CENTER ROUTING SLIP

FROM	DATE
OSP	8/24/70

TO		INITIALS	DATE
DIRECTOR			
DEP/DIRECTOR			
EXEC/DIRECTOR			
SPECIAL ASST	1	M	8/24
ASST TO DIR			
HISTORIAN			
JJH	2	[illegible]	8/31
CH/PPBS			
DEP CH/PPBS			
EO/PPBS			
CH/IEG			
DEP CH/IEG			
EO/IEG			
CH/PSG			
DEP CH/PSG			
EO/PSG			
CH/TSSG			
DEP CH/TSSG			
EO/TSSG			
CH/SSO/TSSG			
PERSONNEL			
LOGISTICS			
TRAINING			
RECORDS MGT			
SECURITY			
FINANCE			
DIR/IAS/DDI			
CH/DIAXX-4			
CH/DIAAP-9			
CH/SPAD			

REMARKS

1-2 FYI

The attached draft paper was left with Sandy + Hank H. by Les Dirks at their meeting on 18 Aug. It relates to the EOI simulation work we will be doing in conjunction with OSP.

IP FM 30 (12-69) - OBSOLETE PREVIOUS EDITIONS

16 May 75

EOI/G-3 IMAGE QUALITY PERFORMANCE COMPARISON STUDY PLAN

Purpose

The purpose of this document is to describe the program plan for a study of the comparative image quality performance of the EOI System now under development and the existing Gambit-3 System. This plan has been developed and is submitted for review at the request of the National Reconnaissance Office.

Study Objective

The objective of the planned study as presented herein is to provide preliminary but meaningful assessment of the comparative image quality performance of various EOI System design configurations and the image quality performance of the current Gambit-3 System under comparable imagery conditions. The study is intended to compare only the image quality performance of these two Systems under best conditions, that is, nadir viewing, clean near optimum camera and atmosphere and sensor operations. It specifically excludes considerations of mission analyses and performance distributions. It is anticipated that the results of this study will provide significant support to the government decision-making process within the structure of the National Reconnaissance Program, particularly in the area of Electro Optical Imaging Readout and its impact upon

future Satellite Photographic Reconnaissance System mixes.

Approach

The basic approach to this image comparison problem is to generate simulated EOI System imagery and compare this imagery to actual Gambit-3 photography, using proven psychophysical techniques for image evaluation and trained photointerpreters from the NPIC. The simulated EOI System imagery will be generated using very high resolution silver halide input transparencies and the facilities of the Perkin Elmer Line Scan Image Generator (LSIG)

Simulation

A key element in this study plan is the utilization of the EOI System image simulation capability which has been developed by this office at the Perkin-Elmer Corporation. To date this simulation capability has provided several hundred sampled images demonstrating the effects of various EOI System imaging parameters and functions including ground sample dimension, signal to noise ratio, bandwidth compression, and data processing. These images, coupled with the appropriate analyses, have provided much critical information relating the design of a sampled image system to the derivable image quality over a wide range of system design and operating requirements.

The fundamental feasibility of the simulation technique derives from the ability to specify those parameters which contribute to the generation of a sampled image (regardless of its source) and the ability to manifest the effect of these parameters in an actual hard-copy image by means of uniquely designed hardware and software. Previous work in this area and laboratory verification of the simulation has attested to the validity of the technique.

The LSIG is basically a ~~relatively~~ large-scale, image dissector and reconstruction device which slowly scans a specially prepared high-resolution input transparency and operates on the resulting waveform in a manner which effects the modulation transfer function operation of the sampled imaging system to be simulated. It then converts the modified analog signal to a discretely sampled digital data matrix, processes this data, and reconstructs the processed matrix as a continuous-tone transparency suitable for viewing and interpretation.

In addition to details on the operating characteristics of the LSIG, a full ~~distribution~~ description and results of a rigorous calibration of the end-to-end simulation process are available in Perkin-Elmer report SPO and will be supplied upon request.

Plan Summary

As noted above, the essence of the study program is to select

ground target areas previously photographed from orbit by the Gambit-3 System under near optimum photographic conditions, acquire very high resolution, low grain noise silver halide transparencies of precisely the scene target areas under similar photographic conditions, use these transparencies to generate the appropriate EOI System simulation imagery, and conduct an experimental comparative analysis of the resultant imagery from both Systems. The photoevaluation experiment will be planned and conducted under the supervision and guidance of the NPIC in conjunction with other recognized authorities in the field of photographic evaluation and analysis. The data from these experiments will be analyzed and compiled in a Final Report. This report will be coordinated with the appropriate government agencies and submitted to the NRO.

Figure 1 depicts the functional plan of activities required to meet the stated objective. A schedule and milestone for the Program is given in Figure 2. It is intended to provide preliminary results early in November 1970 with a final report to follow within one month.

The total cost of the program to the government is approximately [redacted] exclusive of government agency support costs

A more detailed accounting of the significant cost items is given in Table 1.

Discussion

The following discussion presents some of the more pertinent details and rational for the various activities outlined in Figure 1.

