconnaissance Office

SUBJECT : ISINGLASS Research and Development Program

1. Pursuant to your verbal request, I have attached to this memorandum a recommended research and development program for ISINGLASS covering a period of about nine months. This program has been designed specifically with two goals in mind:

a. to determine capability to satisfy our objectives, in particular, to establish system capabilities with regard to resolution, survivability, range, reaction time, tactical flexibility, and target coverage; and

b. to establish reliable program cost estimates based on detailed point design, subsystem analysis, and, insofar as possible, actual manufacturing experience. In order to accomplish the above, a substantial amount of testing, engineering and analysis will be necessary which will further confirm the technical feasibility of the concept.

2. The estimated cost of the McDonnell portion of the program is $5,350,000. In addition, we are recommending camera environment studies totalling $150,000, giving a nine month program total of $5,500,000.

3. The basic study areas at McDonnell are:

a. System Effectiveness: This will include development of a mission performance computer program and analysis of targeting, reaction time, basing recovery, and support operations. In addition, necessary contractor support to government studies on survivability and cost effectiveness will be provided.

b. Configuration Definition: Using extensive wind tunnel testing, full flight range performance of the aircraft and carrier aircraft will be established and design sensitivities assessed. In addition, extensive . . .

testing will be done to establish the photographic performance, to demonstrate the window cavity concept, and to optimize design. Structural elements will be determined, their performance substantiated and refurbishment requirements established.

c. Technology Demonstration: From wind tunnel tests, thermal design criteria will be established and structural elements, including the insulation and waterwick, will be subjected to thermal tests. A full scale fuselage section will be designed and the performance of the cryogenic systems will be demonstrated.

d. Cost and Schedule Substantiation: The results of the work above will be used to develop a high confidence base for cost and schedule performance.

4. In addition to the work at McDonnell Aircraft Corp. we are recommending certain studies to establish camera environment. These studies will investigate the internal turbulence of the camera bay, window temperature gradients, and boundary layer effects. Details are set forth in the attachment. Total cost, over a period of 9 months, would be $150,000.

5. If, on conclusion of the foregoing program, it appears desirable to continue work on this project, we would propose a second phase. In particular, we feel that a full scale fuselage section and window cavity should be constructed. This will permit us to verify weight factors, harden cost data, and determine capability to achieve resolution requirements. We are in the process of preparing this second phase program to last about nine months and cost about 5 million dollars.

Huntington D. Sheldon
HUNTINGTON D. SHELDON
Director of Reconnaissance, CIA

INDEX TO ATTACHMENT TO BYE-2100-66

Attachment to
BYE-2100-66

ISINGLASS RESEARCH & DEVELOPMENT PROGRAM

A. McDonnell Aircraft Corp.

1. System Effectiveness $440,000

The global operating concept, logistics plan, support requirements, and mission effectiveness for the McDonnell Model 192 (ISINGLASS) will be developed. In addition, necessary contractor support to government survivability and cost effectiveness studies will be provided.

a. Mission Effectiveness

i. Operational Plan - the global operating concept will be developed and system deployment requirements such as basing, recovery, logistic support, etc., will be defined. The influence of operational variables, such as response time, data processing, range, etc., on the operating plans will be determined.

ii. Targeting Analysis - Targeting and mission effectiveness analyses will be performed for the Model 192.

iii. Targeting Computer Program - A mission performance computer program will be developed. This program will produce the "missionized" ground track of the Model 192. Basic vehicle characteristics and mission variables, such as launch-recovery base constraints, maneuverability, swath width, speed-altitude-range combinations and flight direction, will be included.

b. Survivability

Support will be provided to U. S. Government vulnerability studies. These will include a first-order evaluation of gross characteristics and a technical evaluation in depth.

c. System Evaluation

Support will be provided to U. S. Government cost effectiveness studies. Necessary data inputs

GROUP 1
Excluded from automatic
downgrading and
declassification

in the areas of operational effectiveness and cost, manufacturing cost, refurbishment, attrition, etc., will be analyzed and prepared. Alternate boost-glide systems based on point designs will be investigated.

2. Configuration Definition $3,250,000

Key parameters of the configuration will be identified and trade-off studies conducted to achieve best design and performance. The objective will be to define a configuration that assures high confidence, substantiated analytically and experimentally. Design aids, such as scaled models, will be utilized where appropriate.

a. Performance

i. Performance characteristics will be established and will include operational effects such as tolerances on launch conditions, guidance, control, navigation accuracy, atmospheric variations, energy management techniques, engine performance, etc.

ii. Developmental wind tunnel testing will be conducted to provide data for design optimization studies. Effects of varying configuration proportions and component size will be investigated throughout the flight envelope. The McDonnell Polysonic and Hypersonic Impulse Tunnels, and the Cornell Aeronautical Laboratory Hypersonic Shock Tunnel will be utilized. Developmental wind tunnel testing will utilize four wind tunnel models for support of the design optimization and sensitivity study for verification of the performance characteristics. The results of these model tests will be used to finalize and validate key items making possible design convergence of the aircraft configuration.

I. A 2-½ percent model will be tested thru the Mach 0.6 to 6.0 range in the M.A.C. polysonic wind tunnel. Primary purpose is for configuration development and tradeoff study support. A total of three series are planned totaling approximately 350 hours.

II. A 2 percent scale model will be tested from Mach 11 to 20 plus in the M.A.C. hypersonic impulse tunnel. Primary purpose is for performance development and verification. A total of two series are planned totaling approximately 150 hours.

III. A 2 percent scale model will be tested from Mach 10 to 20 plus in the Cornell hypersonic wind tunnel. The primary purpose of these tests will be to obtain stability and control and aerodynamic performance data. A total of two series are planned totaling approximately 200 hours.

b. Design Sensitivity

Design sensitivities will be defined to effect the best compromises considering all pertinent factors. The effect of design variables and/or constraints such as volumetric efficiency, aircraft length, glide weight, launch weight, specific impulse, and glide insertion conditions, will be determined so that the full impact of different requirements can be accurately assessed. The type of research and development program proposed provides those design sensitivity factors, including much hard core test data, that are vital to establishing the best size and configuration for ISINGLASS. These design sensitivities will include all factors necessary for a practical, high assurance evaluation of prime design variables, including such items as range, altitude, manned versus unmanned optimization, manned with unmanned option, payload, wing sweep, shape, weight and maneuverability.

c. Landing Characteristics

i. Landing capability and characteristics will be defined. The development of the best piloting techniques will be a primary objective of this activity. Key parameters will be varied to develop design and performance sensitivity relationships.

ii. Landing configuration aerodynamic characteristics will be obtained in the McDonnell low-speed wind tunnel. Configuration variables, such as base geometry, landing gear, canopy, speed brakes, and controls, will be evaluated. Primary resources to be employed in this activity are wind tunnel models and simulators for pilot evaluation. The initial corporate-sponsored activity using a 7-½ percent scale model of ISINGLASS would be continued. The M.A.C. low speed tunnel will again be used for development and verification tests for landing capability. Two series of tests totaling approximately 350 hours are planned. In conjunction with this work, an analog flight simulator program will be conducted to evaluate all dynamic aspects of the landing characteristics and performance.

d. <u>Carrier Aircraft</u>

Carrier aircraft selection will be validated by detailed analysis of availability, extent of required modifications (wing beef-up, additions of cryogenic fuel storage, etc.) operational characteristics and performance.

i. Carrier aircraft-Model 192 performance including flow field effects during cruise and launch will be determined. Appropriate analyses for a variety of speed and attitude conditions will be performed to obtain the complete performance envelope. A key resource for the development and verification of the performance of the carrier/ISINGLASS combination will be a 4 percent scale model to be tested throughout the subsonic speed range. These tests will include the combined configuration for performance and stability and control verification and will include proximity tests to establish the launch characteristics. External tanks or other appendages will be included on the carrier if required for proper simulation. A total of two series totaling approximately 250 hours are planned. This continues the ISINGLASS/B-52 testing that has been accomplished in the M.A.C. low speed wing tunnel utilising the 7-½ percent scale model. This existing model will be used as appropriate for further test development and verification.

of the carrier/ISINGLASS performance and launch characteristics.

ii. Launch techniques will be developed and substantiated. Various launch conditions (speed, altitude, load factor, fuel loading, etc.) will be investigated.

e. Photographic Performance

Technical suitability of all aspects of the sensor installation will be substantiated. This will include analytical and test effort as well as supporting effort by appropriate consultants.

i. Wind tunnel testing will be conducted to develop the window cavity concept and optimize the cavity design. Geometric details will be varied to optimize cavity and window environment. Testing will determine the effects of Mach number, Reynolds number, angle of attack, boundary layer transition, cavity length-to-depth ratio, and forward and aft ramp shapes. Test facilities will include the Cornell Aeronautical Laboratory.

A 10 percent scale model of the ISINGLASS forward fuselage will be used for wind tunnel development. Testing will be conducted from Mach 10 to 20 plus. Temperature distributions and levels will be established and configuration variations will be utilized to optimize the environment and design. In addition to the wind tunnel testing, thermal testing of components in the M.A.C. laboratory will be conducted.

ii. Backup development testing of an active window cooling system will be experimentally conducted. Wall cooling, edge cooling, and cavity boundary layer cooling by coolant gas injection are available techniques for the control and minimization of thermal gradients. Provisions will be included in the 10 percent scale model, used for the activity described in the paragraph above, for an active cooling system. If early testing and/or analytical effort indicate that the active system would be required, appropriate model testing will be conducted.

iii. Boundary layer effects on photographic acuity will be determined by wind tunnel tests utilizing an appropriate scale model. Test details and instrumentation requirements and design will be finalized by collaboration with a qualified sensor supplier. The Mach test range and similitude required indicates that several facilities may be employed including Cornell and AEDC.

f. Structural Elements

i. Mechanical properties of the roll diffusion bonded type primary structure will be demonstrated by numerous specimen tests at room and elevated temperatures. Variables will include basic core shapes, various types of panel joints, attachments, and repairs, and an appropriate variety of fabrication techniques. Many test specimens will be utilized in this program. Small samples (dimensions of several inches) will be used for bending, shear, compression and tension strength capability tests. Larger panels (dimensions up to several feet) will be used for substantiation of design strength allowables.

A 180 gallon tank constructed of roll bond titanium will also be used for structural tests. This tank has been constructed by M.A.C. as a part of the ISINGLASS corporate sponsored activity to date. The tank dimensions are approximately 4 feet by 3 feet by 3 feet. This tank is of double bubble configuration and includes a longitudinal shear web divider and end bulkheads. Access is provided for installing various cryogenic insulations, inspection, and for repair. In addition to evaluation of structural capability, cryogenic system tests including evaluation of dynamic effects will be performed. The M.A.C. altitude chamber facilities will be used for part of these tests.

ii. External shingle design, producibility, and performance will be substantiated. Testing in the design environment (elevated temperatures, etc.), will be performed. Shingle development will utilize both small specimens (about 6 inches square) and full scale shingles (about 24 inches square). Many development specimens using T.D. nickel, Rene' 41, and titanium will be evaluated. Variables to be assessed will include: type of core, face plate bonding, attachment inserts, sealing, oxidation resistant coating, attachment, and high emissivity coatings.

Approximately ten full scale shingles fabricated in accordance with the selected design and material will be tested to verify and demonstrate the design. Variation in design and testing will verify attachment designs, curved as well as flat shingles, strength characteristics, reusability, life capability and emissivity. Test facilities will include the M.A.C. thermal and altitude laboratories.

Approximately ten full scale columbium leading edge specimens will be provided duplicating the radius and support method to be used. Testing under load at room and elevated temperatures will verify strength properties, installation technique and life characteristics. Reusability and operational lifetime test will include cyclic thermal loading. The M.A.C. plasma jet facility will be used during this test program. This program will also include several columbium panel specimens configured for nose transition and control surfaces to substantiate their suitability in the structural and thermal design environment.

An appropriate number of tests specimens for development and life demonstration of the main landing gear skid will be constructed.

The nose cap will be developed utilizing previous ASSET laboratory and flight results. Element tests to demonstrate capability and acceptability to thermal shock and oxidation resistance will determine optimum choice of material and design. Two full scale nose caps will be utilized in the M.A.C. plasma jet facility to demonstrate design acceptability and reusability.

g. Refurbishment

Analytical and test substantiation of refurbishment requirements will be performed. Significant fall out from this will include maintenance requirements, turn-around time, and operational cost factors.

3. Technology Demonstration $1,660,000

The technology demonstration program will consist primarily of component construction and testing of certain key elements of the Model 192 concept to substantiate and demonstrate a high confidence technology base.

a. Structure

A full scale section, approximately 13 feet in length, including an 8 foot long section of the LOX tank and the LOX/LH2 tank bulkhead, will be designed. Carrier pylon attach points for concentrated load inputs will be included. The dimensions at the aft end of the specimen will be approximately 15 feet wide and 11 feet high and will taper to dimensions of approximately 10 feet wide and 8 feet high at the forward end of the specimen. Subsequent manufacture and utilization of this full-scale article in a follow on program will provide demonstrated assurance of all significant structural characteristics including fabricability. This assurance is provided for the design of each element as well as for the assembled aircraft. This will permit evaluation and verification of the strength properties of the basic structure, propellant storage, precise weights, weight factors, manufacturing techniques, and quality and costs of tooling, fabrication and assembly. This will also verify and demonstrate successful transition from element construction to full scale ISINGLASS hardware.

b. Heat Protection

1. Thermal design criteria will be further analyzed by conducting wind tunnel tests to establish quantitative heating rates and temperature levels. Primary resources provided here are two wind tunnel models. One is a 3 percent scale model to be uti-

lized in establishing the thermal suitability of the configuration. This includes the qualitative heat patterns on the vehicle plus quantitative evaluations of the configuration including hot spots or other unique areas. The second is a 5 percent scale model for the determination of actual temperature levels throughout the speed range for verifications of design environment. This is necessary because of the significant impact of design environment on weight, performance, and cost. It is planned to use at least the M.A.C. hypersonic tunnel for heating pattern tests and the Cornell tunnel for the quantitative test program. A total of three series totaling approximately 200 hours are planned.

ii. The performance characteristics and efficiency of the insulation, water-wick, structural arrangement including the effect of heat shorts, will be demonstrated by testing a sample composite structural panel. These tests will also confirm the performance of the wicking material and coolant distribution and servicing system.

Approximately six full scale composite structural panels will be utilized. They will provide a representative section of the aircraft several feet square with the propellant tank liner, basic structure, water wick, passive insulation, and the outer radiative shingle incorporated. Loading tests in compression, shear, torsion, and bending will be applied. Thermal test to verify stability, shock capability, cyclic life limits and mission spectrum loadings, for life verification will be conducted. Attachment integrity will be demonstrated using flight environments. The thermal isolation characteristics will be verified by tests including repeated exposure to design environment.

Water wicking development will include a large structural panel with the water distribution system incorporated to verify the performance of the water blanket system. Dynamic properties of the system (vibration and accelerated loads) will be established. These tests will include testing in the M.A.C. laboratory. Further demonstration of the performance of this system will be furnished by test results from the full scale fuselage test section.

iii. Physical properties and thermal performance of internal insulation will be established by testing promising materials as insulators for the high temperature structure and cryogenic tanks. This work represents the selection and experimental evaluation of candidate materials for passive insulation application. Samples will be tested to establish thermal performance, compatibility, ease of handling, durability, producibility and life characteristics. The best materials derived from the element tests will be utilized in the larger composite test articles.

c. Manufacturing

Evaluation of promising structural fabrication concepts will be continued to develop the best manufacturing methods for the selected materials. This will include fabrication of panels with various geometric configuration and attachment details. Welding and stress relieving methods will be evaluated. Non-destructive inspection and quality control techniques will be developed. These activities and data will establish a solid basis for optimizing manufacturing time and cost parameters.

d. Cryogenics

The performance of the cryogenic systems will be demonstrated. This will include testing to confirm boil-off rates, stratification, transfer-rates, and ullage. Propellant dynamics will be determined by appropriate scale model tests. Results will define those key characteristics necessary for best tankage design.

While available analytical techniques are quite advanced and in some respects well substantiated, a significant amount of experimental cryogenic work is planned to identify items and considerations pertinent to ISINGLASS, including verification of materials selected and fabrication techniques. The 180 gallon, double bubble, diffusion bonded test tank will be utilized for numerous propellant transfer and storage tests with a wide spectrum of environmental design conditions imposed. Many typical lines and components will be evaluated.

A small scale tankage model duplicating the internal geometry and volume distribution of ISINGLASS will be made to conduct verification tests of propellant volumes and attitude sensitivity plus quantitative testing for establishing dynamic load effects with various propellant levels.

4. Cost and Schedule Substantiation*

A primary objective will be to develop a high confidence base for cost and schedule performance. These analyses will utilize the results of the element investigations conducted in the previously delineated tasks and will use prior McDonnell experience in the design, development and production of advanced aircraft and spacecraft systems, ramjet and boost-glide vehicles. Particular attention will be applied to systems involving first generation concepts.

a. Engineering Cost Factors

Technical and cost data generated during this program will provide a base for evaluating engineering design and development cost. Trade-off studies will be used to optimize development solutions.

b. Manufacturing Cost Factors

Experience derived from construction of representative panels and test sections will provide data for developing manufacturing cost factors and refining program estimates. Comparative cost criteria will be used to select the most effective manufacturing methods and best materials.

c. System Cost

Initial cost estimates for the complete system will be progressively refined as the system design and operational requirements are defined. These

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*The cost of these items is included in the costs quoted for the previous paragraphs.

estimates will be frequently revised to maintain an up-to-date program cost picture.

Estimates based on historical and statistical data will be cross checked with detailed staffing and material requirements developed during this program.

d. Schedule Analysis

A master program schedule for the flight vehicle and supporting systems will be refined and updated as results of this research and development program become available, to a level of detail and definition that gives high confidence of achieving the major program milestones. Subsidiary schedules will be maintained for major subsystems. Analysis of detail schedules will encompass outside development and production of both CFE and GFE subsystems. Coordination meetings will be conducted by McDonnell as Program Manager and will provide necessary interchange of data pertinent to the detailed elements of the schedule so as to assure that all significant effects are included in the overall planning.

