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NASA/ESA CV-990
SPACELAB SIMULATION

FINAL REPORT

APPENDIX A — THE EXPERIMENT OPERATOR

A JOINT ENDEAVOR BY
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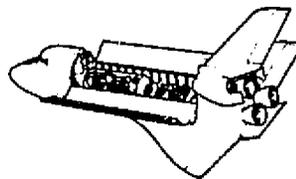
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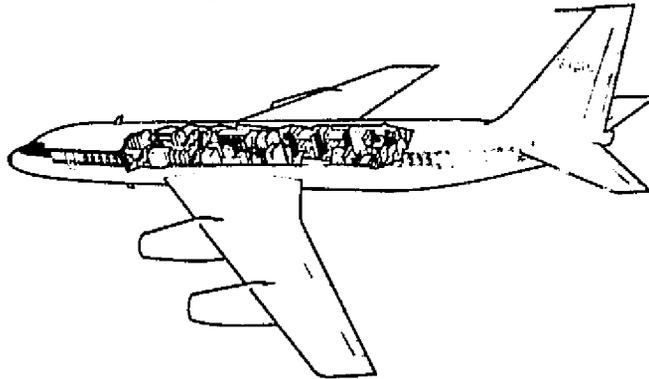
by

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16. Abstract

As a result of interest in the application of simplified techniques used to conduct airborne science missions at NASA' Ames Research Center, a joint NASA/ESA endeavor was established to conduct an extensive Spacelab simulation using the NASA CV-990 airborne laboratory. The scientific payload was selected to perform studies in upper atmospheric physics and infrared astronomy with principal investigators from France, the Netherlands, England, and several groups from the United States. Two experiment operators from Europe and two from the U.S. were selected to live aboard the aircraft along with a mission manager for a six-day period and operate the experiments in behalf of the principal scientists.

This appendix discusses the experiment operators and their relationship to the Joint Mission under the following general headings: selection criteria, training programs, and performance. The performance of the proxy operators is assessed in terms of adequacy of training, amount of scientific data obtained, quality of data obtained, and reactions to problems that arose in experiment operation.

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INTRODUCTION

Beginning in the 1980 time period, an advanced space transportation system will be used to conduct experiments in the space environment. This system will consist of a laboratory (Spacelab) carried into orbit by the reusable Space Shuttle. The pressurized Spacelab module provides a shirt-sleeve environment in which up to four payload specialists can operate experiments using the basic resources provided by the laboratory. Spacelab is being developed and constructed in Europe under the direction of the European Space Agency (ESA). The Space Shuttle Orbiter is being built by the United States under management of the National Aeronautics and Space Administration (NASA).

The Joint Mission

Similarities between the method of experiment accommodation and operations planned for Spacelab and the methods used in conducting experimentation aboard aircraft by the NASA-Ames Airborne Science Office (ASO) led to NASA-ESA Joint Mission, the sixth mission in the ASSESS (Airborne Science/Spacelab Experiment System Simulation) program. Six experiments were selected for the mission: three from Europe and three from the United States. The simulation mission took place at the NASA-Ames Research Center, Moffett Field, California, USA, between April 30 and June 24, 1975.

Spacelab payload manpower will be limited to a maximum of four, which means that payload specialists often will be acting as proxy operators for principal investigators (PIs). To test the concept of proxy operation, four experiment operators (EOs) were selected and trained on the six experiments. During the simulation period, the EOs performed all experiment operations, including data taking, normal servicing, and minor repairs. For the entire simulation period, the four EOs and the Mission Manager were confined to the aircraft and an adjacent sleeping area. All communications with the outside world during the simulation period were handled by communications links (audio and video) simulating those planned for Spacelab. Scientific data were taken on all flights.

Mission preparations, operations, and results are documented in a final report (ref. 1) and five appendixes. Information for these documents was gathered from several sources: the records of a team of observers who flew on all flights and observed mission activities in detail, mission operational records, mission planning documentation, information prepared by the PIs and EOs, an extensive debriefing following the simulation period, and individual interviews with mission participants.

