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Preliminary Project FULCRUM Phase I Tasking

1. Phase I of Project FULCRUM is intended to demonstrate clearly and decisively the feasibility of the FULCRUM Photo Satellite Reconnaissance System. The duration of Phase I will be approximately six months with all final reports delivered to the contracting agency by 31 December 1965. At this time the results of Phase I will be carefully reviewed by all agencies and committees concerned, and a decision will be made to commit funds for hardware or to terminate the program.

2. During the course of Phase I there will be substantial participation by personnel of the contracting agency, and therefore, the five tasks outlined below should not be regarded as final and all inclusive.

Task I: Film Handling Feasibility Studies

Detailed engineering study of alternative approaches to the FULCRUM film handling problem. This will include examination of both the constant film velocity approach as well as the accelerated film approach.

The most promising constant velocity and the most promising accelerated film approach will be built in prototype and instrumented so as to provide a feasibility demonstration and performance evaluation. The prototypes will include the film drum rotation and translation mechanizations for matching v/h over a 120 degree scan angle. The prototypes will be designed for v/h ranging from .06 rad./sec. to .035 rad./sec.

In the case of the constant velocity approach requiring film indexing, the various methods of indexing should be experimentally evaluated and a preferred method selected. A careful study should be made of the reliability and practicality of the film reversing operation. Careful attention should be payed to minimizing film wastage and the trade off between startup

power and minimum time for an off-on cycle.

In the case of the accelerated film approach, an evaluation of wasted film due to degraded imagery should be made. Also, the feasibility of using an interrupted scan mode of operation should be studies. The problem of additional programmer complexity should also be examined in this context.

At the conclusion of the six month program, a detailed evaluation report on each of the two prototypes will be delivered. This report will include the following:

a. The results of experiments designed to measure the film velocity errors.

b. A statistical estimate of image degradation due to film velocity error.

c. The results of environment chamber tests designed to examine high speed film handling problems (such as corona discharge) at operational gas pressures.

d. The results of experiments with Kodak Type 4404 7" film designed to test the two prototypes for film damage (scratching, etc.).

e. A summary comparison of the two prototypes including operational considerations and estimated reliability.

Task II: Camera Dynamics Studies and Engineering Test Mock-Up

A detailed analytical study of the camera dynamics. Particular emphasis should be placed on:

a. Bearing, loading, and gas requirements during both prelaunch testing and in flight operation.

b. The perturbations to camera rotation caused by spacecraft torquing.

c. Effects of start-up transients - - - particularly film supply and takeup spools.

d. Effects of c. g. shifts due to film movement.

In addition to the above analytical studies, a full scale single camera mock-up will be designed and built. The design effort should include a survey of past experience with large air bearings of this type, particularly under near vacuum environmental conditions. The primary purposes of this mock-up will be to test air bearing operation under operational environmental conditions, and to test and evaluate the performance of the slip rings that provide electrical coupling between the optical bar and the space craft. These tests will include start-up and stopping as well as steady-state operation. To this end, the weights and balances of the mock-up should be as realistic as possible, consistant with the prevailing stage of the camera design.

A secondary purpose of the mock-up tests will be to instrument for vibration measurements insofar as they are deemed useful and feasible.

The product of this six month effort will be a detailed report covering the analytical studies outlined above, and a second report covering the mock-up design and experimental results. This second report should include an extrapolation of the test results to free fall conditions, as well as an examination of the launch loads problem. The mock-up experiments should be sufficiently detailed and definitive to permit immediate engineering design of a high confidence bearing and slip ring configuration.

One of the reports should include a summary section discussing the estimated effects on image quality due to gross camera dynamics (not including film velocity air effects).

Preliminary Project FULCRUM Phase I Testing

Task III: Optical Design

A two to three month effort leading to a final FULCRUM optical system design. The design should be carried to preparation of fabrication specifications.

In addition to the engineering specifications, a report will be prepared discussing the essentials of the design and the reasons for image degradation, both on and off axis. This report will include an optical element weight estimate.

If particular elements of the optical system appear to present basic feasibility problems, this study may phase into a three to four month critical component fabrication and test phase. In any case, this task must be completed and reported on by the end of Phase I.

Task IV: Facilities Study

A five month study to identify additional facilities required for the support of the FULCRUM program. Detailed specifications for these facilities will be developed so that, on release of funds, procurement of equipment and facility construction can proceed without delay. This planning should include facilities for dynamic performance measurement of the completed camera system under operational environment conditions. By the end of the five month period, a summary document should be prepared outlining the justifying arguments for the various recommended facilities, including cost and scheduling information.

Task V: Design and Engineering

A detailed camera design effort to be coordinated with the film handling and engineering test mock-up tasks. This is a six month program, involving detailed component and sub-system engineering with the following major goals:

a. Support of the film handling prototype and camera mock-up tasks.

b. Preparation by the end of month two of an interface document to be used by companies involved in the space vehicle competition.

c. A six month report summarizing the engineering effort to that date emphasizing weight, power, and thermal considerations.

While the main purpose of this task is to arrive at firm weight and power numbers, the work should be organized so as to minimize additional design and engineering effort required when funds are released for camera procurement. To this end a full scale design mock-up should be built with all sub-systems in place. This mock-up is intended both to demonstrate packing feasibility and to aid in final design and fabrication.

This task will also include some additional study of alternative camera configurations. This work will be concentrated during the first month of Phase I and may include preliminary weights and power estimates. Work will proceed in close coordination with the contracting agency. Specific reporting requirements will be worked out as necessary.

Task VI - Program Analysis

A continuing analysis of the Phase II program from the point of view schedules and lead times. This effort will lead to a definitive program schedule for Phase II by the end of Phase I. During the course of Phase I any long lead items that may pace phase II should be identified as they emerge.