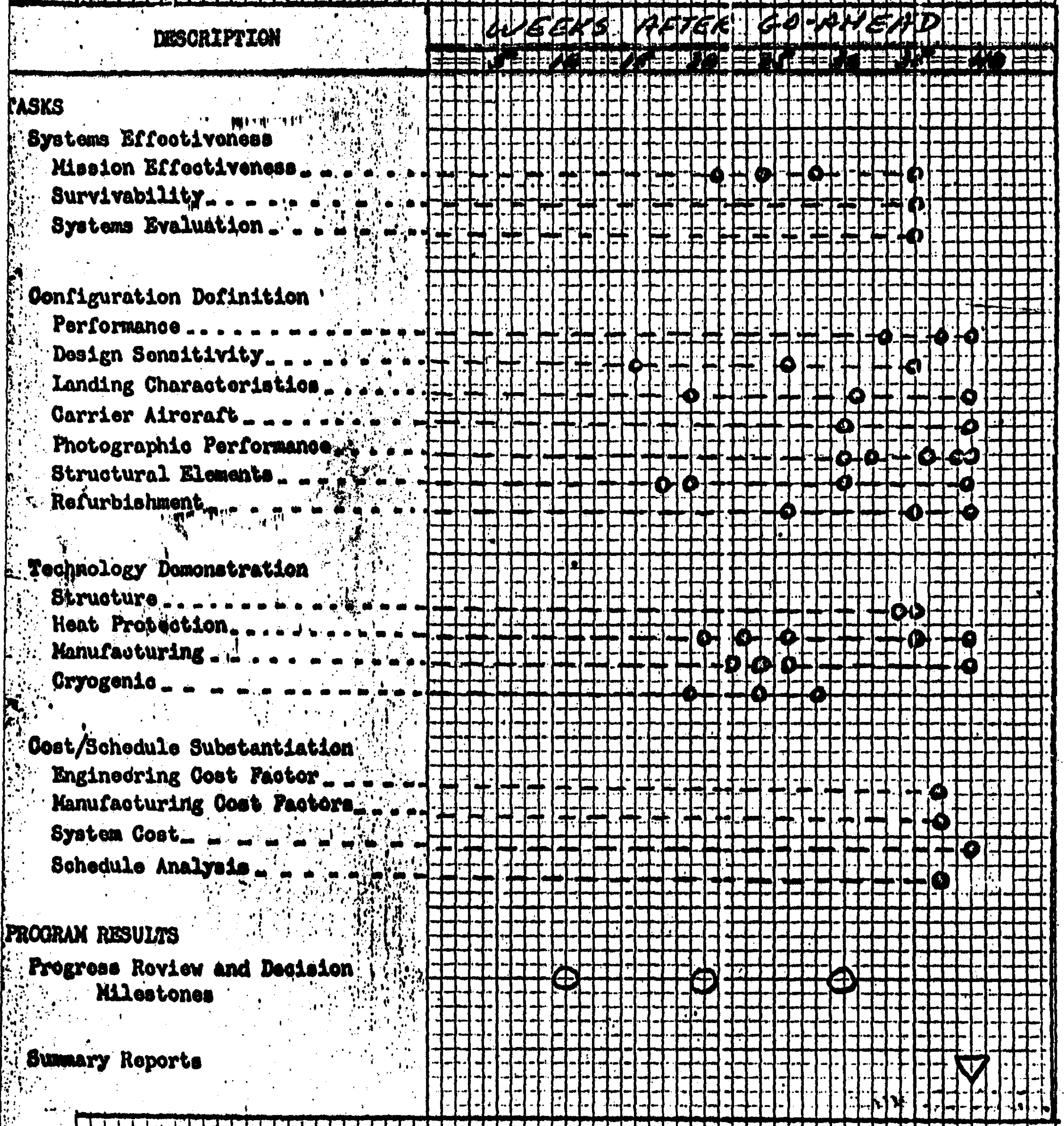
5. Reviews and Documentation.

Progress and results of program effort will be presented in concise form at frequent intervals as shown in the schedule. Reviews and documentation will consist of:

a. Bi-monthly program reviews at McDonnell in which all significant milestone accomplishments and program decision elements will be presented. These will be supplemented with informal reviews of all program activities.

b. A final summary type report containing all program accomplishments.

6. PROGRAM SCHEDULE



○ MAJOR MILESTONES
SEE ATTACHED KEY

HANDLE VIA BYEMAN
CONTROL SYSTEM

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KEY TO PROGRAM SCHEDULE

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	WEEKS FROM GO-AHEAD
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B. Camera Studies

1. Internal Turbulence	$118,000

Tests and analysis will be conducted to evaluate the effects of the internal turbulence generated by the heated window. In conjunction with the window tests below, this will allow reasonable balance in window design between degradation from window distortions and degradation from internal turbulence.

2. Window Gradient Tests and Boundary Layer Effects	$32,000

These tests will evaluate the degrading effects of window gradient and means of reduction of this degradation, using wind tunnel data for evaluation of heat flux distribution. Current estimates are that the window will be the limiting factor on ground resolution. In conjunction with M.A.C., the effects of the boundary layer on optical performance will be evaluated. Current estimates of boundary layer effects, considered negligible, are based on extrapolations of existing data at relatively low speeds and altitudes.

The above three efforts, at a total of $150,000 can best be done by Perkin Elmer, who have done extensive preliminary work, and are leaders in this field.

HANDLE VIA BYEMAN
CONTROL SYSTEM

				S-104(2)			
	TAGBOARD	ISINGLASS	S-103(1)	AIR LAUNCHED (BG-1A)	AIR LAUNCHED (BG-2A)	GROUND LAUNCHED (BG-1B)	
Payload Weight	420	1545	500	500	500	500	
Payload Resolution	1'-1.5'	1'	4-6'	4-6'	4-6'	4-6' *	
Range	3000	7000	Orbital	Orbital	7000	Orbital	3-
Altitude over Target	80-95,000'	205,000' descending to 125,000'	60-80 NM	60 NM	60 NM	60 NM	95-
Speed	M 3.3	M 21 slowing to M 7	Orbital	Orbital	25,500 fps	Orbital	M
Vehicle Weight	—	25,450	1080	4340	6800	4340	55
Launch Vehicle	Modified A-12	B-52	B-52	B-52	B-52	Titan II	B-
Total Launch Weight	—	132,770	73,650	90,000	96,500	—	94
Propulsion	Ramjet (MA20S-4)	LOX-H_2 (New)	Minuteman II/ AJ 1041	J-2/ Centaur	J-2/ Integral Agena	Titan II	Ra Sk
Development Cost(4) (Millions)	(5) 80	570	200	267 ✓	~~338~~ 283	115 ✓	
Development Time (Months)	IOC Nov 66	48	24	46	46	44	

(1) S-103 Air Launch Reconnaissance Satellite

(2) S-104 Boost Glide Vehicle

(3) S-105 Ramjet

(4) All highly suspect of being far too low [illegible]

(5) Includes 14 operational vehicles

			S-104(2)			
TAGBOARD	ISINGLASS	S-103(1)	AIR LAUNCHED (BG-1A)	AIR LAUNCHED (BG-2A)	GROUND LAUNCHED (BG-1G)	S-105(3)
420	1545	500	500	500	500	500
1'-1.5' 3000 80-95,000'	1' 7000 205,000' descending to 125,000'	4-6' Orbital 60-80 NM	4-6' Orbital 60 NM	4-6' 7000 60 NM	4-6' Orbital 60 NM	4-6' 3-4,000 95-110,000
M 3.3	M 21 slowing to M 7	Orbital	Orbital	25,500 fps	Orbital	M 4.0
—	25,450	1080	4340	6800	4340	5500
Modified A-12	B-52	B-52	B-52	B-52	Titan II	B-58
—	132,770	73,650	90,000	96,500	—	9400
Ramjet (MA20S-4)	LOX-H_2 (New)	Minuteman II/ AJ 1041	J-2/ Centaur	J-2/ Integral Agena	Titan II	Ramjet (new) / Skybolt 2nd Stage
80(5)	570	200	267 ✓	~~238~~ 293	115 ✓	45
IOC Nov 66	48	24	46	46	44	24

ich Reconnaissance Satellite

ide Vehicle

ect of being far too low.

rational vehicles

H

February 25, 1966

MEMORANDUM FOR DR. FLAX

SUBJECT: ISINGLASS

1. Attached as Tab A is a detailed memorandum and attachments from Mr. Sheldon, submitted "pursuant to your request," proposing a nine-month R&D program for ISINGLASS at a cost of $5.5 million. The proposed effort covers a gamut of areas -- studies, technology demonstrations, wind-tunnel tests, system design, etc. I suggest, at this point, that you leave this memorandum and read all of Tab A.

* * * * * * * * *

2. As you know, the discussion of a follow-on manned aerospace reconnaissance system has been going on for some time. Over the past 6-8 months, the NRO Staff has sponsored several studies on alternative approaches to a so-called quick reaction, flexible recce system. Perhaps, a quick review of the ISINGLASS background and status of other investigations might be helpful to you. That is the purpose of paragraphs 3 through 9, which follow.

3. In early 1965, General Ledford's initial briefing to Dr. McMillan on the ISINGLASS proposal prompted many comments and questions. (Tab B). Dr. McMillan requested that General Ledford lay out a program plan which would:

(a) Contain a comparative analysis of all competing systems (including satellites) for the quick-reaction, single-pass mission.

(b) Limit contractor commitment to those approved by the DNRO.

(c) Provide for competitive vehicle design studies.

(d) Examine manned versus unmanned vehicles and integral versus separable boosters.

Internal
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(e) Provide the DNRO with a detailed analysis of all possible technical and operational aspects of the proposed program which could be compared with other NRO studies. After such a comparison, the DNRO would report the conclusions to the Secretary of Defense and the DCI.

4. On March 18, 1965, (Tab C) General Ledford submitted an ISINGLASS Feasibility Program to the DNRO, along with contractor work statements, for a b)(1)1.4e six-month study effort (MAC, b)(1)1; Camera b)(1); P&W b)(1)1. The proposed MAC configuration was the only one considered. The intention to reprogram OXCART funds to cover this effort was stated, if DNRO did not allocate the required monies.

5. On March 29, contractor briefings were held at West Palm Beach and led to an AFSC assessment (with CIA cooperation) of the ISINGLASS concept by several working groups, directed by General Ritland. That assessment (Tab D) found the concept technically feasible, questioned system vulnerability, found costs and schedules optimistic, requested definition of the need for such a system and indicated that major operational and support problems could exist. It concluded "We feel it mandatory that technologies contributing to long duration hypersonic flight be identified and pursued, and when mission requirements are firmly established on a cost effective basis, alternate system studies should be accomplished before final approval of any one proposal is given."

6. On June 15, 1965, General Ledford responded to Dr. McMillan's request for a more detailed program plan by defending the sole source selection of MAC and opposing Dr. McMillan's method of validating the ISINGLASS concept (Tab E). A limited analysis by CIA of the vulnerability, manned versus unmanned, etc., questions was provided. (A resume of the manned versus unmanned concept is attached as Tab F). A statement concerning the agreement for high resolution wide swath width photograph and the attractiveness of the boost glide vehicle in satisfying this requirement was questioned by Dr. Brown (pencil note beside paragraph 3 of Tab E). Dr. Fubini posed many questions (Tab G) on the proposal. Dr. Brown concurred in the need for a thorough examination of ISINGLASS, as suggested by Dr. Fubini.

OXCART/TAGBOARD
ISINGLASS

7. On September 15, Dr. McMillan summarized his feelings on ISINGLASS in a memorandum for the record (Tab H). He concluded that:

(a) No intelligence or operational requirement existed against which to examine ISINGLASS or any competitors.

(b) No analysis had been made of the system concept.

(c) The vulnerability analysis presented by CIA was misleading -- simple defense efforts could defeat ISINGLASS.

(d) Costs were questionable. OXCART experience indicated that they will be much higher.

Based mainly on these conclusions, Dr. McMillan refused to fund ISINGLASS in the FY-67 budget.

8. In anticipation of a possible requirement for a single pass, quick reaction mission, the NRO arranged for the conduct of several studies which have been summarized for you in previous memoranda. These included a Mach 4.0 ramjet study by Marquardt and an air-launched reconnaissance satellite and a ground or air-launched boost-glide vehicle by AFSC. In-house studies were also made to define "Tension" targets which could be covered by limited passes. A brief matrix of cost and performance parameters from the NRO vehicle studies, plus those from ISINGLASS and TAGBOARD, is provided as Tab I.

9. Recently, LMSC briefed me on an in-house study which would use a submarine launched Polaris as a booster for either a camera or radar reconnaissance payload. The payload could be used either in a ballistic or low earth orbit mode. I suggested they explore the possibilities of using Posiden rather than Polaris, in view of the former's larger payload. This effort is underway.

10. I would forecast that should Mr. Sheldon's proposal for a $5.5 million R&D program be approved, it would be followed by a

request to also fund P&W's high-pressure LOX-Hydrogen engine. Previously, $9.9 million was requested for initial work by P&W.

11. Since I don't know the nature or purpose of your "request" to Mr. Sheldon, or the context in which it was presented, I am hard-pressed to recommend a specific course of action with regard to Tab A. I would, however, like to discuss this subject with you at your convenience.

S/

James T. Stewart
Brigadier General, USAF
Director
NRO Staff

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~~(S)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

22 November 1966

MEMORANDUM FOR DIRECTOR OF RECONNAISSANCE, CIA
DEPUTY FOR SATELLITE OPERATIONS, NRO STAFF

SUBJECT: ISINGLASS/[redacted] Cost Effectiveness Study

The attached ground rules for an ISINGLASS/[redacted] Cost Effectiveness Study, which were developed in conjunction with your representatives, have been approved by the DNRO. In approving them, Dr. Flax provided the following additional guidance:

1. Only the results of the [redacted] study should be made available to the McDonnell Aircraft Corporation; the actual study should not be forwarded to MAC.

2. The final analysis of the study results will be done by the NRO.

3. The results of the cost effectiveness study should not be construed as approval or disapproval of either program.

[redacted], is the NRO Staff representative for the coordination of the study. All satellite study results will be made available to MAC (via CIA) through [redacted] He will be responsible for liaison between the NRO Staff and CIA/MAC. Please call on him for any assistance you may require.

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/s/

JAMES T. STEWART
Major General, USAF
Director

Attachment

GROUND RULES

Aircraft vs. Satellite Cost/Effectiveness Study

1. The Director of Reconnaissance, CIA, is responsible for the management of the ISINGLASS study.

2. The Deputy for Satellite Operations, NRO Staff, is responsible for the management of the [redacted] study.

3. The present satellite target deck (303 deck) will be used. Only those targets in the Sino-Soviet territories will apply. Any target in the deck which does not have an assigned CCCR number will be eliminated from the study. The study will simulate one calendar year of operation.

4. For those targets having repetitive coverage requirements, the following time factors will apply:

a. Successful coverage must occur in the specified calendar time period, and

b. the successive coverage must be accomplished in the next calendar time period according to the following time schedules:

CCCR Requirement	Time Interval
1. Semi-annual	Min. 4 months - Max. 9 months
2. Quarterly	Min. 2 months - Max. 4 months
3. Bi-monthly	Min. 1 month - Max. 3 months
4. Monthly	Min. 15 days - Max. 45 days

The following example illustrates the procedure to be used:

> "A" is a target in a CCCR category having a 60 day (two calendar months) repetitive requirement. If target "A" were used on 1 January to satisfy the Jan/Feb CCCR, then because of the calendar requirement it can not be used again before 1 March. Because of the 90 day min/max time requirement, it cannot be used after 30 March to satisfy the March/April CCCR.

NRO Approved For Release

Thus, unless Target "A" is acquired successfully in March, it cannot be used until the May/June CCCR 60 days period.

The other limiting case is when Target "A" is successfully acquired and used 29 February for the Jan/Feb CCCR, then min/max time requirement permits Target "A" again to be used for the March/April CCCR time period if it is successfully acquired only during April due to the min. time of 30 days.

5. Target coverage will be in stereo. SAFSS-4 will make a second study to determine the number of satellites required to accomplish the USIB target requirements giving due consideration to the stated mix of stereo and mono coverage.

6. Roll degradations will be accepted in both studies up to ± 45°. The total diameter of the target must be within the film frame and the photography made at or above 8° sun angle.

7. During the study, the following special requests will be incorporated into the year's coverage:

a. Tyura Tam - two requests

b. Lop Nor - one request

c. Severodvinsk - one request

d. Multi-target coverage of SEA-one request

These special requests will be given a Priority 1 rating for scoring purposes. The special requests will be placed in dated envelopes to be opened at the appropriate times during the study.

8. For the aircraft, missions will be planned for the entire year based on climatology. This planning will result in the average number of missions that will be flown each month for the entire year. The maximum number of flights each month and the minimum time interval between successive flights will be based on system limitations. The target coverage and available weather will dictate the number of flights during each month, not to exceed the maximum. The minimum threshold for efficient target collection per flight will be based on the actual weather in the years 1957

to 1960. When the forecast weather is such that a number of targets collected per flight will exceed the threshold, as obtained above, the mission will declared as "On" for a T-minus 24 hour posture. The forecast weather for the next 24 hours will be used to decide on the actual launch day and time. Missions may be cancelled or recalled up to the time of aircraft launch. A factor of one day for film processing and readout will be applied to any flight flown before this data can be used for planning purposes for subsequent operations.

9. For the satellite, missions will be planned individually, and based on climatology. Missions will be of 16 days duration with 2 recovery vehicles. A factor of four days for film processing and readout will be applied to any recovered vehicle before this data can be used for planning purposes for subsequent operations. Film quantity will not be considered a limiting factor. All satellite hardware limitations will be observed. The maximum launch rate to be used is one launch each 14 days not to exceed 14 launches during the year of operations.

10. The target weather, to be used by both the aircraft and the satellite for all missions, will be the 1962 actual weather as provided by the Air Weather Service. AWS will provide this weather data in both "fine grid" and weather conditions at individual targets. The weather data will be expressed in percent clear-sky conditions from 00% to 99%.

11. The weather percent clear-sky numbers will be used as the probability of acquiring photography that will satisfy CCCR needs. This number will be used as the Monte Carlo input to decide whether or not satisfactory photography has been obtained.

12. Reliability factors of 80% for satellites and 95% for aircraft will be used. These factors will be applied to the number of missions flown during the study to obtain the number of missions required for such coverage, rather than random failures during the study to produce the reliability rates.

13. Cost figures for both aircraft and satellite systems will be computed as one-fourth of the development costs plus 1 year of O&M and delivery of the film to the processing facility.