Mission Objectives and Guidelines

The overall objective of the Joint ASSESS Mission was to evaluate a simplified management and implementation concept for conducting Spacelab-like experiment operations. The following were subordinate mission objectives:

1. To experience involvement in international cooperative payload activities
2. To evaluate experiment design approaches for Spacelab experiments
3. To determine the impact of operational requirements and procedures on Spacelab design

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4. To evaluate payload and mission operations
5. To assess techniques for smooth integration of experiments and equipment
6. To analyze factors affecting selection and training of payload specialists, particularly in proxy experiment operation.

The joint ASSESS Mission also served to encourage the development of a cadre of potential Spacelab experimenters. The mission did not address physiological or psychological factors.

The mission guidelines were designed to ensure a high degree of realistic simulation given the capabilities of the CV-990 aircraft, ASO practices, and the requirements for Spacelab as stated about one year before the ASSESS mission. The complete guidelines are provided in the Mission Operating Plan (appendix E) and are summarized below:

1. Authentic science to be performed
2. Six basic experiments to be operated (three European, three U.S.)
3. Ames ASO practices to be used as starting point for mission planning and execution
4. Participation of PIs in overall mission to be maximized
5. Four EOs (two European, two U.S.) to operate experiments in proxy role (i.e., on behalf of the PIs)
6. Simulation period to cover 5 days with a data flight each 24-hr period (experiments operated by EOs), with EOs and the Mission Manager confined to vehicle and living quarters
7. Unconstrained flights to be conducted for 2 weeks following the simulation period (experiments operated by PIs)
8. All supporting equipment, tools, and spare parts to be carried on board
9. Spacelab subsystems to be simulated where possible
10. Use of experiment support equipment to be shared
11. Communication to be limited to one video downlink, two 2-way voice links.

Mission Management

Basic guidance for the mission was provided by the seven-member Mission Planning Group (MPG), which comprised representatives from both NASA and ESA Headquarters organizations and from the Marshall, Johnson, and Ames NASA centers. Six planning sessions were held between May 1974 and May 1975 at which the MPG set the schedule, ratified the selection of experiments and EOs, developed the mission guidelines, and checked the status of the mission at all critical points.

The Mission Manager, from the ASO, was the single point of contact for all negotiations, deci-~s, and assistance in carrying out the mission from inception to completion. With the aid of one ~e assistant, he implemented the directives of the MPG; communicated with the PIs relative ·mission responsibilities; and handled all detailed planning of experiment integration, flight o̧ ...ons, and support activities.

This volume is the first of the five appendixes to the final report. This appendix addresses the subject of the experiment operator, his training, and his performance. Detailed operating procedures for each experiment are included to indicate the scope and complexity of tasks the EOs were expected to perform.

EXPERIMENT OPERATOR SELECTION

The four experiment operators (EOs) for the Joint Mission were recommended by NASA and

ESA and approved by the Mission Planning Group (MPG). The following general criteria governed EO selection:

1. Two U.S. and two European EOs were selected
2. Selection of European EOs was an ESA responsibility, performed under the direction of the European member of the MPG
3. Selection of U.S. EOs was made directly by a designated subpanel of the MPG
4. EO candidates were capable of conducting normal research programs planned by the PIs
5. EO backgrounds together should cover a broad spectrum of experience to permit an analysis of the training and background experience required for satisfactory EO performance.

The European EOs had been selected by September 1974. The selection of U.S. EOs was not finalized until March 1975. Biographies of the EOs selected are given in appendix A-1.

U.S. Operators

In September 1974, two U.S. scientists were recommended for EO positions by one of the NASA HQ members of the MPG. One of the initially selected U.S. EOs was an experienced experimenter in the field of IR astronomy. He has flown more missions on the ASO Lear Jet than any other experimenter and now flies on the C-141 AIRO. After considering the degree of involvement, however, he withdrew from the program in November 1974. After an extensive search, a replacement was selected in February 1975. This scientist, an atmospheric physicist, also had airborne science experience, having flown on an earlier CV-990 mission.