A) An experimental planning function initiates the program. This planning takes into account the nature and objectives of the overall experiment, including schedule and cost. A primary consideration in this planning is the establishment of selection guidelines for the Gambit-3 material. Because of the very limited schedule, it has been decided to use existing photography having the appropriate scene object and spatial frequency content and taking conditions to allow the development of meaningful interpretation and evaluation exercises.

To assist in this effort, the resources of both the NPIC and Human Factors Research Corporation are being used. A dedicated interface with the NPIC for this program has been established and discussions have been held with Dr. Donald Buchner of HFR.

B) The selection of G-3 photography for this study has been made at NPIC by representatives of this office. The

basic criteria used in the selection process required that the G-3 photography be acquired from Domestic Operations, with clear atmosphere, and near nadir conditions. In order to assure the use of outstanding examples of G-3 quality, the MIP (Mission Info Potential) frames for the several "best" G-3 missions were searched; in addition, other frames from these missions exhibiting a very high level of image quality were assessed for useful target scene content. An additional requirement, imposed by schedule/cost considerations was that the frames selected be of geographic areas located within the mid-West portion of the U.S. The process resulted in the following selection of G-3 photography:

Mission	Rev	Frame	Location
4320	142	003	Kansas City, Kansas
4321	095	826	Tullahoma, Tenn
4322	047	030	St Louis, Missouri
4322	047	032	Little Rock, Ark
4327	031	054	Springfield, Ill
4327	031	055	St Louis, Missouri

These frames represent a range of solar elevation conditions from 27° to 57°. Positive transparencies of the

target points are being generated by NPIC for use in the photoelevation task.

C) In order to proceed with the further scene acquisition activities it was necessary to determine the key EOI System related parameters to be input to the simulation, particularly the GSDs and SNRs. These two parameters, when combined, dictate the scale of the input transparencies to be acquired. On the basis of previous sampled imagery quality studies and the type of information required from this study, it was determined that the appropriate GSDs for the comparative study are [redacted] The SNRs at each GSD are 3:1 and 5:1. In addition, modulation transfer functions for each of the EOI System image chain functional elements have been defined.

D) The GSD and SNR of the anticipated simulations require that the scale of the input scene transparency (original negative) be sufficiently high so as to constrain the grain noise of this material to experimentally tolerable levels. The ususal photographic trade was made between film granularity, film speed, exposure time, smear, dynamic range, etc. to define the acquisition specifications. A 12" Zeiss lens at f/4 was

selected. The camera has a 9 inch format and a forward image motion compensation mechanism. The minimum acquisition altitude to be used will be approximately 500 ft. This scaling will permit, as a minimum, the generation of a [redacted] The granularity requirements of all other imagery sets (GSD/SNR) are less stringent.

The camera will be flown in a PC-6 Helioporter under contract to Data Corp., Dayton, Ohio. Data Corp. will also be responsible for the photographic processing of the original negative.

E) To ensure the timely availability of at least a first set of useful input transparencies, Data Corp. has been directed and funded to overfly and photograph the selected target areas as soon as possible. In each target area, a set of specific target points have been identified. (A non-critical limitation imposed by the simulation technique is the restricted image size. In general, the simulated image formation is restricted to approximately 400 feet by 400 feet.) Completion of this scene acquisition task is obviously highly dependent upon prevailing weather conditions. Solar

elevation requirements also severly constrain this operation, thus adding greater impetus to the need for early initiation.

F) Upon completion of the acquisition flights, the film is processed under controlled conditions. Sensitometric step tablets are exposed on the head and tail of the film roll. The goal of the processing is to maintain unity gamma over the maximum available exposure dynamic range. These ONs are then submitted to Perkin_Elmer, where enlarged positive transparencies of the appropriate scale are produced for running on the LSIG.

The modulation transfer functions of the enlarged transparencies are measured by means of the P-E Edge Gradiant Analysis capability. These MTFs are measured at various positions and orientations on the scene transparencies. Granularity measurements are made directly on the LSIG using the sensitometric density steps.

G) The EOI System related modulation transfer functions and the modulation transfer functions of the input transparencies are combined and the results used to specify the characteristics of the read mask parameters. The ~~maks~~ masks are built on photographic plates and tested by microdensitometric techniques.

H) The enlarged transparencies are placed on the LSIG and scanned with the appropriate mask. The scanning parameters are adjusted to simulate the required GSD. In addition, the sensitometric step tablets are scanned and data is obtained for calibration. This calibration data relates the digital values of the simulated transducer outputs to the original ground brightness values.

I) The digital data values recorded during the scanning operation is computer processed to introduce the appropriate noise levels and to effect a degree of modulation transfer function compensation processing. This compensation processing is based upon the known system degrading elements and is conducted in an interative fashion to generate an "optimum" processed image in the presence of noise.

J) The EOI System simulation images are reconstructed on the LSIG using a reconstruction or write mask. This mask produces a pyramid-shaped intensity distribution around each sampling point in the reconstructed image. These reconstructions are scaled and a series of positive transparencies are produced photographically for use in the photoevaluation task.