14. All satellite study results will be forwarded to MAC. MAC will make the cost/effectiveness comparisons.

15. Satellite and aircraft system effectiveness will be evaluated against the following criteria:

A. Weighted target values based on the COMOR Working Group priority structure.

B. The percent of the specified CCCR category coverage actually accomplished weighted against the above priority structure.

C. The percent of the specified CCCR coverage actually accomplished in each category.

Alternative evaluation criteria will be established, as appropriate, during the course of the study.

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MEMORANDUM FOR MR. VANCE
MR. HELMS
DR. HORNIG

SUBJECT: ISINGLASS

On September 7, 1966, I visited the McDonnell plant to review in detail their proposal for development work on the ISINGLASS concept. Their presentations and the discussions indicated a high quality technical effort across the spectrum of technology relevant to this concept. It should be recognized, however, that the DOD and NASA have under way technology programs spanning the same fields, although not so specifically pointed to this single configuration of flight vehicle and single class of flight trajectories.

The McDonnell work in the areas of technology pertinent to ISINGLASS seems to stem from their participation in earlier Air Force programs related to the DYNASOAR program. McDonnell was the contractor on the ASSET Program -- a $40 million scale-model flight test effort in support of DYNASOAR structural and aerothermodynamic technology. This technology has been advanced considerably since the inception of the DYNASOAR Project, and the hypersonic lift-to-drag ratio specifically has been advanced from 1.8 in

DYNASOAR to values of 3, both at McDonnell and at Lockheed (under an Air Force White Contract). The results of on-going Air Force technology programs have generally been made available to the aerospace industry except where contractor proprietary information was involved.

Therefore, it is apparent that the McDonnell efforts cannot be considered in isolation where technology is concerned. The specific vehicle design and mission analysis studies, on the other hand, are unique since no other contractor has focused major attention on this particular mission and this particular class of flight trajectories.

In addition to technological factors, I also reviewed the McDonnell cost-effectiveness studies and the vulnerability analyses which compared ISINGLASS with satellite systems. The cost effectiveness studies were being conducted in accordance with ground rules which did not correspond to current satellite operations. The NRO Staff has since worked with the CIA to set up ground rules for a cost effectiveness model which could be used by McDonnell to compare the ISINGLASS with current and planned satellite systems. With respect to the vulnerability analysis, anti-satellite (or anti-ISINGLASS) technology comparable to that proposed for Air Force System 922, particularly the employment of IR homing, was not being considered in the postulation of defensive weapons systems. Full system netting had also not been considered. Although there is no firm intelligence information which would indicate that the Soviet

Union plans to deploy such an advanced system, it is certainly within the realm of technological possibility in the time period when ISINGLASS could be available. It was my suggestion that a more balanced vulnerability assessment be made including the consideration of advanced defensive systems.

Since the high-pressure liquid hydrogen-liquid oxygen engine is an essential feature of the proposed ISINGLASS vehicle, it should be noted that this effort is being funded as an advanced development by the DOD and NASA for possible application, not only to manned vehicles such as ISINGLASS, but also to unmanned vehicles, recoverable boosters and upper stages of launch vehicles. The time scale of this development is such that a flight-rated engine for an ISINGLASS-type vehicle would not be available before 1971 at the earliest and achievement of this date would require a large increase in effort on the engine program no later than a year from now.

As a result of activities in various DOD and NASA programs, there are at least three qualified contractors other than McDonnell who could undertake the development of a vehicle such as ISINGLASS. They are Boeing, Lockheed, and Martin-Marietta. The advantage which McDonnell has had lies mainly in the concentration of their efforts on this one specific vehicle design and in the contact they have had with the user, which has enabled them to better understand the requirements. However, I feel that if a decision were made to proceed with a full-scale development, and depending upon the degree to which final requirements might accord with those now being studied by McDonnell, it would probably be in the best interests of the Government to avail itself of the advantages of competition.

At the present time, I believe that only study and advanced technology efforts on the ISINGLASS concept are warranted. Study effort should be directed to the most significant areas for further evaluation of the concept. The technology efforts should be limited to those items having a critical bearing on system feasibility, basic characteristics and cost. In addition, it is essential to assure that technology efforts complement rather than duplicate the extensive NASA and DOD technology programs in the same general areas.

Since many uncertainties and doubts exist with regard to the future of this concept, it is essential that McDonnell be made fully aware that the program is still in the study phase, and will not necessarily lead to follow-on efforts of any kind. In particular, McDonnell should be cautioned against the premature build-up of a sizeable work force in anticipation of a full-scale development program. In view of the objectives of the study and advanced technology effort appropriate to this concept at this time, extensive large scale structural tests and comprehensive detail design need not be initiated.

The recommended NRO funding for a twelve month program is as follows:

1) System effectiveness studies including mission analyses, cost-effectiveness and participation in vulnerability analyses.

$ 550,000

2) Advanced technology program centered on the unique and critical aspects of this concept including additional wind tunnel tests, preliminary designs, major design trade-off studies, window, window cavity, and cooling design and testing, and selected structural and materials tests.

$1,500,000

Since there are comprehensive DOD and NASA programs in hypersonic vehicle structures, materials and associated manufacturing processes, details of the McDonnell plans for structural element fabrication and test, as part of the advanced technology effort, should be reviewed by the CIA prior to approval to proceed. The NRO Staff will make available to the CIA details of the on-going DOD and NASA programs so that complementarity may be assured.

Upon approval by the ExCom, this program will be funded from the approved FY-67 and FY-68 budgets for aircraft research.

~~TOP SEC~~
ISINGLASS

DEPARTMENT OF THE AIR FORCE
OFFICE OF THE ASSISTANT SECRETARY

MEMORANDUM

January 5, 1967

MEMORANDUM FOR DIRECTOR OF RECONNAISSANCE, CIA

Attached is a draft of my proposed memorandum to the ExCom on ISINGLASS. Your comments and suggestions are solicited. If possible, I would like to send an agreed-on version to assure prompt approval.

Alexander H Flax

Alexander H. Flax
Director
National Reconnaissance
Office

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CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

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24 MAR 1967

NRO Approved For Release

MEMORANDUM FOR: Director, National Reconnaissance Office

SUBJECT: Project ISINGLASS

REFERENCE: BYE-52014-67

1. This memorandum is to confirm our conversation of last week wherein I told you that we do not feel that it is advisable for this Agency to go any further on the ISINGLASS Project. It is our feeling that the Air Force is presently better equipped to pursue an effort of this magnitude. If at some future time it appears that this type of program indeed has some merit, and you feel that our technical resources would help to advance the art, we will be happy to take another look at it and provide assistance as needed.

2. As you know, McDonald Aircraft Corporation and Pratt and Whitney have put considerable effort into this concept. They would like to be advised if any other Government agency is interested in this program and, if so, would like permission to discuss the program with the agency and turn over the available technical data which they have accumulated to date.

Carl E. Duckett
CARL E. DUCKETT
Director
CIA Reconnaissance Programs

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~~(S)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

OFFICE OF THE DIRECTOR

April 24, 1967

MEMORANDUM FOR THE DIRECTOR OF RECONNAISSANCE PROGRAMS, CIA

SUBJECT: Project ISINGLASS

This is in response to your March 24, 1967 memorandum to me which confirmed your previous suggestion that any further effort on the ISINGLASS Project might best be undertaken by the Air Force. Although there is no established Air Force system requirement for a vehicle of this kind, there is a broad overlapping area of technology R&D covering both the vehicle and the engine.

In order to protect NRO security with regard to the origin of the ISINGLASS Project, I have asked Colonel C. B. Saunders, Director, NRO Program D, to serve as a focal point during the transition of any of the ISINGLASS effort into the Air Force technology program. He will assist the contractors in making contact with the appropriate organizations in the Air Force and will disseminate information derived from ISINGLASS in appropriate form.

Alexander H. Flax
Alexander H. Flax

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15 JUN 1965

MEMORANDUM FOR: Director, National Reconnaissance Office

SUBJECT : Proposed Boost Glide Device

REFERENCE : a. BYE-36169-65, Dated 6 March 1965
b. ISI-0040-65, Dated 8 March 1965

1. I want to acknowledge your memorandum of 6 March and mention that I too share your concern for a full analysis of all aspects of Project ISINGLASS.

2. As I understand your communication, we are in general agreement that a requirement exists for high resolution wide swath width photography and that the boost glide approach appears attractive from both the launch/recovery and vulnerability aspects. With this as a point of departure, BYE-36169-65 then suggests that the first phase of effort be devoted to competitive design studies of a manned integral booster, manned second stage with disposable first stage, unmanned integral booster, unmanned second stage with disposable first stage, preliminary aerodynamic data regarding camera interface, and recommend preferred designs by contractor and Program B to NRO for review and approval.

3. A second phase would then address itself to detailed studies by the responsive companies demonstrating the competence of their respective preferred systems. The results of such preferred studies would then be presented to a panel of competent authority for review and determination of program orientation.

4. Following the second phase conclusions, it would appear we would then engage in a third phase wherein we fund studies to accomplish a program definition.

→ FUNCTIONS : NRO

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5. My review of the briefing and support data furnished to us by McDonnell Aircraft Corporation and Pratt & Whitney when coupled with our extensive evaluations of the requirement and vulnerability considerations strongly suggested, and convinced me, that McDonnell is prepared presently for the final step in Phase II, i.e., a governmental review of the validity of their proposal. You will note that we have in effect suggested in Reference b. that such evaluation can be made in the immediate future. We also requested funding for feasibility studies to permit us to accomplish a Phase III type program definition.

6. It was hoped that in the briefing given to you that we could convey the above conclusions to you. We, in fact, attempted to show why we had eliminated to our satisfaction, and hopefully yours, the necessity for needless competition. We apparently failed to do so. This does not mean that I believe we should turn our back on the applicable knowledge gained from the DYNASOAR Program. Actually, the contrary is true. I am convinced that such data is being integrated into the program. Attachment I reflects, in general terms, what we consider as convincing evidence of the MAC superiority in this area. As you can see from the chart, MAC is the only company with flight experience in this regime. Because of the value of practical and current technology in a program of this type, I am sure you will agree that flight experience is essential in contractor selection.

7. There are other considerations that support my recommendation that a competitive review be curtailed. To facilitate your examination of my thinking I have set forth below the principal points:

a. A loss of momentum and a slippage in eventual operation by as much as 18 months. The Reference a. approach requires a cessation of the work at McDonnell while Boeing and Martin are brought up to speed; time for Boeing and Martin to accomplish their program definition and submit proposals; followed by the time for the conventional Government evaluation.

b. A significant loss of security. This consideration is related to a sizeable increase in the number of people who must be apprised of extremely sensitive intelligence objectives. It also results in the dilution of the sense of personal responsibility to protect the ongoing program in addition to the security problems associated with binding up the wounds of the loser.

c. The technology is perishable. An unnecessary delay, possibly as much as 18 months, will directly reduce the operational lifetime of the vehicle. Moreover, this employment delay increases the risk of leakage of information on the system specifications and the chances of countermeasure. This compounding of hazards correspondingly reduces the total intelligence effectiveness of the operations.

d. Increase in program costs. As implied above, with the inherent delay and a subsequent larger involvement of contractor people in a DOD type program administration, we will experience a significant increase in cost, occasioned by the higher costs of conventionality and idle engineering time.

e. Level of activity at MAC. We need to recognize that McDonnell has voluntarily invested about $1,500,000 of corporate funds in background development toward the ISINGLASS solution, and is currently proceeding at the rate of approximately $150,000 per month. In connection with this, I share the publicly stated DOD view that where private industry has invested its own funds, the Government,and particularly this Agency, should not be arbitrarily required to go to competitive contractors to stimulate artificial state-of-the-art programs.

8. I recognize the responsibility you have for control of NRO funds and comparison of alternative programs; however, I feel greater weight should be given to the legislative umbrella, granted the Agency for security reasons to protect intelligence sources and methods, under which the Agency may conduct procurement. With legislative approbation we can proceed on a directed procurement basis where it materially facilitates accomplishing an intelligence objective rapidly and securely; being certain, of course, to have had a complete, although perhaps unconventional, source selection.

9. For the above reasons I am reluctant to undertake the suggested method of validating the ISINGLASS Program. I am convinced we can establish a workable solution whereby we achieve the technical and financial management objectives outlined in your communication. With this objective in mind I have attached for your consideration the extensive analysis which led us to ISINGLASS. Hopefully, this will allay your misgivings.

10. Accordingly, I recommend that you reconsider and approve the technical confirmation program outlined in my ISI-0040-65 memorandum of 8 March 1965. As you know, this is designed to further harden the technology in critical areas, while preserving for the Government several options including possible termination should this period of intensive investigation with MAC and P&W so indicate.

Jack Ledford

JACK C. LEDFORD
Brigadier General, USAF
Director, Program B, NRO

Attachments: 3

~~TOP SECRET~~

ISINGLASS

DEPARTMENT OF THE AIR FORCE
WASHINGTON

OFFICE OF THE UNDER SECRETARY

September 15, 1965

MEMORANDUM FOR DEPUTY SECRETARY OF DEFENSE

SUBJECT: ISINGLASS

My recommended NRO financial plan for FY 66 and budget for FY 67 contain no money explicitly labelled for ISINGLASS, as against a request from CIA for $110 million in '66 and $200 million in '67. The attached memorandum for record explains why.

The more critical comparative analyses that the memorandum refers to as being needed have been initiated. As the memorandum suggests, I am convinced that these will show the concept to be worthless. If they do not, further, more penetrating, more time consuming, and more costly studies can be undertaken. There is in the FY 66 plan fully enough money for these studies and even for an orderly initiation of the project, should my present conclusions be wrong or be rejected.

Brockway McMillan

Brockway McMillan

Attachment
Memorandum for Record

cc: Dr. Flax

1. Dep Sec Def
2 Dr Flax
3 Dr McMillan
4 SS-1
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BYE-36808/65

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DEPARTMENT OF THE AIR FORCE
WASHINGTON

OFFICE OF THE UNDER SECRETARY

NRO Approved For Release

September 15, 1965

MEMORANDUM FOR RECORD

SUBJECT: Deficiencies of ISINGLASS Concept and Proposal

It is my judgment that the arguments so far advanced for initiating the ISINGLASS program are totally inadequate. It is also my judgment that the structure of the program that has been proposed is wrong. I further conclude that if the concept were given an adequate examination it would be found to be without merit. Specific deficiencies in the arguments, the proposal, and the concept that lead to these judgments are cited below.

1. No specific statement of intelligence or operational requirements has been made, against which to examine the performance of ISINGLASS or potential competitors. The "justification" so far advanced for ISINGLASS is based on a statement of performance requirement: namely that there is a requirement for a collection system which has the performance claimed for ISINGLASS.

2. Even accepting for the moment the "requirement" for a collection system having the flight performance claimed for ISINGLASS, no adequate analysis has been reported to show that the specific manned vehicle that is proposed is the best way, or even a desirable way, to achieve that performance. In particular, no valid examination has been made of an unmanned alternative and no valid examination has been made of alternatives, manned or unmanned, that use optimally staged separable boosters. There is no question that an unmanned vehicle with optimized separable booster would be smaller and lighter than the version proposed. Findings to the contrary that have been reported have been based on the unjustified assumption that an unmanned vehicle must look like the manned vehicle with a robot pilot added. A valid question that can be raised, relative to an unmanned alternative, is whether its operation would be more costly because of problems in landing or recovery. This question has not been examined in a proper context.

3. The ISINGLASS vehicle as proposed has a range of over 7000 miles. To reach this long range requires a vehicle much larger and heavier - hence more expensive - than would be required to reach, say, a range of 5000 miles. No analysis has been provided to show that 7000 miles range is required, and no cost tradeoffs have been examined in this connection.

4. In fact, whatever intelligence collection requirement may be at issue here, it is impossible for me to believe that the requirement translates uniquely into the performance requirement that is asserted as justifying ISINGLASS. There are, therefore, indeed many alternatives to ISINGLASS other than those which more or less duplicate its flight path. Such alternatives include satellites and ballistic devices, air launched or launched from the Western Test Range, suitably configured for rapid, and perhaps repetitive, return of relatively small amounts of "take". No such alternatives have been effectively compared with ISINGLASS in terms of cost for equivalent intelligence "take". Other alternatives, also not examined, include high speed high altitude aircraft and drones.

5. The vulnerability analysis presented for ISINGLASS is so sensitive to the assumptions made that it is misleading. What the analysis shows is that ISINGLASS might have a good chance to survive passage over a NIKE X site, without any early warning. This conclusion would change sharply if the postulated defense system were allowed to direct its radars down to 1° above the horizon, rather than being cut off at 5° as NIKE is now. There are many locations where a 1° limit is entirely feasible. It would also change sharply if the Soviets were to engage in some simple netting of their Tall King radars to provide advance warning and crude tracking. Both of these relatively simple changes in the defense system are ruled out in the analysis given, which starts from the hypothesis that the Soviets would make no special defense effort, not even a simple one, to defeat ISINGLASS.

It is true that ISINGLASS would be safe from SA-2's or from a considerably improved SA-2. So would a vehicle flying lower and more slowly than ISINGLASS. But it is also true that ISINGLASS is as vulnerable as a naive ballistic missile, is more vulnerable than a naive satellite, and is impossible to disguise or protect in the ways that are available for satellites.

6. The costs claimed for ISINGLASS are highly questionable. Development and investment costs are probably seriously underestimated, because of an inadequate accounting for the extensive and expensive support facilities that will have to be deployed. Estimates of operating costs sound completely wrong. It is asserted that five years of operating several flight vehicles and their launch aircraft would cost $113 million. ISINGLASS is not simpler than OXCART and this estimate does not stand up under comparison with OXCART. One year of operating ten OXCART airplanes is now estimated to cost over (b)(1)1.4c Current OXCART costs are higher than this.

7. ISINGLASS at launch looks like an air-launched ballistic missile. In flight it will have the radar cross-section of a large airplane, an impressive infra-red signature, and a sonic boom that is at least detectable. It has only slightly more flexibility of maneuver than a satellite, and lacks the automatic repetitive coverage of the satellite. Operationally therefore, it combines the worst provocative features of the airplane with some more of its own and with the worst features of the satellite. These are important reasons why I believe that no amount of analysis will ever uncover valid reasons for development of ISINGLASS.

8. The program proposed for ISINGLASS development lacks any provisions for the kind of trade-off analyses that are noted above as lacking. The program also calls for an award, sole source, to McDonnell. There is no justification for such an award. Most of the technology at issue is available from other contractors. Alternative technologies are also available and should be considered. In particular, the Government has already spent about $200 million developing essentially equivalent technology for DYNA SOAR. The proposed program makes no provision for realizing on this investment.