The second of the EOs initially approved by the MPG, a scientist/astronaut at NASA-JSC, participated in the first Lear ASSESS mission as an observer and copilot. In this case, JSC withheld final approval until March 1975, at which time an alternate selection from JSC was approved by the MPG. The individual ultimately selected was an astronomer who had previously specialized in ultraviolet studies. As the possibility of his selection was known to the MPG and ASO, his attendance at mission planning sessions was invited from early in the preparation period.

European Operators

The European EOs were recommended by ESA HQ. One was an experienced IR astronomer and had flown on the Concorde eclipse mission in 1973. He was also readily available at the time of the mission as a visiting scientist at ESTEC. For the second EO, ESA deliberately sought an individual with no airborne science experience from among PhD candidates willing to invest time away from their graduate programs. The EO selected had experimental experience in atmospheric physics and was personally acquainted with some of the University of Southampton experiment team members through a cooperative program between that university and the University of Sussex where he was enrolled.

EXPERIMENT OPERATOR TRAINING

This section considers the training of EOs at the PI home laboratories, during the integration and checkout period at Ames, and during the integrated mission simulation prior to the simulation period itself. EO and PI observations on the effectiveness and deficiencies of the training program are discussed in the next section.

Training Approach

Previous experience with EOs on an ASSESS mission (ref. 2) indicated that EO training could be successfully handled directly between the PIs and the EOs. Accordingly, the same approach was planned for the Joint Mission. It was requested that the PIs set up training plans and schedules jointly with the EOs. Primarily because of the incomplete development state of the experiments and lack of sufficient funding, these ideal plans did not work out, although training plans of varying completeness were prepared for three experiments. Visits to experimenters' home bases were scheduled primarily at the convenience of the EOs. The EOs obtained valuable information from their visits to PI laboratories, but demands of experiment preparation and other factors forced the bulk of the training into the experiment installation period.

It also was planned that the PIs would provide operating instructions for the EOs during the training process. Only one set of procedures, that for the University of New Mexico, was prepared in time for EO initial training. Procedures for operation of the Southampton experiment and the Meudon telescope were prepared before the installation period and were used by the EOs. Queen Mary College prepared preliminary operating procedures for the training period, but because of continuing changes in the experiment configuration, they were of little use. All others were prepared by the EOs and PIs jointly during the installation and checkout period. Available training plans and operating procedures are provided in appendix A-2.

Mission Training Chronology

Each experiment operator was assigned prime responsibility for an experiment, or group of experiments, and secondary (backup) responsibility for additional experiments (Table A-1). Because the Spacelab life support system is designed to support a maximum of three people continuously, only three EOs were permitted to operate the equipment on any given flight. The primary and secondary experiment responsibilities were chosen to ensure sufficient cross training that any three of the four EOs could operate the payload on a given flight. This arrangement was designed to provide an effective one-man backup for a three-man crew.

An overview of EO training throughout the mission is provided in figure A-1. Note that operator B the least experienced EO, the graduate student on the ESA team, received by far the most training time (66 days). The detailed chronology from this EO's notebook indicates the day-by-day activities of his training in Europe, Alaska, and at JPL. It is provided in appendix A-3. Operator D, the scientist/astronaut, in contrast, received only one day of training prior to the installation and checkout period in May.

Operator B visited all European experiments in the September 1974 through January 1975 period. He then visited all U.S. experiments at their home locations except the University of Colorado. Operator A visited all European experiments at their home locations, but did not train on U.S. experiments until May. Operator C visited all U.S. experiments at their home locations except Colorado before the installation period but did not see the European experiments until May. Operator D visited only his prime experiment before May.

No need for EO training at the Colorado laboratory was originally anticipated. Initial plans of the JPL PI had included loan of the Colorado instrument and its incorporation into experiment preparation and EO training at JPL. However, these plans were not implemented and the Colorado investigator was requested to bring the instrument to Ames and operate it himself.

