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CENTRAL INTELLIGENCE AGENCY

WASHINGTON 25, D. C.

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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. <u>System Effectiveness</u>: 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. <u>Configuration Definition</u>: 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 . . .

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GROUP 1
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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 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 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.

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.

Attachment to
BYE-2100-66

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

*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

DESCRIPTION

TASKS

Systems Effectiveness
- Mission Effectiveness
- Survivability
- Systems Evaluation

Configuration Definition
- Performance
- Design Sensitivity
- Landing Characteristics
- Carrier Aircraft
- Photographic Performance
- Structural Elements
- Refurbishment

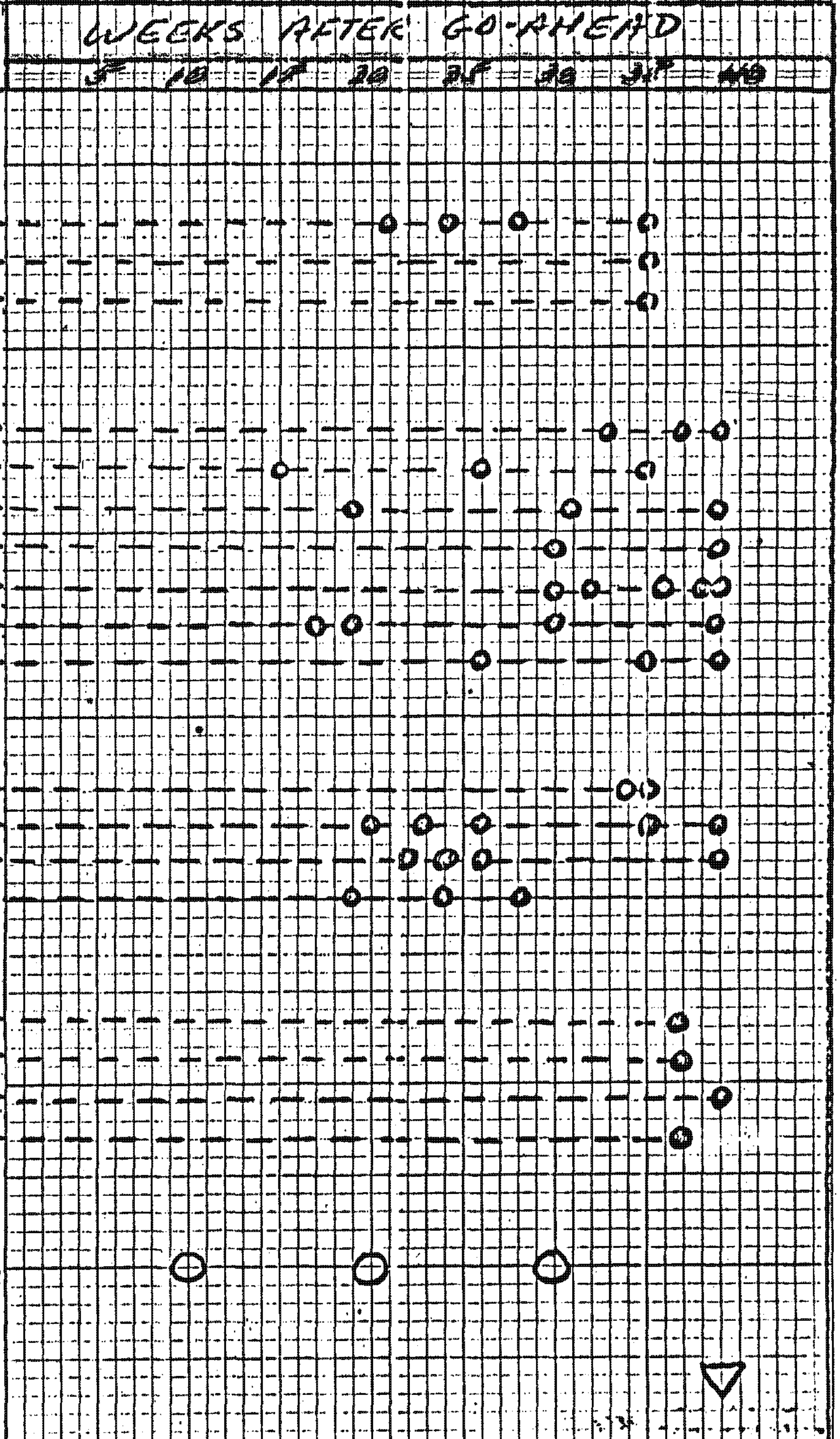
Technology Demonstration
- Structure
- Heat Protection
- Manufacturing
- Cryogenic

Cost/Schedule Substantiation
- Engineering Cost Factor
- Manufacturing Cost Factors
- System Cost
- Schedule Analysis