9. It is proposed to conduct the ISINGLASS development as a covert program, in the pattern of the U-2 and OXCART. In my judgment this is not feasible for a program of the scope and complexity of ISINGLASS. In fact, OXCART really exceeded the capabilities of this kind of management. It succeeded as well as it did largely because of the special qualities of Kelly Johnson. These qualities will not be available to ISINGLASS.

10. Of the more than [redacted] requested for ISINGLASS for 1966, some [redacted] is identified as for feasibility studies to be conducted prior to full scale initiation. Although feasibility of the proposed vehicle system is certainly a major issue, it should be made clear that the comments in this memorandum apply with full force even if one knew with certainty that all technical problems related to the proposed vehicle could be solved. The proposed feasibility studies do not address any of the operational or comparative studies mentioned here as being necessary.

Brockway McMillan

Brockway McMillan

March 6, 1965

MEMORANDUM FOR DIRECTOR, PROGRAM B

SUBJECT: Proposed Boost Glide Device

Your briefing to me on this subject was quite interesting. As you indicated, there are questions, in addition to those of basic technology, which must be addressed in order to get a full evaluation of the possible costs and usefulness of a system based on a boost glide vehicle. I was glad to see that you have already begun to examine some of these. As you point out, a program to exploit the possibilities of a boost glide vehicle will be very expensive, equal in cost to or greater in cost than the development of an advanced airplane. I think that you will agree with me that if a program of this potential size is to survive it must be subjected to analyses of its problems and of the possible alternatives that are complete and of the highest integrity.

Your briefing brought out several conclusions, the most interesting and important of which, in my judgment, were the following.

1. The requirement exists for a flexible rapidly reacting system capable of returning data after a single pass over the target area.

2. A photographic swath 50 miles in width is useful in connection with this requirement.

3. A boost glide trajectory over the area of interest appears a feasible approach to the requirement.

4. Such a trajectory requires about two-thirds of the energy per pound of flight vehicle that is required of an orbital device, making an air launched device appear attractive.

5. Except in the presence of a major deployment of AICBM defenses, a boost glide trajectory is not highly vulnerable to defensive action.

6. A boost glide system would probably call for a large initial investment, but in an active market might experience relatively low operating costs.

I have several concerns about the proposal as you have now described it. First, it is not clear to me, at all, that a manned vehicle is required, or even desirable, for the mission in question. It seems likely that an unmanned glider for this mission would weigh very much less in flight than the 25,500 lbs. you estimate for the manned vehicle. Its launched weight would then be correspondingly less, and the whole system simpler and possibly cheaper both in development and in operation.

Second, I note that the vehicle you describe, although somewhat different in structural concept, is in size and performance very similar to the X-20 (DYNASOAR), toward the development of which the Government has spent about $250 million. Any undertaking now to study vehicles of this kind must permit bringing to bear the knowledge gained, and the technology developed, on the X-20. Further, at the present time, the Air Force is studying with the Martin Company a proposed program for an ablatively cooled hypersonic glide vehicle at a somewhat smaller scale. Advantage would result from drawing on this technology as well.

Third, it is not clear to me that a fully integral, completely recovered, single stage boost is the best for this mission. In particular, a smaller vehicle, properly staged at boost, might not require development of a new propulsion system.

Fourth, it is quite clear to me that a program of the size and scope of that visualized in your briefing cannot practicably be carried out in a clandestine manner. Should it develop that the scope of the program cannot significantly be reduced by simplification of the vehicle and of its propulsion requirements,

it will be necessary for the NRO to manage the program in such a way that major elements can be covered by overt identification and financing.

Finally, we must recognize, as your briefing already has, that a boost glide system is in potential competition with satellite and ballistic systems. These could be available sooner than a boost glide system of the kind described in your briefing, or alternatively they could be of a generation later than systems now in operation or development. If configured against the now recognized requirement for quick reactions, these competitors would have operational characteristics, and costs, requiring careful comparison with those of a boost glide device.

In view of your conclusions, I agree that proper consideration must be given to a boost glide system. In view of my concerns, and because of the potential cost of any final program that might result, I feel that I cannot recommend even initial steps to the Secretary of Defense and to the Director of Central Intelligence until I am satisfied that two conditions can be met:

First, that a program can be laid out that provides the DNRO, and thus also the Secretary of Defense and the Director of Central Intelligence with a full and objective comparative analysis of all competing means that might reasonably satisfy the requirement stated;

Second, that financial commitments and obligations to contractors during the program can at all times be limited to those which in the judgment of the DNRO are justified by their expected contribution toward the achievement of approved goals.

Accordingly, I would like you to lay out for my consideration a program along the following lines.

The interest is in a boost glide vehicle, air launched from a carrier no larger than a B-52, and capable of a useful trajectory of 6000 nautical miles or more. Competitive paid vehicle design studies would be undertaken with at least two contractors, McDonnell and Boeing, and preferably also with Martin. These design studies would proceed in two steps. For each contractor, the objective of the first step would be to examine alternative configurations in sufficient detail that each contractor's preferred configuration or configurations would be identified. The objective of the second step would then be to pursue design studies of the preferred configurations in sufficient detail that effective evaluations and comparisons can be made among the designs of the competing contractors. Comparisons in all cases are to be made on the basis of weights, costs (both development and operating), mission performance, possible operational limitations, and factors bearing on operational reliability and development risk.

Initially, consideration must be given by each contractor to at least the following four general configurations.

1) Manned vehicle with integral booster,

2) manned second stage vehicle with a disposable first stage,

3) and 4): unmanned vehicles, respectively with integral and separable boosters.

In considering vehicles with separable boosters, an optimally staged configuration should be identified; consideration must also be given, however, to disposing of the first stage within 300 nautical miles of the launch point.

For the first step, all vehicle contractors would be given the same interface requirements for the camera system.

For each contractor, the output of the first step would consist of at least the following:

1. Preliminary aerodynamic data permitting initiation of camera window studies, to be done under other contracts.

2. Comparative analysis of the configurations studied carried to the point for each that further study or rejection can be justified. For the more likely or attractive configurations, some indication should be given of the sensitivity of each to the constraints imposed by the camera interface.

3. One or more recommended preferred configurations, with justification.

I would expect you to submit your recommendations for those configurations to be carried into the second step, with justification, for my review and approval.

Each contractor, during the second step, would concentrate on the configurations approved to him. Arrangements would be made at this time with propulsion contractors, as necessitated by the particular configurations under study. For each vehicle contractor the output of the second step should include an overall system concept, and a vehicle design or designs in sufficient detail that specific structural techniques, specific propulsion requirements and subsystems, and recommended other subsystems are identified. Analyses should be presented permitting comparisons among competitors according to the criteria listed earlier.

At or near the close of the second step, it would be necessary for the NRO to convene a panel to examine the structural, propulsion, and other problems associated with each proposed vehicle system. Using the results of the second step, the findings of this panel, and the results of such other analyses as the NRO will make, the DNRO would then report to the Secretary of Defense and the Director of Central Intelligence. Were the findings to justify it, such a report could recommend the initiation of a program definition phase, with vehicle and propulsion contractors to be selected by such procedures as might appropriately be recommended at that time.

There is little question that the cost and time to develop a boost glide system will be dominated by the problems of the vehicle itself. Nevertheless, should a program definition phase be undertaken, it will be necessary to include definitive work by a camera contractor. Accordingly, it is appropriate, at about the close of the first step of the vehicle studies, to invite three or four camera contractors to compete in a paid design competition for selection of a camera design and contractor. Prior to that time, additional study is needed of the camera requirements, and of the relation of these requirements to those that might be imposed by a ballistic system configured for comparable missions.

Please let me have your recommendations for a study program conforming to the objectives and guidance just outlined.

Signed

Brockway McMillan
Director
National Reconnaissance Office

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PRO-3

This paper summarizes the history of manned reconnaissance aircraft programs for peacetime overflight of denied territory with emphasis on the rationale, statements of need, and authority which led to their development and operation, as well as the management arrangements under which they were carried out. The present situation is then reviewed wherein the ISINGLASS effort has been terminated, the OXCART is in the process of being phased out, and the U-2 is considered as effective only in limited areas away from a Soviet-type defensive environment. The future role of manned reconnaissance aircraft systems, or even the need for them, when viewed with and compared to the rapidly improving capabilities of satellites and drones, then emerges as the fundamental issue which is to be resolved.

BACKGROUND

During the year 1954, as for some years previous, the urgent problem of defense against surprise attack by Soviet

Russia continued to occupy the attention of all those in Washington who bore the responsibility for the National Security. A high level committee, whose membership represented the best minds in the country, continually met in Washington to study every facet of cold war strategy and to advise the President. There was no lack of brain power available for the task, and the shortage which was recognized by all concerned came to be known as the "Intelligence Gap."

The existence of the iron curtain and the growing hostility of Soviet Russia toward the West made it increasingly difficult to mount classic intelligence collection operations against the USSR. In the summer of 1954, the U.S. intelligence community had come around to the view that the only prospect of gaining the vital intelligence was through systematic aerial reconnaissance of the USSR.

The special study group of the Hoover Commission, set up under the Chairmanship of General James H. Doolittle to investigate CIA's covert activities, in its report of 30 September 1954, expressed the belief that: "every known technical scheme be used and new ones developed to increase our intelligence by high altitude photo reconnaissance and other means and that no price would be too high to pay for the knowledge to be derived therefrom."

On 5 November 1954, Dr. Edwin H. Land, Chairman of the "Project 3" Technical Capabilities Panel (a subgroup under the Office of Defense Mobilizations "Surprise Attack Committee"), wrote to Mr. Allen Dulles, Director of CIA, proposing a program of photo reconnaissance flights over the Soviet Union and recommending that CIA, with Air Force assistance, undertake to carry out such a program. The Land Panel's proposal, entitled "A Unique Opportunity for Comprehensive Intelligence," recognized the risks of provocation toward war that such an intensive program of overflights might run, as well as the danger involved should one of our military arms engage in such activity, especially in view of the tense political situation vis-a-vis Soviet Russia. "On the other hand," the proposal continued, "because it is vital that certain knowledge about industrial growth, strategic targets, and guided missile sites be obtained at once, we recommend that the CIA, as a civilian organization, undertake (with Air Force assistance) a covert program of selected flights."

The airplane that the Land Panel had in mind for the overflights was the CL-282 (later designated the U-2) which Lockheed had proposed to the USAF in 1952 and which the Panel came across in 1954 during their search for a technical capability of collecting intelligence over the USSR. The Panel concluded that the program was feasible and should be pursued by the Government.

In Dr. Land's letter to Mr. Dulles submitting the proposal, he made it clear on the Panel's belief that the activity was appropriate for CIA (always with Air Force assistance) and recommended "immediate action" through the CIA covert means, to produce the aircraft and equipment and set up a task force. He stated further that "the opportunity for safe overflights may last only a few years because the Russians will develop radars and interceptors or guided missile defense for the 70,000 ft. regime," and that the aircraft itself was "so obviously unarmed and devoid of military usefulness that it would minimize affront to the Russians, even if through some remote mischance it were detected and identified."

Dr. Land and Dr. Jim Baker, of the President's Advisory Council, had continually reviewed all advances made in the optical field for application to the photo reconnaissance overflights. Dr. Baker emphasized that the Air Force was already years ahead in the development of suitable camera systems as a result of their many years of experience gathered from sponsorship of basic research and development programs; "this is particularly true of the electronic computation of optical systems. The development of these complicated optical systems would have taken years in Germany by the older methods--but now is about to be accomplished in 16 working days with our IBM/CDC computers."

In the two weeks following the Land Panel's proposal to CIA, discussions took place between the Air Force and CIA as to the feasibility of undertaking the recommended program. On 19 November 1954, a meeting was held in the office of the Secretary of the Air Force, Harold E. Talbott. It was agreed that the CL-282 proposal was practical and desirable and should be contracted for (along with the modified Canberra recommended by the Air Force). It was further agreed that the project should be a joint Air Force/CIA effort and that regardless of a source of funds to support it, CIA unvouchered channels should be employed for passing the funds.

Later in November 1954, Mr. Dulles and General John Samford (USAF) met, and it was agreed that the DCI would prepare a memorandum seeking Presidential approval for the program. This memorandum, dated 24 November 1954, recommended Presidential approval of a National requirement for the reconnaissance overflights, asked that the Air Force and CIA be directed to implement the development of the aircraft, and requested that the overflights be conducted at the earliest possible time. This memorandum was approved by the President verbally.

A face to face meeting of Mr. Dulles and the top Air Force officials concerned reached a joint agreement on the organizational and management responsibilities of the program, and on 3 August 1955, in a memorandum entitled "Organization and Delineation of Responsibility--Program Oil Stone," signed by General Twining and Mr. Dulles, responsibility was given for general direction and control of the project to the Director of

CIA and the Chief of Staff, USAF, to be exercised jointly. The agency appointed project director and the Air Force appointed deputy project director would be responsible for conduct of the project through all its facets, subject to guidance from higher authority. The Air Force project group (headed by Colonel Russell A. Berg) would act in the name of the Chief of Staff, and SAC would perform a supporting (not a controlling) role in the training and operational facets. The essential guidelines under which the program would be operated were that it would be a clandestine intelligence gathering operation to be conducted in such a way, as to minimize the risk of detection and of plausible attribution to the U.S. Government.

The first U-2 overflight of the Soviet Union took place on June 20, 1956, passing directly over Moscow. Several successive flights occurred that same week and, on July 11th, the first Soviet protest was delivered to the State Department. Requests for subsequent flights were more closely scrutinized before receiving final approval. The overflights continued, although less frequently, and in ever shrinking areas due to the Soviets improving air defense systems, for four years, well past all predictions on longevity.

As the CIA/Air Force overflights continued, the Strategic Air Command acquired its own fleet of U-2s which were assigned the peripheral photo and SIGINT missions.

On May Day 1960, with the downing of Mr. Powers' U-2 over Sverdlovsk, the overflights of the Soviet Union came to an end. At that time, a Presidential ban on further manned overflights of the USSR was imposed and remains in effect.

The U-2 has continued, by the addition of electronic countermeasures, the J-75 engine, modification for aircraft carrier operation, and a variety of other improvements, to perform a successful and useful role in intelligence collection in those areas, such as China, Southeast Asia, and Cuba, where its presence or even loss, is of less political consequence.

With these continuing U-2 operations and the attendant attrition, it became apparent that there would be a need to replace these losses in order for this vehicle to continue to fill its special reconnaissance role and, accordingly, on 21 June 1965, in a joint memorandum to the NRO, [illegible] Director, Program B, and the Director, Program D, recommended that the Air Force and CIA, in joint enterprise, initiate a new buy of an improved U-2 (U-2R) as a means of realizing the maximum benefit from the newer and other reconnaissance systems which could not be profitably diverted to those tasks handled by the U-2 and as a means of replenishing the U-2 fleet. The U-2R, now in flight tests, will be operational by the summer of 1968 and should remain a useful intelligence tool at least through the early 1970's, albeit in the non-Soviet environment.

Early in 1957, while the overflights of the Soviet Union were underway with the U-2, and it will be recalled that the period during which overflight would be possible was to be relatively short-lived, and with the understanding that photographic satellite systems were well into the future, the CIA, in reaction to the improved ability of the Soviets to track the U-2, and as a means of prolonging the overflights, began research in radar camouflage as a means of hiding the U-2 from the radars. It quickly became apparent that only limited and temporary success could be hoped for through the application of the passive camouflage of an aircraft of conventional structure since the materials themselves were either too heavy or narrow banded, and further degraded aircraft performance. Already the Russian radar systems were characterized by a considerable degree of frequency diversity. These circumstances suggested the need for a much more radical approach in order to obtain satisfactory results. Preliminary consideration led to the conclusion that any such radical approach would involve the use of unconventional material, structures, and configurations of aircraft and most probably a combination thereof. Accordingly, an exploration of possible design approaches was set in motion in August 1957. Two basic designs resulted from this effort: The GUSTO concept of a supersonic vehicle using a drone powered by ram-jet engines launched from a B-58 mother aircraft and the other approach, OXCART, for an unstaged aircraft with roughly the same performance specifications. On 15 November 1958, the Land Panel, in response to the need for such an advanced system, recommended the GUSTO system to Dr. Killian. Further consideration by those involved in carrying out this development program came to the conclusion that only the OXCART was technically feasible in the immediate future and, accordingly, in the summer of 1958, members from the DOD, Air Force, CIA, and with the President's Scientific Advisory Council obtained the necessary Presidential approval to implement the OXCART program. A Joint Source Selection Board was established which chose the Lockheed proposal over the one from General Dynamics.

During the very early stages of the OXCART design, radar cross section goals were chosen which were felt could be achieved in an operational aircraft and which would permit a near covert penetration of the Soviet radar defense net or at a sufficiently reduced detection range to permit a safe transit. A program was also implemented to assess the OXCART vulnerability. Simultaneously, a special ELINT measurements program was begun to assure the vulnerability studies would be based upon actual measurements of the Soviet threat radars rather than estimates. By 1963, it became apparent from the vulnerability studies, which were receiving data on the newer and improved Soviet radars, that the OXCART would not be able to covertly penetrate the radar net undetected and tracked, and accordingly, recommended the development of a "Supermarket" of electronic countermeasures systems.

This ECM program was carried out and produced the variety of threat warning and jammer systems now available for operational use.

Although the OXCART achieved its design goals by flying at specified altitude and speed 48 months after the contract date, it did not receive the necessary authority for overflights and in 1966, while being held in a state of operational readiness, and at a considerable cost, came under increasing scrutiny by the Bureau of the Budget. The decision was subsequently made to phase out the program by December 1967. Later, however, in response to an urgent USIB requirement, the OXCART, as the only practical vehicle for the job, was deployed to Okinawa for overflights of North Vietnam in search of possible surface-to-surface offensive missile sites. The decision to phase out the OXCART has been extended three months to allow additional time for the Air Force's SR-71 to prepare to take over these missions.