During the installation and checkout period at Ames, relatively little time was available for training, although the plan called for an appreciable amount of training during this portion of the

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TABLE A-1.— EXPERIMENT OPERATOR ASSIGNMENTS

Experiment Group	Code No.	Responsible EO	
		Primary [1]	Secondary [2]
Queen Mary College	E2		Operator C
University of Southampton	E3	Operator B	
University of New Mexico	US3		Operator A
Meudon Observatory and University of Groningen	E1	Operator A	Operator B [3]
NASA-Ames Research Center	US1	Operator D	Operator C [3]
Jet Propulsion Laboratory			Operator D
University of Alaska	US2	Operator C	
University of Colorado			Operator B

1. Primary responsibility includes capability to maintain and repair equipment integral to the experiment.

2. Secondary responsibility limited, in principle, to operation of experiment and data interpretation.

3. Assignment made, some training effected, but never operated in this capacity.

EO	TRAINING ASSIGNMENT	EXPERIMENT	AT HOME LABORATORIES*									AT AMES*		TRAINING DAYS	
			SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.		MAY	JUNE	PI LAB	AMES
OPERATOR A SELECTED 9-12-74	PRIMARY	SH												12	
		QMC												19	
		NM												4	
	SECONDARY	ALASKA												12	28
		JPL/COLO												8	
	SECONDARY (ALTERNATE)	MEUDON/GRON												11	
OPERATOR B SELECTED 9-12-74	PRIMARY	MEUDON/GRON												8	
	SECONDARY	SH												4	26
		QMC												12	
		NM	NO LABORATORY TRAINING											0	
OPERATOR C SELECTED 2-3-75	PRIMARY	ALASKA												6	
		JPL/COLO												8	

(AT AMES column spans SIMULATION PERIOD)

Figure A-1.— Integrated EO training schedules and management reviews.

EO	TRAINING ASSIGN-MENT	EXPERI-MENT	AT HOME LABORATORIES									AT AMES		TRAINING DAYS	
			SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.		MAY	JUNE	PI LAB	AMES
OPERATOR C (CONT.)	SECONDARY	SH	△	△	△ NO LABORATORY TRAINING					△			△		0	
		OMC			△ NO LABORATORY TRAINING				△						0	
		NM				△			🗆△ △						4	27
	SECONDARY (ALTER-NATE)	AMES							🗆△	△					3	
OPERATOR D SELECTED 9/12/74	PRIMARY	AMES							🔱	△			△		1	
	SECONDARY	ALASKA			NO LABORATORY TRAINING					△ △					0	25
		JPL/COLO			NO LABORATORY TRAINING					△					0	

|← TRAINING PLANS TO MISSION MANAGER
|← SCHEDULED START OF TRAINING

△ MANAGEMENT REVIEWS OF TRAINING
*TIME BLOCKS ARE PERIODS IN RESIDENCE, NOT NECESSARILY CONSECUTIVE DAYS OF TRAINING.

Figure A-1.— Concluded.

mission. All four EOs were on hand at Ames during the month of May, however, and spent considerable time assisting the PIs in final experiment assembly, alignment, and checkout. This period provided the first significant opportunity for hands-on training.

For the most part, the EOs found the presimulation flight training the most valuable part of their training, and the learning process continued well into the simulation portion of the mission.

Management reviews of training plans and progress occurred at intervals in the program; most notably in the first three months, near the end of the home laboratory period, and in the final week before simulation flights. The number of such reviews ranged from five to two (fig. A-1). Early events included visits to PI laboratories in Europe by the ESA program manager and the submission of training plans by three PIs to the ASO Mission Manager for approval. Later in the February to March period the Mission Manager personally reviewed training status with three EOs who visited Ames for training on experiment support systems and/or the Ames experiment, while the ESA manager visited one U.S. laboratory to substantiate preparations for European EOs. The final at-home review of training was part of the formal experiment readiness review (ERR) by personal visit of the ESA manager in Europe and by telecom with the Mission Manager in the U.S. After final integration, checkout, and flight training at Ames training status was summarized by PIs and EOs together, for both managers at the mission readiness review (MRR) on May 29.