PROGRAM RESULTS

Progress Review and Decision Milestones

Summary Reports



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Attachment to
BYE-2100-66

KEY TO PROGRAM SCHEDULE

	WEEKS FROM GO-AHEAD
CONTRACT GO-AHEAD	--
Mission Effectiveness	--
1. Operations Plan	21
2. Targeting Analysis - Scenario I	24
3. Targeting Analysis - Scenario II	28
4. Targeting Computer Program	35
Survivability	35
Systems Evaluation	35
Performance	--
1. Lift/Drag Ratio Established	33
2. Flying Qualities Established	37
3. Flight Envelope Established	39
4. Operational Performance Established	39
Design Sensitivity	--
1. Weight Sensitivities	15
2. Performance Sensitivities	--
3. Sensor, Engine, and Equipment Install. Verified	26
4. Vehicle Size and Shape Defined	35
Landing Characteristics	--
1. Visibility Techniques Defined	19
2. Low Speed Lift/Drag Ratio Established	30
3. Landing Techniques Established	39
Carrier Aircraft	--
1. Performance Summary	30
2. Launch Techniques Defined	39

HANDLE VIA BYEMAN
CONTROL SYSTEM

Attachment to
BYE-2100-66

	WEEKS FROM GO-AHEAD
Photographic Performance	--
1. Cooling System Analysis	30
2. Boundary Layer and Shock Flow Field Characteristics Defined	32
3. Cooling System Performance Verified	36
4. Boundary Layer Effects Determined	38
5. Window Cavity Configuration Defined	39
Structural Elements	--
1. Roll Bond Mechanical Properties Verified	17
2. Nose Cone Material Properties Defined	19
3. Alternate Structural Concept Analysis	30
4. Shingle Characteristics Completed	39
Refurbishment	--
1. Initial Maintenance Requirements Defined	26
2. Refurbishment Quantities Defined	35
3. Material Replacement Schedule Established	39
Structure	--
1. Producibility Studies Complete	34
2. Structural Section Engineering Complete	35
Heat Protection	--
1. Initial Water Wick Efficiency Test	20
2. Initial Cryogenic Insulation Efficiency Test	23
3. Water Wick/Structural Element Development Test	26
4. External Heat Transfer Rates Defined	35
5. External Temperature Levels Defined	39
Manufacturing	--
1. Roll Bond Development Completed	22
2. Inspection Techniques Defined	24

	WEEKS FROM GO-AHEAD
3. Repair Fabrication Techniques Verified	26
4. Shingle Fabrication Techniques Verified	39
Cryogenics	--
1. Initial Volume and Ullage Analysis	19
2. Initial Insulation Qualities Defined	24
3. Initial Cryo. System Helium Press. and Trans. Tests	28
Engineering Cost Factors	37
Manufacturing Cost Factors	37
System Cost	39
Schedule Analysis	37

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.

	TAGBOARD	ISINGLASS	S-103[1]	S-104[2] AIR LAUNCHED (BG-1A)	AIR LAUNCHED (BG-2A)	GROUND LAUNCHED (BG-1G)	S-
Payload Weight	420	1545	500	500	500	500	500
Payload Resolution	1'-1.5'	1'	4-6'	4-6'	4-6'	4-6' *	4-6
Range	3000	7000	Orbital	Orbital	7000	Orbital	3-4,0
Altitude over Target	80-95,000'	205,000' descending to 125,000'	60-80 NM	60 NM	60 NM	60 NM	95-110
Speed	M 3.3	M 21 slowing to M 7	Orbital	Orbital	25,500 fps	Orbital	M 4.0
Vehicle Weight	—	25,450	1080	4340	6800	4340	5500
Launch Vehicle	Modified A-12	B-52	B-52	B-52	B-52	Titan II	B-58
Total Launch Weight	--	132,770	73,650	90,000	96,500	--	9400
Propulsion	Ramjet (MA20S-4)	LOX-H_2 (New)	Minuteman II/ AJ 1041	J-2/ Centaur	J-2/ Integral Agena	Titan II	Ramjet Skyboi
Development Cost[4] (Millions)	80[5]	570	200	267 ✓	~~238~~ 283	115 ✓	45
Development Time (Months)	IOC Nov 66	48	24	46	46	44	24

(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.

(5) Includes 14 operational vehicles

	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'-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
ht	--	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
4)	80 (5)	570	200	~~267~~ ✓	~~838~~ 283	115 ✓	45
	IOC Nov 66	48	24	46	46	44	24

aunch Reconnaissance Satellite

Glide Vehicle

uspect of being far too low.

operational vehicles

Approved for Release: 2017/01/25 C05096211