In 1964 and again in response to the continuing increase in the capabilities of the Soviet air defense net against aircraft operating in the OXCART regime, the CIA, in anticipation of a need to develop a more advanced manned reconnaissance system, initiated a study which led to the definition of the ISINGLASS boost-glide concept. The Agency had set forth those performance specifications that would be required to successfully penetrate the Soviet environment during the next decade. The objective of the ISINGLASS effort was to conduct covert photographic reconnaissance of those geographical areas normally denied U.S. overflight. The vehicle envisioned relied entirely on its operational characteristics for survival; it would enter denied territory at Mach 21 and 200K ft altitude, and exit at Mach 7 and 120K ft. The proposed launch method was from a B-52 near the periphery of the USSR with recovery planned at ZI bases. The program as proposed would cost in excess of one billion dollars.

In March 1967, in recognition of the magnitude of undertaking the ISINGLASS program, and the expense which would be required to bring the program to an operational stage, the

Director of CIA Reconnaissance Programs recommended that this effort be terminated.

In review, it is seen that the development of the manned aircraft reconnaissance systems has been based on deduced need and agreement thereto, and has preceded the statement of a formal requirement delineating this need. Stated requirements against which the manned systems have been targeted have always followed. These joint CIA/Air Force enterprises have worked and worked well, reducing duplication while making maximum use of each organization's assets and abilities; such as the Air Force world-wide operational capabilities and the CIA's "Skunk Works" approach to the research and development.

It is not possible to adequately review manned reconnaissance in proper perspective without going back to another date in 1960. In that year, on August 20th, the first photography of denied territory from a satellite was successfully recovered by the DISCOVERER program which was the forerunner of the present CORONA. This initial reconnaissance satellite operated for one day, and returned 4000 ft. of film. The photography obtained was monoscopic and had a ground resolution of 20 ft. Since that time, about 100 CORONA vehicles have been launched, lifetime has increased to 15 days, and 30 to 40 thousand feet of film are returned from each mission. Most photography acquired is in stereo and resolution has improved to less than 10 feet.

In addition to the CORONA search capability, spotting systems have been developed and are now producing photography of resolution between (b)(1)1.4g

<u>PRESENT SITUATION</u>

The present situation then can be summed up as one in which satellite photographic resolution is rapidly approaching that of present aircraft systems. Satellite photographic systems for search and surveillance which will achieve resolutions of 2-3 feet and will remain on orbit for 30 days or more. The advanced technical intelligence systems will remain on orbit an equal length of time and should achieve a resolution of (b)(1)1.4g Technology for reading out images from satellites in near real time has been developed and could be flown in the early 1970's.

At the same time, the operational concepts for advanced aircraft are taking on many of the characteristics of satellites. To achieve the speeds necessary to survive in denied territory such aircraft would operate at very high altitudes well above all weather and near the limit of the sensible atmosphere, and would provide only minimal maneuverability. Such systems would tend to operate on the basis of a single pass over the target area. Thus, the fundamental issue which must be considered concerns the need for future manned reconnaissance systems and what efforts, if any, should be undertaken in this direction at this time.

The question arises as to the direction and scope of the NRO effort in the area of advanced reconnaissance aircraft.

Many questions come to mind when considering this issue; not the least of which concerns whether satellites (or drones) can ever completely replace the manned system. If overflight by either system can be accomplished at will, the manned system is in general by far the more cost effective. What are the unique attributes of the future manned system when compared with other future sensor systems on a cost effectiveness basis? Will the present ban imposed on manned overflights be lifted? If future overflights by manned systems are indicated, is it necessary that the mission, as in the past, be carried out as a "clandestine intelligence gathering operation to be conducted in such a way as to minimize the risk of detection and of plausible attribution to the U.S. Government" and can such a mission be truly covert? Could other organizations, therefore, be called upon to fill these future National needs on a more or less overt basis?

The present situation is also one in which there is concern over the vulnerability of the satellite programs as well. During the past year the Soviet technical capability to interdict our satellites has become most clearly defined. The HEN HOUSE radars at Sary Shagan and Angarsk are identified as satellite acquisition and tracking radars of a very sophisticated nature. Coupled with DOG HOUSE, ABM HEN HOUSE radars and possible modified TALL KINGS, the Soviets will have an excellent and rapid orbit capability very soon. The GALOSH missile has the acceleration, payload, and accuracy required for intercept, and the TRIAD radars are considered adequate for the target and missile tract functions. Although the NRO has emjoyed a considerable amount of freedom in the conduct of its space programs to date, the future is not so certain when weighed against this ominous defensive environment.

CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

ISINGLASS

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MEMORANDUM FOR: Director, National Reconnaissance Office

UBJECT : Proposed Boost Glide Device

REFERENCE : a. BYE-36169-65, Dated 6 March 1965
b. ISI-0040-65, Dated 8 March 1965

1. I want to acknowledge your memorandum of 6 March and nention that I too share your concern for a full analysis of all aspects f Project ISINGLASS.

2. As I understand your communication, we are in general greement that a requirement exists for high resolution wide swath ridth photography and that the boost glide approach appears attractive rom both the launch/recovery and vulnerability aspects. With this as point of departure, BYE-36169-65 then suggests that the first phase f effort be devoted to competitive design studies of a manned integral ooster, manned second stage with disposable first stage, unmanned ntegral booster, unmanned second stage with disposable first stage, reliminary aerodynamic data regarding camera interface, and ecommend preferred designs by contractor and Program B to NRO or review and approval.

3. A second phase would then address itself to detailed studies y the responsive companies demonstrating the competence of their espective preferred systems. The results of such preferred studies ould then be presented to a panel of competent authority for review nd determination of program orientation.

4. Following the second phase conclusions, it would appear we ould then engage in a third phase wherein we fund studies to ccomplish a program definition.

ISINGLASS

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CONTROLLED

5. My review of the briefing and support data furnished to us by McDonnell Aircraft Corporation and Pratt & Whitney when coupled with our extensive evaluations of the requirement and vulnerability considerations strongly suggested, and convinced me, that McDonnell is prepared presently for the final step in Phase II, i.e., a governmental review of the validity of their proposal. You will note that we have in effect suggested in Reference b. that such evaluation can be made in the immediate future. We also requested funding for feasibility studies to permit us to accomplish a Phase III type program definition.

6. It was hoped that in the briefing given to you that we could convey the above conclusions to you. We, in fact, attempted to show why we had eliminated to our satisfaction, and hopefully yours, the necessity for needless competition. We apparently failed to do so. This does not mean that I believe we should turn our back on the applicable knowledge gained from the DYNASOAR Program. Actually, the contrary is true. I am convinced that such data is being integrated into the program. Attachment I reflects, in general terms, what we consider as convincing evidence of the MAC superiority in this area. As you can see from the chart, MAC is the only company with flight experience in this regime. Because of the value of practical and current technology in a program of this type, I am sure you will agree that flight experience is essential in contractor selection.

7. There are other considerations that support my recommendation that a competitive review be curtailed. To facilitate your examination of my thinking I have set forth below the principal points:

a. A loss of momentum and a slippage in eventual operation by as much as 18 months. The Reference a. approach requires a cessation of the work at McDonnell while Boeing and Martin are brought up to speed; time for Boeing and Martin to accomplish their program definition and submit proposals; followed by the time for the conventional Government evaluation.

b. A significant loss of security. This consideration is related to a sizeable increase in the number of people who must be apprised of extremely sensitive intelligence objectives. It also results in the dilution of the sense of personal responsibility to protect the ongoing program in addition to the security problems associated with binding up the wounds of the loser.

c. The technology is perishable. An unnecessary delay, possibly as much as 18 months, will directly reduce the operational lifetime of the vehicle. Moreover, this employment delay increases the risk of leakage of information on the system specifications and the chances of countermeasure. This compounding of hazards correspondingly reduces the total intelligence effectiveness of the operations.

d. Increase in program costs. As implied above, with the inherent delay and a subsequent larger involvement of contractor people in a DOD type program administration, we will experience a significant increase in cost, occasioned by the higher costs of conventionality and idle engineering time.

e. Level of activity at MAC. We need to recognize that McDonnell has voluntarily invested about $1,500,000 of corporate funds in background development toward the ISINGLASS solution, and is currently proceeding at the rate of approximately $150,000 per month. In connection with this, I share the publicly stated DOD view that where private industry has invested its own funds, the Government, and particularly this Agency, should not be arbitrarily required to go to competitive contractors to stimulate artificial state-of-the-art programs.

8. I recognize the responsibility you have for control of NRO funds and comparison of alternative programs; however, I feel greater weight should be given to the legislative umbrella, granted the Agency for security reasons to protect intelligence sources and methods, under which the Agency may conduct procurement. With legislative approbation we can proceed on a directed procurement basis where it materially facilitates accomplishing an intelligence objective rapidly and securely; being certain, of course, to have had a complete, although perhaps unconventional, source selection.

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9. For the above reasons I am reluctant to undertake the suggested method of validating the ISINGLASS Program. I am convinced we can establish a workable solution whereby we achieve the technical and financial management objectives outlined in your communication. With this objective in mind I have attached for your consideration the extensive analysis which led us to ISINGLASS. Hopefully, this will allay your misgivings.

10. Accordingly, I recommend that you reconsider and approve the technical confirmation program outlined in my ISI-0040-65 memorandum of 8 March 1965. As you know, this is designed to further harden the technology in critical areas, while preserving for the Government several options including possible termination should this period of intensive investigation with MAC and P&W so indicate.

Jack Ledford
JACK C. LEDFORD
Brigadier General, USAF
Director, Program B, NRO

Attachments: 3

We simply cannot afford to lose very many. In addition, the electronics required to replace the man in this type vehicle is very expensive. If the test program is unmanned, it requires more development time than a comparable program for a manned vehicle, this will also add to the program expense. If the test program is manned and the operational vehicle unmanned nothing is saved in vehicle cost by excluding the man. These points are considered in detail in attachment II (It should, of course, be pointed out that the present ISINGLASS vehicle can be operated unmanned if required. Additional electronics would be required. However, it would be impossible to develop an unmanned vehicle and later, if desired, add a manned option.)

5. <u>Operations and Targeting</u>: We see no insurmountable problems in the operation and mission planning of ISINGLASS. Some points need careful consideration in the early stages o the program. A generalized computer program will be established very early that will enable us to simulate a large number of missions. Such a program will ideally have as inp possible launch areas, several (3-6) key targets, and a list of possible landing sites. The program will then allow us t

Plan missions maximizing the number (or value) of other targets along the route.

Select launch conditions and burnout velocity, altitude, and azimuth.

Print out maneuver program.

Select prime and alternate landing fields, as well as recovery fields for launch or boost abort.

Prepare a mission program tape.

With this program, or some early substitute, we will run enough missions to determine the required launch and landin facilities. This will enable us to:

Confirm the number of B-52s required.

Estimate transport requirement for liquid hydroge (LH_2).

Plan unique fuel storage facilities, recovery aid maintenance facilities, etc.

These should all be done as part of a comparative analyses of alternatives before $ are spent

Simulate realistic missions in pilot training.

Plan required communications facilities.

Later, it will be necessary to establish both a technical intelligence target list and a crisis target list. Pre-planned missions should be prepared from both lists in order to reduce reaction time.

A number of possible operational problems have been discussed with members of General Schriever's staff:

a. In pilot training, simulated missions should include realistic B-52 fly-out times to determine the effect of long periods of inactivity on pilot efficiency and required in-flight life support sensing system.

b. Based on the projected landing sites, plans should be drawn for rapid return and development of film. Possible methods are:

1. In-flight processing.
2. Special processing and PI center at key recovery areas for crisis management situations.
3. High speed return to Rochester.
4. High speed return to Washington and establishment of a processing facility in Washington. (Studies on these alternates are now underway at NRO staff).

c. A complete analysis will be needed of anticipated landing conditions on the basis of computer-simulated missions, projected landing sites, and weather analysis. This will permit selection of necessary communications and landing aids.

6. <u>Aerodynamics</u>: The single most significant aerodynamic parameter related to the success of the ISINGLASS vehicle is the aerodynamic lift-to-drag (L/D) ratio. This vehicle must attain a hypersonic L/D of 3.0 - 3.5 if the quoted range is to be met. L/D values of this order have been demonstrated in wind tunnel

testing of certain configurations. Further configuration optimization is required. Also, the effect on L/D of the rocket motor on the aft end of the vehicle must be investigated. Previous successful correlation between wind tunnel test results and full scale flight test results of ASSET and the Model 122 boost-glide re-entry vehicle have adequately proven the capability of McDonnell Aircraft Corp. (MAC) to extrapolate from scale model results to full scale.

7. Structure and Materials: The nose of the vehicle which experiences the maximum temperature of 4650° F. will consist of a thoria nose cap. The leading edges will be made of columbium to withstand estimated temperatures of 2830° F.; the entire bottom surface (which experiences the maximum temperatures exclusive of the nose and the leading edges) will be made of thoria-dispersed nickel (T-D nickel). Rene 41 and beryllium will be used for the upper surface which must withstand considerably lower temperatures. The primary load carrying structure, i.e., the fuel tanks, will be manufactured from titanium. All of these materials, with the exception of T-D nickel, have been used successfully by MAC in other programs such as ASSET, GEMINI, MERCURY, F3H, F4H, and F101.

T-D nickel is a relatively new material with very little previous application, particularly in the ISINGLASS environment. (Considerable laboratory data are available, as well as results of limited application by Pratt and Whitney (P&W) at temperatures higher than contemplated for this vehicle). P&W results have been quite favorable. The material is very producible and MAC has had no major difficulty developing fabrication techniques. At the present time, Dupont is the only manufacturer of T-D nickel.

The structural build-up of the T-D nickel shingles has never been tested under flight conditions and its resistance to high temperatures, i.e., the ability to maintain the primary titanium structure at a relatively low temperature, is based on thermodynamic estimates. Verfication in high temperature test chambers of structural-thermal characteristics is mandatory.

The results of the above mentioned tests could have a significant effect on the overall vehicle performance. For example, should additional material be required for thermal protection, the gross weight would increase, resulting in a range reduction.

MAC estimates of ASSET temperatures at hypersonic speeds were very accurate compared to flight test results and have clearly demonstrated MAC competence in this field.

8. Launch Aircraft: Extensive modifications to the B-52 will be required, including wing structural beef-up, fuselage modifications to accommodate the LOX tank, and plumbing for handling fuel transfer to ISINGLASS. All modifications could readily be made without any apparent major problems; however, upon completion these B-52's could be a special, single purpose vehicle. Wind tunnel testing must be done to define the stability and control parameters for the B-52 with the ISINGLASS vehicle and LH_2 tank attached. Also, wind tunnel tests to verify the satisfactory separation of the vehicle at launch are required. No major problems are indicated, based on analysis to date of available B-52 data.

9. Propulsion: Detailed evaluation of Pratt and Whitney's "Proposed Development Program for the RL20 A-1 Engine" indicates that this is a sound development program. This program is based on P&W's previous experience in developing the RL10 engine and their broad background of development of air-breathing engines for manned aircraft. It must be realized that P&W's only previous development experience in the area of rocket engines involved the RL10 engine. A comparison of significant milestone time periods actually accomplished for the RL10 and those proposed for the RL20 are:

	RL10 A-1	RL20 A-1
First Engine Run	9 months	9 months
PFRT or FST	36 months	30 months
Q.T.	49 months	45 months*

(*This represents an approximate date at which the Qualification Test could have taken place on the RL10 A-1 engine. Effort had already refocused on qualifying the RL10 A 3-1 advanced version.) Due to the rather tight time schedule and the fact that problems can be expected to arise in the course of development of the RL20 rocket engine, the program will require rigorous technical monitoring at all times. Some potential technical problem areas, generally common to rocket engines, which will require especially close technical scrutiny are:

Isp and thrust performance

Engine Weight

Pump performance and possible surge

Turbine durability

Injector performance and reliability

Durability of combustion chambers and adequate cooling

Combustion instability

Nozzle performance

Rubbing and static seal and bearing durability.

The most significant item listed above is overall engine performance, i.e., thrust and Isp. Failure to meet the design goals established for overall engine performance will result in reduced range of the ISINGLASS vehicle.

Since Isp and thrust values are determined primarily by the performance of the main combustion chamber and nozzle, the detailed performance of these two primary components must be carefully monitored so that the source of any performance improvements or deficiencies can be ascertained.

P&W has also indicated a growth potential for this engine of about 10 seconds in Isp beyond the values attainable at the time of the Qualification Test (Q.T.). Money for this added development is provided by currently planned production and field support funding after the Q.T. This added potential can be utilized as either Isp or thrust or a combination of both, whichever may be more desirable for the vehicle requirements at that point in time. If performance improvements are achieved through somewhat higher chamber pressure, the balance between Isp and thrust improvement can probably be made rather simply by adjusting nozzle throat area.

A critical timing factor in the RL20 program is the availability of test facilities. Unavailability of test facilities on a timely basis due to construction delays (such as weather, strikes, etc.), test stand accidents, or other factors, could delay the engine development program. Scheduling of facility availability dates is included in figure 1 (facing page 8) together with major engine milestone target dates.

10. Cameras: An examination of the flight environment, considering the need for one foot ground resolution (nadir, low contrast), 60 mile swath width, and 6500 n.m. range, reveals that a focal length of less than 50 inches would be needed to avoid extreme weight penalties and a focal length of more than 36 inches to get the necessary resolution. Vehicle roll, pitch and yaw rates, as yet undetermined, will define the amount of camera stabilization required, and to a large extent the trade-off between weight in large aperture lenses and mirrors or weight in the stabilization system.

The measures taken to control the internal and external window temperatures will also have a direct bearing on the design of the camera system, i.e., more low emissivity window coatings means less light transmission through the window, requiring a larger aperture and possible reduction of focal length to reduce weight. Image motion compensation rates (V/H rates) range from the same to three times those of satellites; however, they are not considered critical.

In general, the problems associated with the design of a camera for this environment do not appear insurmountable; the best design will depend upon an accurate definition of the environment and vehicle.