EO training activities during each major segment of the mission are described in the following subsections.

Laboratory Training

This section summarizes the training the EOs received at PI laboratories prior to the payload integration and checkout period at Ames. Tables A-2 and -3 group their comments by experiment. In some cases, actual EO training appears to have consumed a relatively small fraction of the apparent available time at a given institute; overall, the average was about 70 percent. The EOs indicated that this deficiency was due in most cases to the many pressures associated with experiment preparation. Personal instruction varied from 20 to 75 percent of the full time available, with an average of about 50 percent, while hands-on experience was only 5 to 45 percent of the total and averaged about 25 percent. Thus, it appears that the EOs were left to their own devices about half the time, to study documents supplied by the PI or to otherwise become familiar with the experiment (e.g., by observation).

Tables A-2 and -3 also indicate some parts of experiments and some documents that the EOs felt were not available for study and/or instruction, either because the hardware was not completed or the documents did not exist.

Hours of training in PI laboratories are summarized in figure A-2 by experiment, by type of experience (classroom or hands-on), and by major subject area (theory, operations, maintenance) for each experiment operator. Data are shown for primary, secondary, and secondary-alternate assignments, with the last being those experiments on which some training was done but no operation in flight (table A-1).

As shown in figure A-2(a), EO experience on primary assignments varied widely from almost 200 hours for operator B to 5 hours for D, while hours on individual experiments ranged from 5 to over 100 with an average of about 50. Secondary assignments involved up to 150 hours total, with individual experiments averaging about 50 hours. Both operators A and B spent more time on one of their secondary experiments than on one or two of their primary ones. With one exception, operators trained on all their primary experiments, but all lacked home laboratory training on at

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TABLE A-2,-EO TRAINING AT PI HOME LABORATORIES, OPERATORS A AND B

	Meudon/Groningen		Queen Mary College		University of Southampton	
	Operator A	Operator B	Operator A	Operator B	Operator A	Operator B
Duration of training	Meudon 7 days Groningen 1 day	Meudon 10 days Groningen 1 day	12 days	19 days	4 days	12 days
% of time spent directly on EO training	45%	40%	65%	70%	70%	70%
% of time personally instructed	35%	20%	60%	55%	70%	30%
% of time with hands-on experience	20%	5%	15%	15%	50%	30%
Timeline procedure evolved and practiced	Yes	Yes	Yes	Yes	Yes (preliminary)	Yes (preliminary)
Parts of experiment studied	IR detector/cryostat Telescope pointing and tracking IR offset problems	Molecular cloud astronomy; EO procedures	Interferometer optics Fourier spectroscopy IR detector/cryostat Science objectives		Science aims TV camera and recorder	Science aims TV camera and recorder Detailed electronics IR photometer
Parts of experiment not covered	Detailed electronics, computing hardware and software		Data acquisition system		IR photometer Detailed electronics All-sky camera	All-sky camera
Literature provided	Technical notes and meeting summaries (Groningen) Experiment technical reports (Meudon)		Background scientific papers Technical manuals for all commercial equipment A paper on the scientific aims		Technical summary of TV camera equipment Troubleshooting manual for TV camera equipment Technical manuals as appropriate Background scientific papers	
Literature not provided	Detailed notes and manuals on individual pieces of equipment Planned background reading list		Detailed technical guides to experiment-built		Manuals for home-built electronics	