K) The photoevaluation experiment task is conducted under the guidance and supervision of the NPIC in conjunction with the Human Factor Research Corp. The photointerpretation of the images is accomplished by trained professional photointerpreters from the joint CIA/DIA Image Exploitation Group at NPIC. The imagery used is presented to the P. I. 's in compatible scale "chip" form for convenient use with conventional B&L photomicroscopes. Standard photointerpretation control procedures are provided. The specific evaluations include judged interpretability detail analysis, and measurement precision.

L) The data acquired from the photoevaluation experiments is processed and reduced using well-known statistical procedures at the facilities of HFR. The resultant data is analyzed and conclusions are formulated. An interim report, consisting of the basic raw results and minimum of imagery is prepared and submitted to the appropriate agencies and groups for coordination and concurrence. Minority gx reports, if any, are prepared and reviewed at this time.

M) A final report describing the complete experimental procedure, interpretation results, all imagery and conclusions, is prepared and submitted to the National Reconnaissance Office.

FIGURE 2

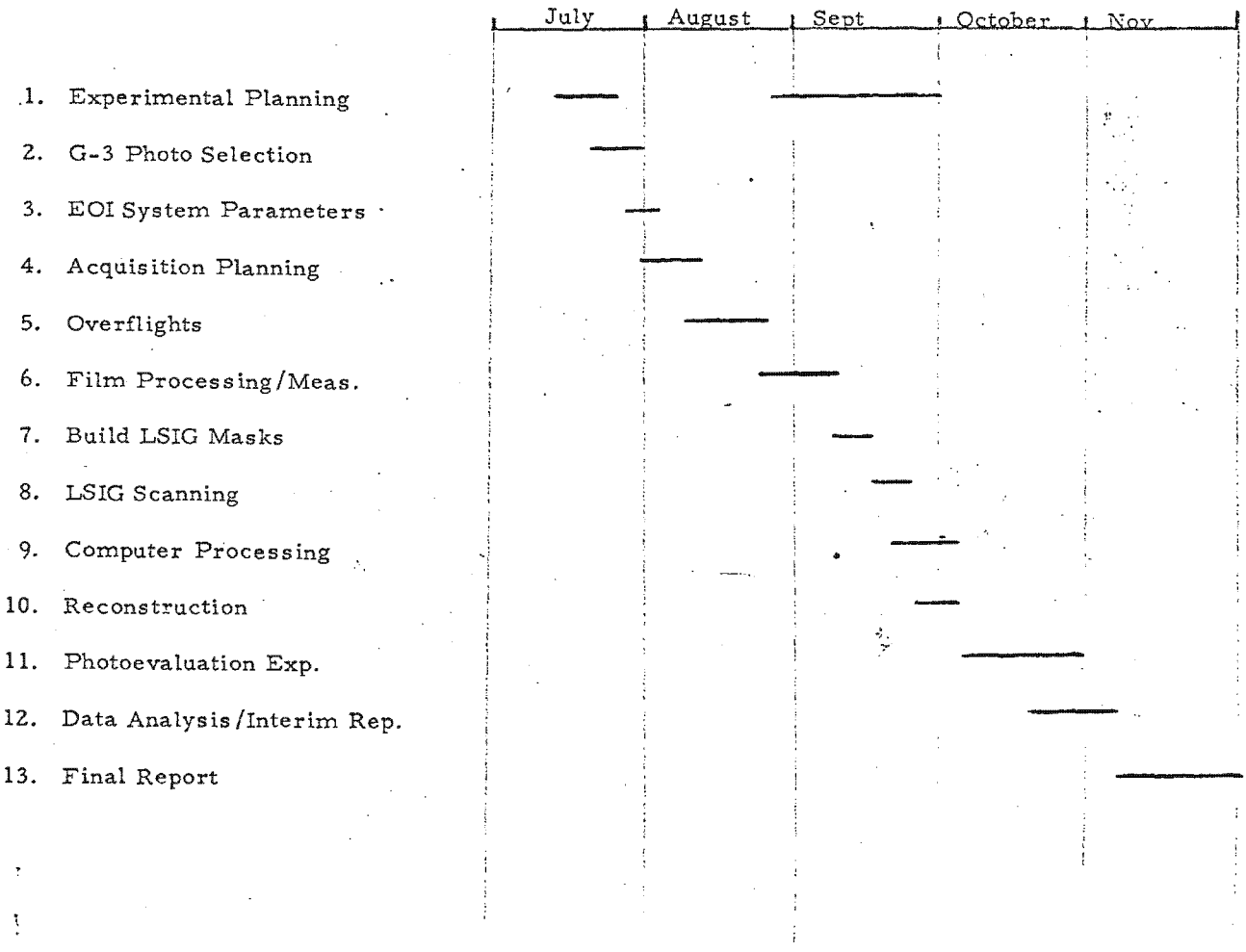

FIGURE 1