11. Windows and Seeing: The above camera system has a low contrast photographic system resolution of 5 x 10^{-6} radians under operating conditions. Vehicle altitudes range

between 100,000' and 200,000'; speeds between Mach 7 and Mach 21. Factors which must be considered in the evaluation of the environmental effects on the system performance are: 1) Optical path distortions from the shock wave, from the boundary layer, from the window, and from the camera bay turbulence; 2) luminescence effects from the hot gases in the shock wave; and 3) boundary layer window effects; and 4) internal bay problems.

a. <u>The Luminescence Problem</u>: A preliminary analysis has been made of the visible radiation from the boundary layer using a real-gas model, based on nitrogen, oxygen, etc. Because of the "optical thinness" of this layer, it does not appear to be a problem. The presence of contaminants, particularly particles ablating from the vehicle, may drastically change this picture. While ionization and recombination do not appear to give sufficient radiation in the visible spectrum to be effective, the black-body radiation from small hot particles is a definite hazard. The effect of heavy molecules also needs to be investigated more thoroughly; here again, the low concentration and thinness of the layer will reduce possible magnitude of the effect. In short, there does not appear to be a significant problem in the ISINGLASS system ascribable o the luminescence of the external gases, nor from the uminescence of the window components, proper. However, he prospect for infra-red visibility is not so promising, nd need additional evaluation.

b. <u>Shock Wave and Boundary Layer Effects</u>: The rimary effect is the distortion introduced on the ncoming plane wave. The prismatic effect, the uniform ending of the incoming rays, has little or no effect n resolution, but affects primarily the mensuration apabilities of the system. In the overall operational se, the mensuration capability must be considered, but t is of secondary importance. Analyses by Perkin-lmer indicate that no problem will occur in the flight egime; the modulation transfer function will remain bove 0.9 for all spatial frequencies. Additional tudies are called for when the configuration becomes ore firmly fixed and as additional wind tunnel data become available. The favorable factor here is, again, the small value of the mean optical thickness of the layers, so that even large fractional deviations from the mean cause only small, almost negligible variations in the absolute values of the optical path length.

c. Window Effects: Ignoring again the possible prismatic effect, the adverse effect comes from non-uniform optical path length variations. As the window glass is optically thick, variations in relative path length can become important, even for relatively small percentage deviations. Mr. Rosenau of Perkin-Elmer has estimated, on a preliminary basis, that variations less than 1° F from a straight line gradient cause on significant deformation in the wave front. Reproducible and predictable gradient deviations can be partially taken care of in the optical design. The over-all window problem, in conjunction with the associated heat-transfer from the boundary layer, is the most critical in the total system. The principal approach to date in reduction of window heating has been use of a step and cavity, reducing pressure and heat transfer at the window. Helium injection into the boundary layer is available as a back-up, supplementary window cooling technique. Only preliminary work on the cavity has been done to date. Wind tunnel tests at Cornell Aeronautical Laboratories by MAC have shown that temperatures compatible with materials for the window can be achieved. Preliminary data from these tests show decided curvature in the heat input profile, implying corresponding curvature of the temperature profile. Much additional detailed work needs to be done on this, particularly including three-dimensional thermal analyses of temperatures during the flight regime--on the transient basis which we will, in fact, have during the photographic operational period. The helium injection at the boundary layer may be useful in reducing and controlling gradients.

d. Internal Bay Problems: The analyses by Perkin-Elmer show acceptable optical performance, with respect to turbulence in the camera bay, if internal window temperatures are maintained below 150°F. A simple analysis of the heat transfer problem showed that this internal window temperature could be achieved with a triple-glazed window, having a single infra-red reflecting coating; a second coating is tolerable from light transmission considerations and provides additional thermal design margin. Further, design margin is available with the possible use of coolant gas in the inter-glazing region.

12. Pilot and Support Equipment: The principal problems in the pilot-life support region will be those involved in the maintenance of the pilot during the fly-out to the launch area. The effect on pilot performance of possibly extended periods of inactivity and tension while riding under the wing of the B-52 will have to be closely examined. We will investigate work done at Convair under project TOM-TOM in which two aircraft were suspended under the wing of a B-36. The life support equipment will require provisions for biological telementry to the mother ship for monitoring the pilot's condition. The escape system will provide for pilot escape under abort conditions at speeds below Mach 3.2 using existing technology. Escape at the higher speed regimes is impractical. Throttleability of the engine does provide for a reasonable abort envelope, allowing the pilot, under some conditions, to fly the aircraft subsonically to a landing site. Extensive, but normal, pilot equipment will be needed, so that he may usefully function during the flight time. The general life support system problems are expected to be similar to that of OXCART, although total flight time is shorter and external temperatures are higher.

13. Logistics and Support: A complete logistics and support plan including personnel requirements, aircraft support, ground support equipment, aero-medical support, etc., can be defined only after a detailed investigation and analysis is made of all aspects. Certain of the problems recognized now are noted below:

Considerable study and investigation remains to be done to establish if a requirement exists for an overseas manufacturing LH2 facility, and if so, the required capacity of such a facility. As an alternative, a study prepared by P&W (for an unrelated program) investigated design requirements for LH_2 to be air transported in tanks in a C-124.

Support aircraft of several categories will be required in addition to the B52H launch aircraft. High speed jet aircraft similar to the F-4 will be needed for launch monitoring and for landing phase surveillance; C-141 or similar type aircraft will be required for overseas staging support. Exact numbers of each type of aircraft are not established.

The ISINGLASS vehicle must be capable of landing at night at remote bases and under adverse conditions; augmentation of landing aids will be required at the recovery base.

14. Contracting Officer Evaluation: From a costing and proposal preparation standpoint the OSA Contracting Officer has been most favorably impressed with McDonnell's competency, methodology and with the calibre of its staff. This impression has, of course, been gained from very preliminary price and cost analysis (a two-day visit for preliminary cost analysis and proposal-preparation procedures orientation). Without program and funding approval, no detailed preparation for negotiations has been undertaken.

MAC proposal are exceedingly well documented, with back-up work papers utilizing experience on other programs, and relying heavily on the statistical approach.

The ISINGLASS proposal was first prepared, using this largely statistical approach, and priced as for a standard DOD program. This then was connected to an "autonomous project" (their word for "skunk works") which revised price equated to 60 percent of their standard DOD program price.

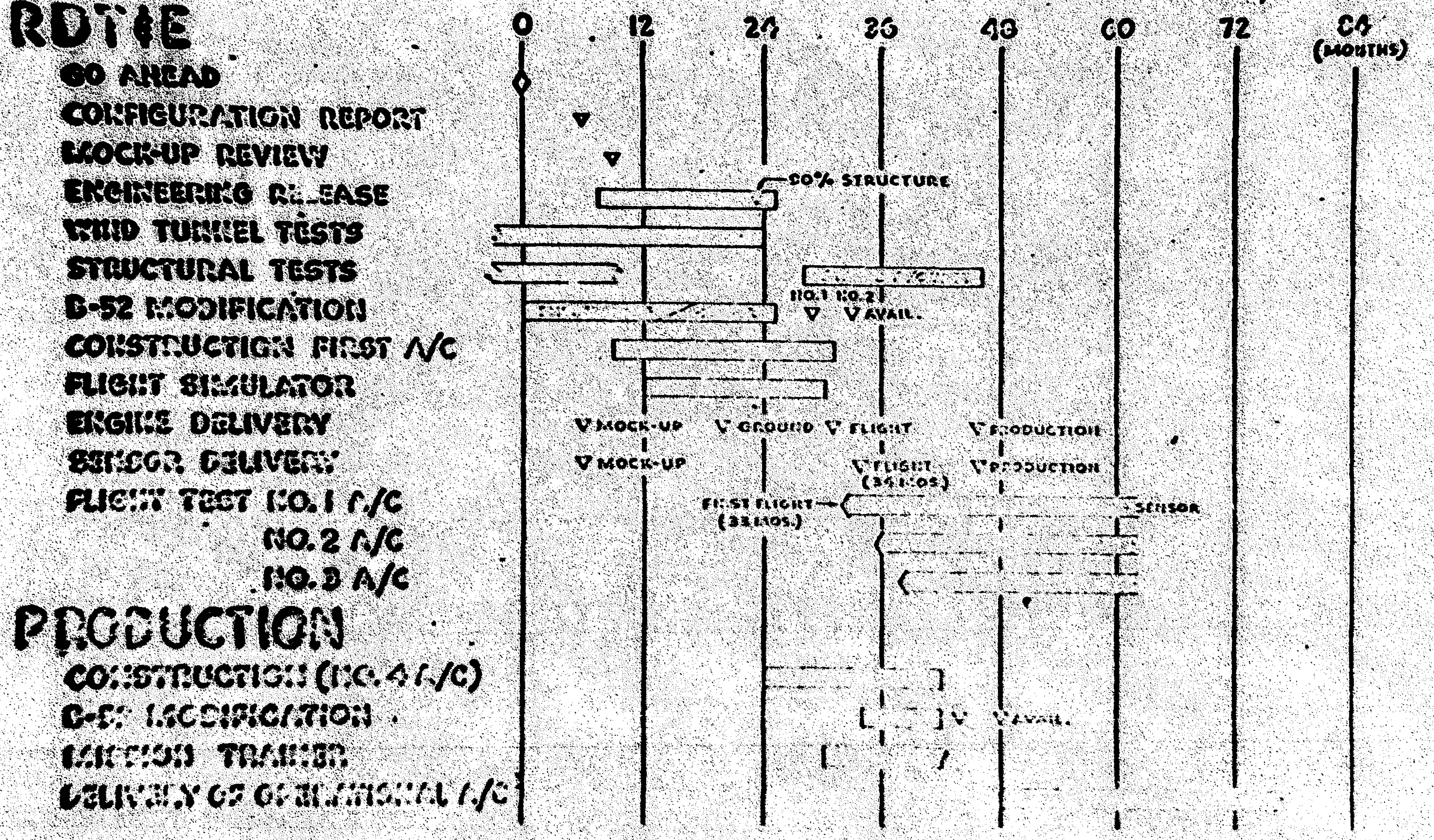
The OSA Contracting Officer, and accompanying auditor, were of the opinion that their material costs were most realistic, even including major subsystems--which at the time were admittedly estimates only based on previous similar sub-systems, security having not yet permitted any detailed discussions with prospective subsuppliers.

Respecting engineering hours, the feeling was that the company could still reduce perhaps another ten percent to meet reasonable "autonomous project" proportions. This company will never become as "skunky" as LAC, with respect to engineering hours, but they are motivated to reduce as far as prudent.

Fig 2

EYES ONLY TO: [illegible]

PROGRAM SCHEDULE



15. Security: All indications suggest that ISINGLASS can be handled with a style of security programming develope first for IDEALIST and later repeated successfully for OXCA and other programs. A significant departure from the normal approach to security investigations has already been employe with ISINGLASS in that, for a comparatively modest cost an investigative apparatus has been set up in the St. Louis are and approximately 150 investigations have been successfully completed on MAC employees. With these investigations toget with others that will be conducted in the weeks immediately ahead, MAC will be in a position to begin productive efforts immediately upon contract formation without loss of time previously experienced by contractors awaiting clearances.

Both McDonnell and Pratt & Whitney, the two firms with whom security interaction has occurred thus far, have demonstrated superb cooperation with Security Officers and give indications of an adaptability to assume the kind of "skunk works" security philosophy used before.

The project ISINGLASS has been placed in the BYEMAN Security Control System under special holddown arrangements and thus far all aspects of security, including document controls and clearances, have gone smoothly.

16. Costs: Current cost estimate for the total ISINGL program have been based on a five-year operational life, wi approximately 100 missions flown. The total program cost, this basis, is about $1,043 million, broken down as follow

RDT&E (3 test aircraft, 7 eng.)	$570 M
Production (8 Aircraft, 16 engines)	282 M
Facilities	53 M
Cameras	25 M
Five Year Operating Costs	113 M

The first year of effort totals about $110 million, including a six-month feasibility program at $16.3M. Peak expenditure rate is approximately $200 M/year, reached in t second or third year, followed by a gradual tapering down about $60 M/year in the eighth or ninth year for maintenan engineering and operational support. The above costs do not include contingency funding. A 5% contingency fund addition would be a logical safety margin action in a program of this type.

18. Program Schedule: The program schedule, figure 2, facing page has been developed by OSA with both McDonnell Aircraft Corp. and Pratt and Whitney. This schedule is a tight one, but realistically based on the "skunk works" approach to doing business. The pacing item in the program is the delivery of a qualified flight suitability test rated engine within 30 months of go-ahead. It is felt that this objective can be met if the programmed Pratt and Whitney test stand facilities are brought in on schedule. Pratt and Whitney plans to underwrite these facilities out of corporate funds on the basis that the government will reimburse Pratt and Whitney in the event of a program termination. Arrangement should be made, if at all possible, to direct Pratt and Whitney to proceed with their facilities installation prior to a full-fledged program go-ahead to add insurance to the preservation of the qualified flight rated engine delivery schedule. All other aspects of the program naturally fit into the schedule noted in Figure 2. The objective of the program schedule is to have the first flight test aircraft and propulsion system ready within 33 months; sensor system ready for flight test within 38 months; and the first operational aircraft delivered within 48 months of go-ahead. The B-52 launch aircraft modification, flight test program, and readiness of test site facilities are compatible with the program schedule.

Additional confidence in the program schedule can be attained from the demonstrated performance observed in the "six month" preprogram go-ahead technical feasibility study contemplated with McDonnell, Pratt and Whitney, and sensor contractors.

EYES ONLY
~~TOP SECRET~~

HANDLE VIA BYEMAN
CONTROL SYSTEM

ATTACHMENT III TO:
BYE-2575-65

MANNED VS. UNMANNED

NRO Approved For Release

CASE I

Model 122 MODIFIED BOOST GLIDE RE-ENTRY VEHICLE, UNMANNED, THRO-AWAY BOOSTERS

1. The Model 122 Boost Glide Re-Entry Vehicle is a high fineness ratio, radiatively cooled aerodynamic vehicle with a maximum L/D of 3.7 and range of 5300 n.mi. Peak altitude is 280,000 ft. and peak glide velocity is about Mach 20. Glide weight is 2100 lbs. with a maximum diameter of 29 inches and overall length of 23 ft. The fineness ratio of 9.69 is firmly established on the basis of aerodynamics, structure, packaging and cost.

2. This vehicle has been resized to permit inclusion of two cameras providing one foot resolution stereo coverage with 60 mile swath and a parachute re-entry system. The rotation of the vehicle (used for cooling) has been employed as the scanning method. With the cameras and necessary control surface equipment the base diameter becomes about 65 inches and the length 52.8 ft. Glide weight of the vehicle is 7,160 lbs. In order to enable launch from a B-52, new boosters and engines are required. The Minuteman, for instance, would not carry this vehicle to required initial glide conditions. A larger booster, such as Thor or Atlas, could not be carried. Assuming a high pressure LOX/LH_2 engine with specific impulses of 458 seconds (the trade-off now favors a 5:1 mixture ratio) the vehicle has the following characteristics:

Launch Weight	76,278 lbs.
Glide Weight	7,160 lbs.
Booster Weight	9,202 lbs. } ?
Propellant	59,916 lbs. }

3. Because of the high wing loading inherent in this design, it is not possible to recover the vehicle horizontally. A vertical, parachute recovery system has been provided.

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4. Vehicle costs, in comparison to the manned 192 (ISINGLASS) are estimated as follows:

Unit Vehicle Cost @ 4 Vehicles (millions of dollars)

	Manned Model 192	Unmanned Model 122
Vehicle	13.7	10.0
Booster	--	2.1
Engine	1.5	1.5
Total/Unit	15.2	13.6

5. A program costing basis of 100 operational missions has been established. In the case of the unmanned 122 type vehicle, 40 R&D missions have been used for costing purposes.

6. If an attrition rate of zero is used for each vehicle, then no vehicles are consumed in either program, but 140 boosters and engines are thrown away in the 122 type program, at a total cost of about 250 million dollars. This more than offsets the lower vehicle costs. In fact, the attrition rate on the unmanned vehicle would be considerably higher than that for the Model 192 because of failure rate in the electronic systems and more important, because of losses and damage in the vertical landing.

7. At zero attrition, the program costs* for both vehicles are estimated as follows:

	Manned Model 192	Unmanned 122 Type
R.D.T.E.	$512 M (3 vehicles)	$480 M (3 vehicles and 40 boosters)
Production	340 M (8 vehicles spare, AGE, etc.)	630 M (8 vehicles 100 boosters AGE, etc.)
Operations	76 M	90 M
Total	$928 M	$1,200 M

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*These costs do not include facilities (53M), camera (25M) and costs of operating (b)(1)1.5c for five years (about 37M). These additional amounts would be comparable for both systems.

Beginning in 1966, large hypersonic wind tunnels with real gas characteristics will be available for SCRAM-jet engine optimization. Both of these high volume air-breathing vehicle concepts will have some susceptibility to sonic boom constraints. The intensity, however, in both cases should be less than 1 psfa since flight is maintained at sufficiently high altitudes to minimize boom strength. Both vehicles have the distinct advantage of making a conventional landing.

3. Boost Glide

This particular concept represents a relatively attractive approach but does result in some complexity and reduced payload fractions when compared to a ballistic vehicle. The volumetric efficiencies are generally reduced with increasing lift-to-drag ratio (0.12); and the payload fraction will probably be in the order of 10%. This fraction is also a function of wing loading but this value is generally in accord with the state of the art. The configuration and structural complexity will be somewhat aggravated and experimental substantiation and verification of the aerodynamic efficiencies and thermal protection must be augmented. The major advantage of this approach is associated with performance versatility and the fixed mission time does not require orbital systems. The vehicle will operate at relatively low angles of attack; the I. R. and radar detection appears to be reasonably low and the altitude/velocity time history over pertinent target areas is relatively high, $150K \leq h \leq 200K$, $^{14} \leq M \leq 21$. The maneuvering capability and the potential for evasive actions also contribute to a system which should have a relatively low vulnerability. The photographic resolution should be improved over a ballistic technique because of the operating altitude; however, experimental investigations must be made to verify optical quality in the presence of the plasma. In addition, temperature and density gradient factors must be assessed. This vehicle will employ the re-radiative thermal protection concept and considerable confidence now exists for such materials both from ground and flight tests such as the ASSET, although specific fabricability of selected materials and construction techniques must be proven. Based on current information, however, it is felt that this can be accomplished and that such an approach can offer a reasonably high degree of reusability with minimum refurbishment. The high fineness ratios and configuration geometrics required for increased efficiencies in gliders lend themselves to and are commensurate with the same requirements for launch or booster systems. Consequently, an integrated launch/entry vehicle offers a promising approach for air-launch applications particularly when increased Isp (450) capabilities are considered. The mobile launch platform (aircraft) also significantly enhances the performance/operation coverage. The inherent aerodynamic gliding capability of the vehicle also allows some latitude in performance in the event of a premature engine shut-down which would not be available with a ballistic system. These vehicle concepts can be made amenable with the constraints for a conventional landing and should result in an overall greater reliability, thereby reducing the number of vehicles required. This, of course, is directly related to the fact that the vehicle technologies associated with hypersonic glide systems are reasonably well established, although admittedly, increased aerodynamic efficiency must be verified. Based upon an assumed schedule of 100 launches and reusable vehicles the program costs would most probably be in the order of $2.5 billion.