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EO	ASSIGN-MENT	HOURS OF TRAINING
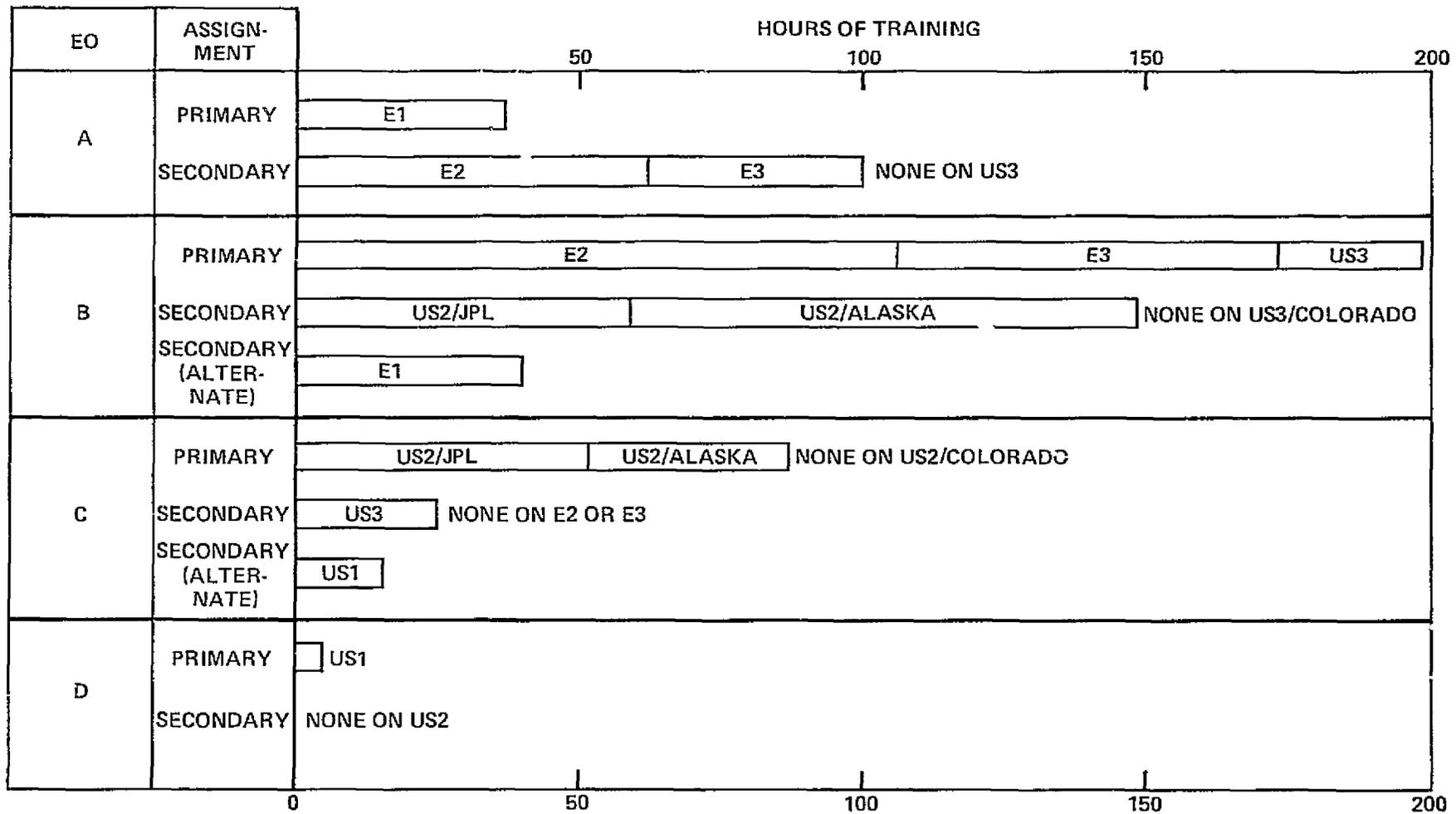
(a) By experiment

Figure A-2.— Operator training experience at PI laboratories.