4. Orbital Vehicle with Aerodynamic or Propulsive De-Orbit Capability

An aerodynamic de-orbit capability as reflected in an orbital decay re-entry is not believed to be competitive. The points of entry and flight path time history would be reasonably unpredictable from the pilot's point of view. It is felt that a propulsive device or retro-rocket offers a much greater degree of on-board predictability and reliability if an orbital system is under consideration. It is worthwhile to mention that after performing a normal de-orbit maneuver with retro-rockets, considerable energy still exists within the system and the velocity at the start of entry is very near orbital. This condition is such that very large ranges could exist, considerably in excess of the 6000 mi and either aerodynamic breaking or propulsive retardation may be required to limit the performance. If the system is ballistic and depending upon initial orbital altitude and retro-velocity drag modulation by various forms of aerodynamic decelerators could be employed. In the case of a lifting entry vehicle, it may be necessary to use large values of drag and fly at low values of the lift-to-drag ratio to assure range containment. As mentioned previously, propulsive deceleration is also a possibility but trade-offs would have to be performed for the specific entry vehicle to assure that this approach would be weight competitive.

The orbital mode has certain disadvantages, however, in that during orbit a long-term predictable ephemeris is possible and possibly vulnerable. In addition, a full orbital capability must be developed with all subsystem so engineered for the design orbital life. The photographic resolution most likely will not be relatively high, although perhaps improved over near-apogee conditions of the ballistic approach. Depending on orbital altitude, however, plasma effects can be minimal and some versatility is permitted in the photographic techniques which could alleviate design problems such as gaps. The composite system, booster and orbital/entry vehicle will most likely require a ground launch with relatively large booster systems. It should be emphasized that the entry mode can be either ballistic or lifting depending upon the degree of performance versatility required. One significant advantage, however, may be associated with contingency requirements while in orbit. Depending on the specific target coverage involved and also time dependency of information, it may be advantageous to consider orbital operation, for this mode could permit long-term observations and if wide coverage could be coupled with adequate resolutions (based on carefully selected orbital altitudes) the systems become attractive candidates. This could be augmented with an entry vehicle with a wide range of operating aerodynamic efficiencies. The vehicle could conceivably be dispatched to a specific point of coverage on the earth's surface based upon information received from an orbital mode; most likely a companion vehicle. The technology base is reasonably well established but varies in confidence/experience level depending upon the choice of the entry system. Program costs are estimated to be between $2.5 and $3.2 billion. If the orbital system is [illegible] [illegible] techniques, considerable upgrading of the technology will result relative to many scientific disciplines.

5. Combination Methods

There are a number of perturbations and combinations for accomplishing the prescribed mission which are worthy of some comment. These are essentially variations in the ballistic, cruise and gliding modes and improved booster capabilities such as the Scram-jet with its postulated high Isp of approximately 2500. The Aeroballistic approach essentially combines ballistic and gliding trajectories; an additive range capability is accrued as a potential advantage but does not appear to offer significant gains over the boost/glide mode. In addition, a roll rate is employed for thermal and structural efficiency and is not particularly commensurate with the requirements imposed by the constraints of the man and photographic equipment. An advantage is that such a concept is currently under close investigation with the 122 program (SGRV); however, the program objectives and design criteria being employed are not compatible with reusability requirements of a manned vehicle. The vehicle concept as currently being pursued does not accommodate a soft landing; consequently, auxiliary equipment such as a parachute (discussed under the "Ballistic Vehicle Concept") would have to be provided. The SCRAM concept as applied to propulsive systems offers perhaps one of its most significant advantages and if such a capability could be developed, increased performance could be attained with many different combined concepts. Again it is important to emphasize, however, that long lead [illegible] may be appropriate. Combinations such as Rocket/SCRAM/Rocket/Glide and Rocket/SCRAM/Rocket/Ballistic are possible but because of the multi-stage requirements and the present state of the art could represent high risk approaches. The initial rocket is required to accelerate to the velocity for SCRAM operation and the interim rocket is to generate additional velocity at Mach numbers in excess of those currently supported by the SCRAM Technology. Many additional combination techniques are possible particularly by using various modules of propulsion and depending upon specific mission requirements perhaps optimum fuel/propulsive/vehicles can be determined. Again reliability and complexity, however, must be carefully scrutinized and most likely will present problems which will be reflected in program extensions and cost escalations.

D. <u>CONCLUSIONS AND RECOMMENDATIONS</u>

1. It is to be pointed out that while the costs appear higher than previously discussed, they contain "flange-to-flange" costs of RDT/E, vehicle costs, flight test costs, range modifications, support and overseas operations.

2. In considering all the approaches the boost-glide is the <u>earliest</u> achieveable with <u>good</u> mission characteristics with the least growth potential, least alternate applications, and minimum technical risk and hence narrowest push on technology. The system with the greatest growth potential is the cruise vehicle and the one that will have many variations in many mission areas, i.e., recoverable [redacted] launch vehicles, satellite intercept, etc.

3. The entire spectrum of hypersonic work, i.e., engines, structures, START, plus other work not visible to me needs a centralizing focus in order to make rapid and significant progress toward the goal of manned

March 6, 1965

MEMORANDUM FOR DIRECTOR, PROGRAM B

SUBJECT: Proposed Boost Glide Vehicle

Your briefing to me on this subject was quite interesting. As you indicated, there are questions, in addition to those of basic technology, which must be addressed in order to get a full evaluation of the possible costs and usefulness of a system based on a boost glide vehicle. I was glad to see that you have already begun to examine some of these. As you point out, a program to exploit the possibilities of a boost glide vehicle will be very expensive, equal in cost to or greater in cost than the development of an advanced airplane. I think that you will agree with me that if a program of this potential size is to survive it must be subjected to analyses of its problems and of the possible alternatives that are complete and of the highest integrity.

Your briefing brought out several conclusions, the most interesting and important of which, in my judgment, were the following.

1. The requirement exists for a flexible rapidly reacting system capable of returning data after a single pass over the target area.

2. A photographic swath 50 miles in width is useful in connection with this requirement.

3. A boost glide trajectory over the area of interest appears a possible approach to the requirement.

4. Such a trajectory requires about two-thirds of the energy per pound of flight vehicle that is required of an orbital device, making an air launched device appear attractive.

ISINGLASS

5. Except in the presence of a major deployment of AICBM defenses, a boost glide trajectory is not highly vulnerable to defensive action.

6. A boost glide system would probably call for a large initial investment, but in an active market might experience relatively low operating costs.

I have several concerns about the proposal as you have now described it. First, it is not clear to me, at all, that a manned vehicle is required, or even desirable, for the mission in question. It seems likely that an unmanned glider for this mission would weigh very much less in flight than the 25,500 lbs. you estimate for the manned vehicle. Its launched weight would then be correspondingly less, and the whole system simpler and possibly cheaper both in development and in operation.

Second, I note that the vehicle you describe, although somewhat different in structural concept, is in size and performance very similar to the X-20 (DYNASOAR), toward the development of which the Government has spent about $250 million. Any undertaking now to study vehicles of this kind must permit bringing to bear the knowledge gained, and the technology developed, on the X-20. Further, at the present time, the Air Force is studying with the Martin Company a proposed program for an ablatively cooled hypersonic glide vehicle at a somewhat smaller scale. Advantage would result from drawing on this technology as well.

Third, it is not clear to me that a fully integral, completely recovered, single stage boost is the best for this mission. In particular, a smaller vehicle, properly staged at boost, might not require development of a new propulsion system.

Fourth, it is quite clear to me that a program of the size and scope of that visualized in your briefing cannot practicably be carried out in a clandestine manner. Should it develop that the scope of the program cannot significantly be reduced by simplification of the vehicle and of its propulsion system,

it will be necessary for the NRO to manage the program in such a way that major elements can be covered by overt identification and financing.

Finally, we must recognize, as your briefing already has, that a boost glide system is in potential competition with satellite and ballistic systems. These could be available sooner than a boost glide system of the kind described in your briefing, or alternatively they could be of a generation later than systems now in operation or development. If configured against the now recognized requirement for quick reactions, these competitors could have operational characteristics, and costs, requiring careful comparison with those of a boost glide device.

In view of your conclusions, I agree that proper consideration must be given to a boost glide system. In view of my concerns, and because of the potential cost of any final program that might result, I feel that I cannot recommend even initial steps to the Secretary of Defense and to the Director of Central Intelligence until I am satisfied that two conditions can be met:

First, that a program can be laid out that provides the NRO, and thus also the Secretary of Defense and the Director of Central Intelligence with a full and objective comparative analysis of all competing means that might plausibly [illegible] the requirement stated;

Second, that financial commitments and obligations to contractors during the program can at all times be limited to those which in the judgment of the NRO are justified by their expected contribution toward the achievement of approved goals.

Accordingly, I would like you to lay out for my consideration a program along the following lines:

The interest is in a boost glide vehicle, air launched from a carrier no larger than a B-52, and capable of a [illegible] trajectory of [illegible] nautical miles or more. [illegible]

It will be necessary for the NRO to manage the program in such a way that major elements can be covered by overt identification and financing.

Finally, we must recognize, as your briefing already has, that a boost glide system is in potential competition with satellite and ballistic systems. These could be available sooner than a boost glide system of the kind described in your briefing, or alternatively they could be of a generation later than systems now in operation or development. If configured against the now recognized requirement for quick reactions, these competitors would have operational characteristics, and costs, requiring careful comparison with those of a boost glide device.

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First, that a program can be laid out that provides the DNRO, and thus also the Secretary of Defense and the Director of Central Intelligence with a full and objective comparative analysis of all competing means that might reasonably satisfy the requirement stated;

Second, that financial commitments and obligations to contractors during the program can at all times be limited to those which in the judgment of the DNRO are justified by their expected contribution toward the achievement of approved goals.

Accordingly, I would like you to lay out for my consideration a program along the following lines.

The interest is in a boost glide vehicle, air launched from a carrier no larger than a B-52, and capable of a [illegible] trajectory of 6000 nautical miles or more. Compatible [illegible] vehicle design studies would be undertaken with at least two contractors, McDonnell and Boeing, and preferably also with Martin. These design studies would proceed in two steps. For each contractor, the objective of the first step would be to examine alternative configurations in sufficient detail that each contractor's preferred configuration or configurations could be identified. The objective of the second step would then be to pursue design studies of the preferred configurations in sufficient detail that effective evaluations and comparisons can be made among the designs of the competing contractors. Comparisons in all cases are to be made on the basis of estimated costs (both development and operating), mission performance, possible operational limitations, and factors bearing on operational reliability and development time.

Initially, consideration must be given by each contractor to at least the following four general configurations:

1) Manned vehicle with integral booster,

2) Manned second stage vehicle with a disposable first stage,

3) and 4): Unmanned vehicles, respectively with integral and separable boosters.

In considering vehicles with separable boosters, an optimally staged configuration should be identified; consideration must also be given, however, to disposing of the first stage within 300 nautical miles of the launch point.

For the first step, all vehicle contractors would be given the same interface requirements for the camera system.

For each contractor, the output of the first step would consist of at least the following:

1. Preliminary aerodynamic data permitting initiation of camera window studies, to be done under other contracts.

1. Comparative analysis of the configurations should be carried to the point for each that further study or rejection can be justified. For the most likely or attractive configurations, some indication should be given of the sensitivity of each to the [illegible] imposed by the enemy defenses.

2. The one or more recommended preferred configurations, with justification.

I would expect you to submit your recommendations for those configurations to be carried into the second step, with justification, for my review and approval.

Each contractor, during the second step, would concentrate on the configurations approved by me. Arrangements would be made at this time with propulsion contractors, as necessitated by the particular configurations under study. For each vehicle contractor the output of the second step should include an overall system concept, and a vehicle design or designs in sufficient detail that specific structural techniques, specific propulsion requirements and subsystems, and recommended other subsystems are identified. Analyses should be presented permitting comparisons among competitors according to the criteria listed earlier.

At or near the close of the second step, it would be necessary for the NRO to convene a panel to examine the structural, propulsion, and other problems associated with each proposed vehicle system. Using the results of the second step, the findings of this panel, and the results of such other analyses as the NRO will make, the DNRO would then report to the Secretary of Defense and the Director of Central Intelligence. Were the findings to justify it, such a report could recommend the initiation of a program definition phase, with vehicle and propulsion contractors to be selected by such procedures as might appropriately be recommended at that time.

There is little question that the cost and time to develop a boost glide system will be dominated by the problems of the vehicle itself. Nevertheless, should a program definition phase [illegible] it will be necessary to include definition work by a camera contractor. Accordingly, it is suggested that, at about the close of the first step of the vehicle studies, we invite three or four camera contractors to compete in a paid design competition for selection of a camera design and contractor. Prior to this time, additional study is needed of the camera requirements, and of the relation of these requirements to those that might be imposed by a satellite system configured for comparable missions.

Please let me have your recommendations for a study program conforming to the objectives and guidance just outlined.

Brockway McMillan
Director
National Reconnaissance Office

8 Mar 63

BYE 14189-63

TOP SECRET

Copy memo to DNRO re Proposed Boost Glide Device

1. Col Ledford
2. Col Ledford
3. Dr. Fubini
4. SS-1
5. SS-2
6. Maj Stanton
7. SS-1

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AF Form 310b

DOCUMENT RECORD AND RECEIPT

~~TOP SECRET~~
ISINGLASS

CENTRAL INTELLIGENCE AGENCY
WASHINGTON 25, D. C.

BYE-2100-66
Copy 1

23 FEB 1966

MEMORANDUM FOR : Director, National Reconnaissance Office

SUBJECT : ISINGLASS Research and Development Program

1. Pursuant to your verbal request, I have attached to this memorandum a recommended research and development program for ISINGLASS covering a period of about nine months. This program has been designed specifically with two goals in mind:

a. to determine capability to satisfy our objectives, in particular, to establish system capabilities with regard to resolution, survivability, range, reaction time, tactical flexibility, and target coverage; and

b. to establish reliable program cost estimates based on detailed point design, subsystem analysis, and, insofar as possible, actual manufacturing experience. In order to accomplish the above, a substantial amount of testing, engineering and analysis will be necessary which will further confirm the technical feasibility of the concept.

2. The estimated cost of the McDonnell portion of the program is $5,350,000. In addition, we are recommending camera environment studies totalling $150,000, giving a nine month program total of $5,500,000.

3. The basic study areas at McDonnell are:

a. System Effectiveness: This will include development of a mission performance computer program and analysis of targeting, reaction time, basing recovery, and support operations. In addition, necessary contractor support to government studies on survivability and cost effectiveness will be provided.

b. Configuration Definition: Using extensive wind tunnel testing, full flight range performance of the aircraft and carrier aircraft will be established and design sensitivities assessed. In addition, extensive

602-23-002

testing will be done to establish the photographic performance, to demonstrate the window cavity concept, and to optimize design. Structural elements will be determined, their performance substantiated and refurbishment requirements established.

c. Technology Demonstration: From wind tunnel tests, thermal design criteria will be established and structural elements, including the insulation and waterwick, will be subjected to thermal tests. A full scale fuselage section will be designed and the performance of the cryogenic systems will be demonstrated.

d. Cost and Schedule Substantiation: The results of the work above will be used to develop a high confidence base for cost and schedule performance.

4. In addition to the work at McDonnell Aircraft Corp. we are recommending certain studies to establish camera environment. These studies will investigate the internal turbulence of the camera bay, window temperature gradients, and boundary layer effects. Details are set forth in the attachment. Total cost, over a period of 9 months, would be $150,000.

5. If, on conclusion of the foregoing program, it appears desirable to continue work on this project, we would propose a second phase. In particular, we feel that a full scale fuselage section and window cavity should be constructed. This will permit us to verify weight factors, harden cost data, and determine capability to achieve resolution requirements. We are in the process of preparing this second phase program to last about nine months and cost about 5 million dollars.

Huntington D. Sheldon

HUNTINGTON D. SHELDON
Director of Reconnaissance, CIA

INDEX TO ATTACHMENT TO BYE-2100-66

Attachment to -
BYE-2100-66

ISINGLASS RESEARCH & DEVELOPMENT PROGRAM

A. McDonnell Aircraft Corp.

1. System Effectiveness $440,000

The global operating concept, logistics plan, support requirements, and mission effectiveness for the McDonnell Model 192 (ISINGLASS) will be developed. In addition, necessary contractor support to government survivability and cost effectiveness studies will be provided.

a. Mission Effectiveness

i. Operational Plan - the global operating concept will be developed and system deployment requirements such as basing, recovery, logistic support, etc., will be defined. The influence of operational variables, such as response time, data processing, range, etc., on the operating plans will be determined.

ii. Targeting Analysis - Targeting and mission effectiveness analyses will be performed for the Model 192.

iii. Targeting Computer Program - A mission performance computer program will be developed. This program will produce the "missionized" ground track of the Model 192. Basic vehicle characteristics and mission variables, such as launch-recovery base constraints, maneuverability, swath width, speed-altitude-range combinations and flight direction, will be included.

b. Survivability

Support will be provided to U. S. Government vulnerability studies. These will include a first-order evaluation of gross characteristics and a technical evaluation in depth.

c. System Evaluation

Support will be provided to U. S. Government cost effectiveness studies. Necessary data inputs

GROUP 1
Excluded from automatic
downgrading and
declassification

in the areas of operational effectiveness and cost, manufacturing cost, refurbishment, attrition, etc., will be analyzed and prepared. Alternate boost-glide systems based on point designs will be investigated.

2. Configuration Definition $3,250,000

Key parameters of the configuration will be identified and trade-off studies conducted to achieve best design and performance. The objective will be to define a configuration that assures high confidence, substantiated analytically and experimentally. Design aids, such as scaled models, will be utilized where appropriate.

a. Performance

i. Performance characteristics will be established and will include operational effects such as tolerances on launch conditions, guidance, control, navigation accuracy, atmospheric variations, energy management techniques, engine performance, etc.

ii. Developmental wind tunnel testing will be conducted to provide data for design optimization studies. Effects of varying configuration proportions and component size will be investigated throughout the flight envelope. The McDonnell Polysonic and Hypersonic Impulse Tunnels, and the Cornell Aeronautical Laboratory Hypersonic Shock Tunnel will be utilized. Developmental wind tunnel testing will utilize four wind tunnel models for support of the design optimization and sensitivity study for verification of the performance characteristics. The results of these model tests will be used to finalize and validate key items making possible design convergence of the aircraft configuration.

I. A 2-½ percent model will be tested thru the Mach 0.6 to 6.0 range in the M.A.C. polysonic wind tunnel. Primary purpose is for configuration development and tradeoff study support. A total of three series are planned totaling approximately 350 hours.

II. A 2 percent scale model will be tested from Mach 11 to 20 plus in the M.A.C. hypersonic impulse tunnel. Primary purpose is for performance development and verification. A total of two series are planned totaling approximately 150 hours.

III. A 2 percent scale model will be tested from Mach 10 to 20 plus in the Cornell hypersonic wind tunnel. The primary purpose of these tests will be to obtain stability and control and aerodynamic performance data. A total of two series are planned totaling approximately 200 hours.

b. Design Sensitivity

Design sensitivities will be defined to effect the best compromises considering all pertinent factors. The effect of design variables and/or constraints such as volumetric efficiency, aircraft length, glide weight, launch weight, specific impulse, and glide insertion conditions, will be determined so that the full impact of different requirements can be accurately assessed. The type of research and development program proposed provides those design sensitivity factors, including much hard core test data, that are vital to establishing the best size and configuration for ISINGLASS. These design sensitivities will include all factors necessary for a practical, high assurance evaluation of prime design variables, including such items as range, altitude, manned versus unmanned optimization, manned with unmanned option, payload, wing sweep, shape, weight and maneuverability.

c. Landing Characteristics

i. Landing capability and characteristics will be defined. The development of the best piloting techniques will be a primary objective of this activity. Key parameters will be varied to develop design and performance sensitivity relationships.

ii. Landing configuration aerodynamic characteristics will be obtained in the McDonnell low-speed wind tunnel. Configuration variables, such as base geometry, landing gear, canopy, speed brakes, and controls, will be evaluated. Primary resources to be employed in this activity are wind tunnel models and simulators for pilot evaluation. The initial corporate-sponsored activity using a 7-½ percent scale model of ISINGLASS would be continued. The M.A.C. low speed tunnel will again be used for development and verification tests for landing capability. Two series of tests totaling approximately 350 hours are planned. In conjunction with this work, an analog flight simulator program will be conducted to evaluate all dynamic aspects of the landing characteristics and performance.

d. Carrier Aircraft

Carrier aircraft selection will be validated by detailed analysis of availability, extent of required modifications (wing beef-up, additions of cryogenic fuel storage, etc.) operational characteristics and performance.

i. Carrier aircraft-Model 192 performance including flow field effects during cruise and launch will be determined. Appropriate analyses for a variety of speed and attitude conditions will be performed to obtain the complete performance envelope. A key resource for the development and verification of the performance of the carrier/ISINGLASS combination will be a 4 percent scale model to be tested throughout the subsonic speed range. These tests will include the combined configuration for performance and stability and control verification and will include proximity tests to establish the launch characteristics. External tanks or other appendages will be included on the carrier if required for proper simulation. A total of two series totaling approximately 250 hours are planned. This continues the ISINGLASS/B-52 testing that has been accomplished in the M.A.C. low speed wing tunnel utilizing the 7-½ percent scale model. This existing model will be used as appropriate for further test development and verification of the carrier/ISINGLASS performance and launch characteristics.

ii. Launch techniques will be developed and substantiated. Various launch conditions (speed, altitude, load factor, fuel loading, etc.) will be investigated.

e. Photographic Performance

Technical suitability of all aspects of the sensor installation will be substantiated. This will include analytical and test effort as well as supporting effort by appropriate consultants.

i. Wind tunnel testing will be conducted to develop the window cavity concept and optimize the cavity design. Geometric details will be varied to optimize cavity and window environment. Testing will determine the effects of Mach number, Reynolds number, angle of attack, boundary layer transition, cavity length-to-depth ratio, and forward and aft ramp shapes. Test facilities will include the Cornell Aeronautical Laboratory.

A 10 percent scale model of the ISINGLASS forward fuselage will be used for wind tunnel development. Testing will be conducted from Mach 10 to 20 plus. Temperature distributions and levels will be established and configuration variations will be utilized to optimize the environment and design. In addition to the wind tunnel testing, thermal testing of components in the M.A.C. laboratory will be conducted.

ii. Backup development testing of an active window cooling system will be experimentally conducted. Wall cooling, edge cooling, and cavity boundary layer cooling by coolant gas injection are available techniques for the control and minimization of thermal gradients. Provisions will be included in the 10 percent scale model, used for the activity described in the paragraph above, for an active cooling system. If early testing and/or analytical effort indicate that the active system would be required, appropriate model testing will be conducted.

iii. Boundary layer effects on photographic acuity will be determined by wind tunnel tests utilizing an appropriate scale model. Test details and instrumentation requirements and design will be finalized by collaboration with a qualified sensor supplier. The Mach test range and similitude required indicates that several facilities may be employed including Cornell and AEDC.

f. Structural Elements

i. Mechanical properties of the roll diffusion bonded type primary structure will be demonstrated by numerous specimen tests at room and elevated temperatures. Variables will include basic core shapes, various types of panel joints, attachments, and repairs, and an appropriate variety of fabrication techniques. Many test specimens will be utilized in this program. Small samples (dimensions of several inches) will be used for bending, shear, compression and tension strength capability tests. Larger panels (dimensions up to several feet) will be used for substantiation of design strength allowables.

A 180 gallon tank constructed of roll bond titanium will also be used for structural tests. This tank has been constructed by M.A.C. as a part of the ISINGLASS corporate sponsored activity to date. The tank dimensions are approximately 4 feet by 3 feet by 3 feet. This tank is of double bubble configuration and includes a longitudinal shear web divider and end bulkheads. Access is provided for installing various cryogenic insulations, inspection, and for repair. In addition to evaluation of structural capability, cryogenic system tests including evaluation of dynamic effects will be performed. The M.A.C. altitude chamber facilities will be used for part of these tests.

ii. External shingle design, producibility, and performance will be substantiated. Testing in the design environment (elevated temperatures, etc.), will be performed. Shingle development will utilize both small specimens (about 6 inches square) and full scale shingles (about 24 inches square). Many development specimens using T.D. nickel, Rene' 41, and titanium will be evaluated. Variables to be assessed will include: type of core, face plate bonding, attachment inserts, sealing, oxidation resistant coating, attachment, and high emissivity coatings.

Approximately ten full scale shingles fabricated in accordance with the selected design and material will be tested to verify and demonstrate the design. Variation in design and testing will verify attachment designs, curved as well as flat shingles, strength characteristics, reusability, life capability and emissivity. Test facilities will include the M.A.C. thermal and altitude laboratories.

Approximately ten full scale columbium leading edge specimens will be provided duplicating the radius and support method to be used. Testing under load at room and elevated temperatures will verify strength properties, installation technique and life characteristics. Reusability and operational lifetime test will include cyclic thermal loading. The M.A.C. plasma jet facility will be used during this test program. This program will also include several columbium panel specimens configured for nose transition and control surfaces to substantiate their suitability in the structural and thermal design environment.

An appropriate number of tests specimens for development and life demonstration of the main landing gear skid will be constructed.

The nose cap will be developed utilizing previous ASSET laboratory and flight results. Element tests to demonstrate capability and acceptability to thermal shock and oxidation resistance will determine optimum choice of material and design. Two full scale nose caps will be utilized in the M.A.C. plasma jet facility to demonstrate design acceptability and reusability.

g. Refurbishment

Analytical and test substantiation of refurbishment requirements will be performed. Significant fall out from this will include maintenance requirements, turn-around time, and operational cost factors.

3. Technology Demonstration $1,660,000

The technology demonstration program will consist primarily of component construction and testing of certain key elements of the Model 192 concept to substantiate and demonstrate a high confidence technology base.

a. Structure

A full scale section, approximately 13 feet in length, including an 8 foot long section of the LOX tank and the LOX/LH2 tank bulkhead, will be designed. Carrier pylon attach points for concentrated load inputs will be included. The dimensions at the aft end of the specimen will be approximately 15 feet wide and 11 feet high and will taper to dimensions of approximately 10 feet wide and 8 feet high at the forward end of the specimen. Subsequent manufacture and utilization of this full-scale article in a follow on program will provide demonstrated assurance of all significant structural characteristics including fabricability. This assurance is provided for the design of each element as well as for the assembled aircraft. This will permit evaluation and verification of the strength properties of the basic structure, propellant storage, precise weights, weight factors, manufacturing techniques, and quality and costs of tooling, fabrication and assembly. This will also verify and demonstrate successful transition from element construction to full scale ISINGLASS hardware.

b. Heat Protection

i. Thermal design criteria will be further analyzed by conducting wind tunnel tests to establish quantitative heating rates and temperature levels. Primary resources provided here are two wind tunnel models. One is a 3 percent scale model to be utilized in establishing the thermal suitability of the configuration. This includes the qualitative heat patterns on the vehicle plus quantitative evaluations of the configuration including hot spots or other unique areas. The second is a 5 percent scale model for the determination of actual temperature levels throughout the speed range for verifications of design environment. This is necessary because of the significant impact of design environment on weight, performance, and cost. It is planned to use at least the M.A.C. hypersonic tunnel for heating pattern tests and the Cornell tunnel for the quantitative test program. A total of three series totaling approximately 200 hours are planned.

ii. The performance characteristics and efficiency of the insulation, water-wick, structural arrangement including the effect of heat shorts, will be demonstrated by testing a sample composite structural panel. These tests will also confirm the performance of the wicking material and coolant distribution and servicing system.

Approximately six full scale composite structural panels will be utilized. They will provide a representative section of the aircraft several feet square with the propellant tank liner, basic structure, water wick, passive insulation, and the outer radiative shingle incorporated. Loading tests in compression, shear, torsion, and bending will be applied. Thermal test to verify stability, shock capability, cyclic life limits and mission spectrum loadings, for life verification will be conducted. Attachment integrity will be demonstrated using flight environments. The thermal isolation characteristics will be verified by tests including repeated exposure to design environment.

Water wicking development will include a large structural panel with the water distribution system incorporated to verify the performance of the water blanket system. Dynamic properties of the system (vibration and accelerated loads) will be established. These tests will include testing in the M.A.C. laboratory. Further demonstration of the performance of this system will be furnished by test results from the full scale fuselage test section.

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iii. Physical properties and thermal performance of internal insulation will be established by testing promising materials as insulators for the high temperature structure and cryogenic tanks. This work represents the selection and experimental evaluation of candidate materials for passive insulation application. Samples will be tested to establish thermal performance, compatibility, ease of handling, durability,producibility and life characteristics. The best materials derived from the element tests will be utilized in the larger composite test articles.

c. Manufacturing

Evaluation of promising structural fabrication concepts will be continued to develop the best manufacturing methods for the selected materials. This will include fabrication of panels with various geometric configuration and attachment details. Welding and stress relieving methods will be evaluated. Non-destructive inspection and quality control techniques will be developed. These activities and data will establish a solid basis for optimizing manufacturing time and cost parameters.

d. Cryogenics

The performance of the cryogenic systems will be demonstrated. This will include testing to confirm boil-off rates, stratification, transfer-rates, and ullage. Propellant dynamics will be determined by appropriate scale model tests. Results will define those key characteristics necessary for best tankage design.

While available analytical techniques are quite advanced and in some respects well substantiated, a significant amount of experimental cryogenic work is planned to identify items and considerations pertinent to ISINGLASS, including verification of materials selected and fabrication techniques. The 180 gallon, double bubble, diffusion bonded test tank will be utilized for numerous propellant transfer and storage tests with a wide spectrum of environmental design conditions imposed. Many typical lines and components will be evaluated.

A small scale tankage model duplicating the internal geometry and volume distribution of ISINGLASS will be made to conduct verification tests of propellant volumes and attitude sensitivity plus quantitative testing for establishing dynamic load effects with various propellant levels.

4. Cost and Schedule Substantiation*

A primary objective will be to develop a high confidence base for cost and schedule performance. These analyses will utilize the results of the element investigations conducted in the previously delineated tasks and will use prior McDonnell experience in the design, development and production of advanced aircraft and spacecraft systems, ramjet and boost-glide vehicles. Particular attention will be applied to systems involving first generation concepts.

a. Engineering Cost Factors

Technical and cost data generated during this program will provide a base for evaluating engineering design and development cost. Trade-off studies will be used to optimize development solutions.

b. Manufacturing Cost Factors

Experience derived from construction of representative panels and test sections will provide data for developing manufacturing cost factors and refining program estimates. Comparative cost criteria will be used to select the most effective manufacturing methods and best materials.

c. System Cost

Initial cost estimates for the complete system will be progressively refined as the system design and operational requirements are defined. These

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*The cost of these items is included in the costs quoted for the previous paragraphs.

estimates will be frequently revised to maintain an up-to-date program cost picture.

Estimates based on historical and statistical data will be cross checked with detailed staffing and material requirements developed during this program.

d. Schedule Analysis

A master program schedule for the flight vehicle and supporting systems will be refined and updated as results of this research and development program become available, to a level of detail and definition that gives high confidence of achieving the major program milestones. Subsidiary schedules will be maintained for major subsystems. Analysis of detail schedules will encompass outside development and production of both CFE and GFE subsystems. Coordination meetings will be conducted by McDonnell as Program Manager and will provide necessary interchange of data pertinent to the detailed elements of the schedule so as to assure that all significant effects are included in the overall planning.

5. Reviews and Documentation

Progress and results of program effort will be presented in concise form at frequent intervals as shown in the schedule. Reviews and documentation will consist of:

a. Bi-monthly program reviews at McDonnell in which all significant milestone accomplishments and program decision elements will be presented. These will be supplemented with informal reviews of all program activities.

b. A final summary type report containing all program accomplishments.

6. PROGRAM SCHEDULE

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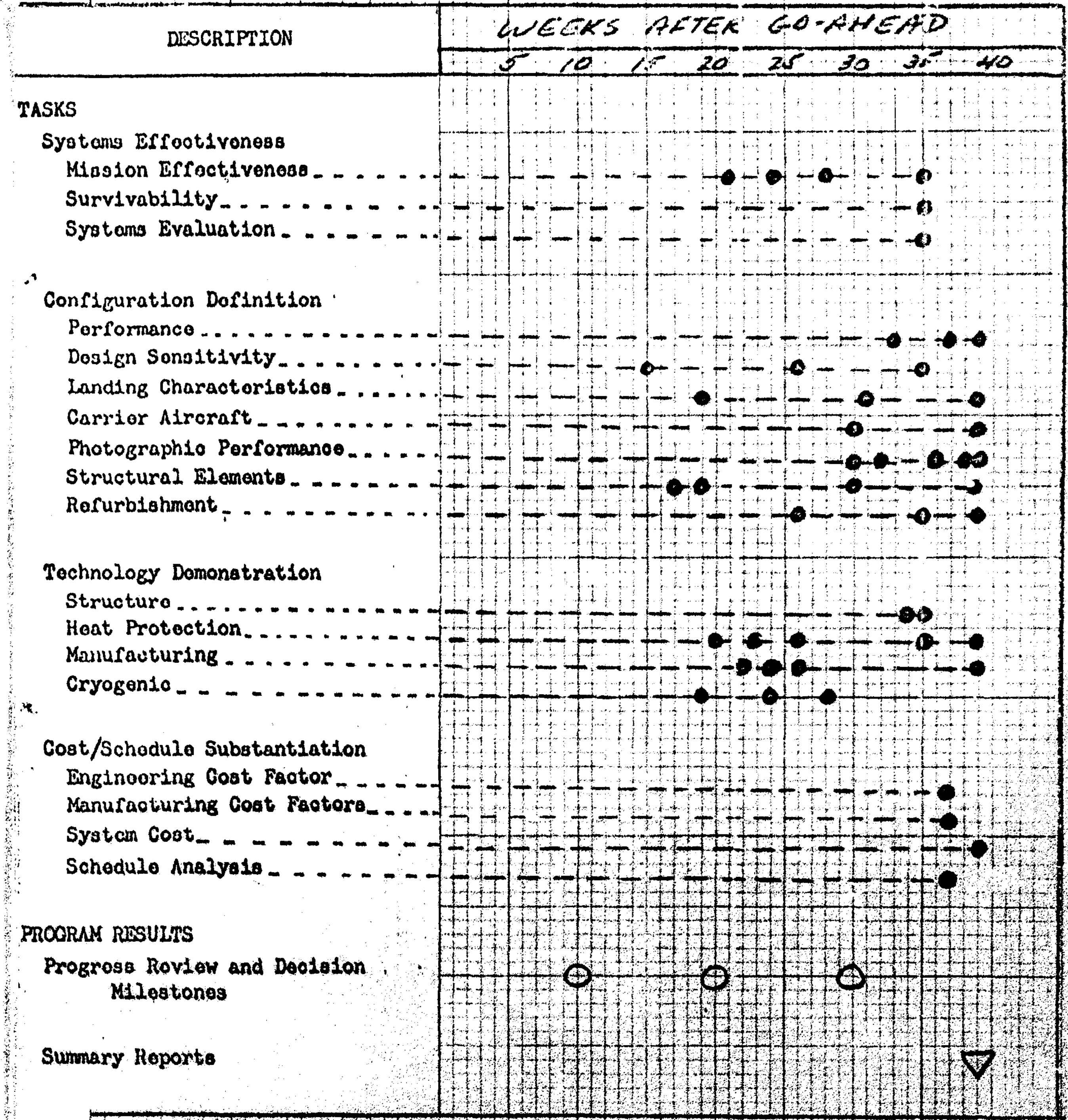

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KEY TO PROGRAM SCHEDULE

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B. Camera Studies

1. Internal Turbulence	$118,000

Tests and analysis will be conducted to evaluate the effects of the internal turbulence generated by the heated window. In conjunction with the window tests below, this will allow reasonable balance in window design between degradation from window distortions and degradation from internal turbulence.

2. Window Gradient Tests and Boundary Layer Effects	$32,000

These tests will evaluate the degrading effects of window gradient and means of reduction of this degradation, using wind tunnel data for evaluation of heat flux distribution. Current estimates are that the window will be the limiting factor on ground resolution. In conjunction with M.A.C., the effects of the boundary layer on optical performance will be evaluated. Current estimates of boundary layer effects, considered negligible, are based on extrapolations of existing data at relatively low speeds and altitudes.

The above three efforts, at a total of $150,000 can best be done by Perkin Elmer, who have done extensive preliminary work, and are leaders in this field.