HOURS OF TRAINING

EO	ASSIGN-MENT	
A	P	CR HO
	S	CR HO
B	P	CR HO
	S	CR HO
	S (A)	CR HO
C	P	CR HO
	S	CR HO
	S (A)	CR HO
D	P	CR HO
	S	NONE

50   100   150   200

0   50   100   150   200
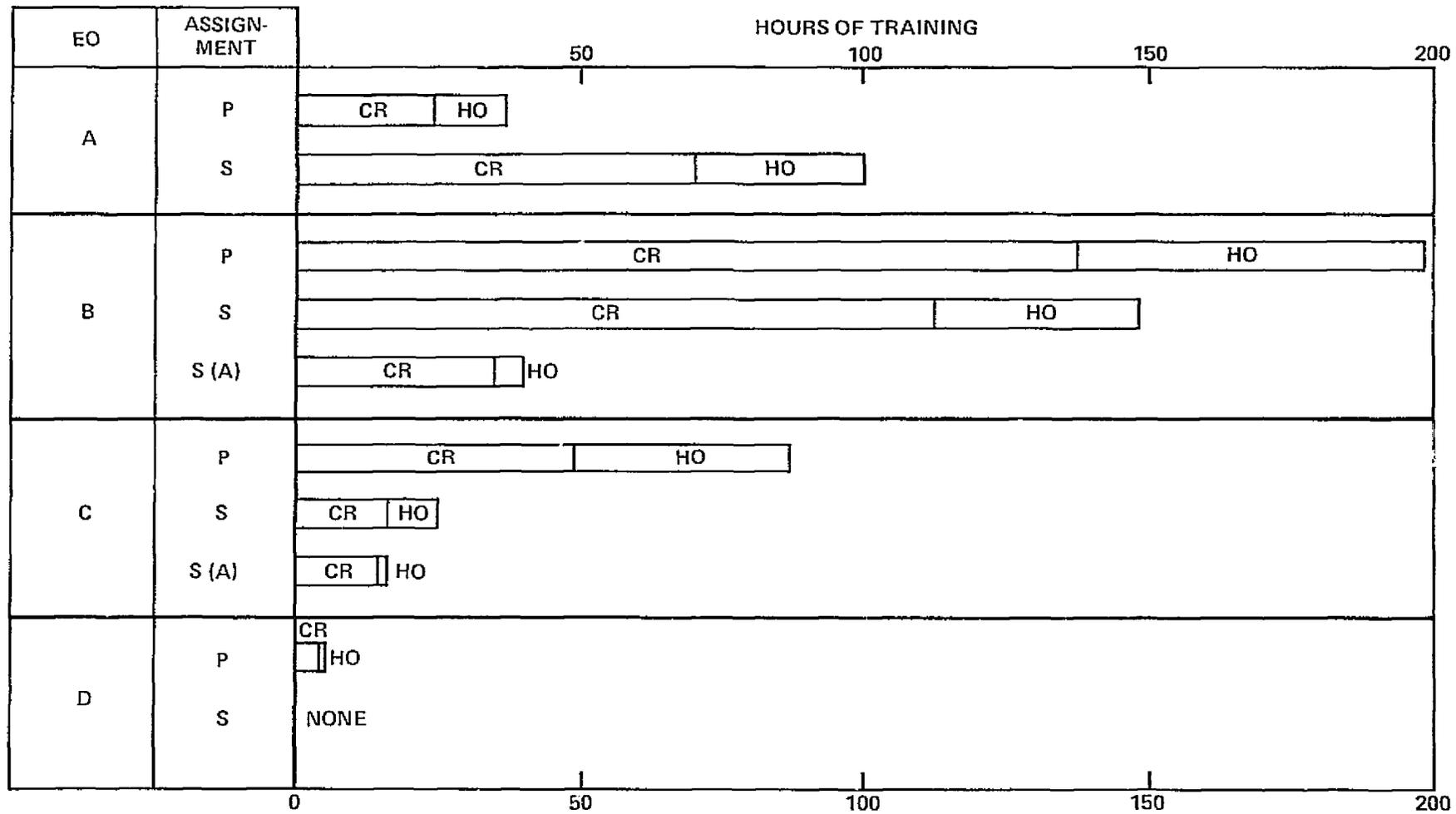
(b) By type of training: classroom (CR), hands-on (HO)

Figure A-2   Continued.

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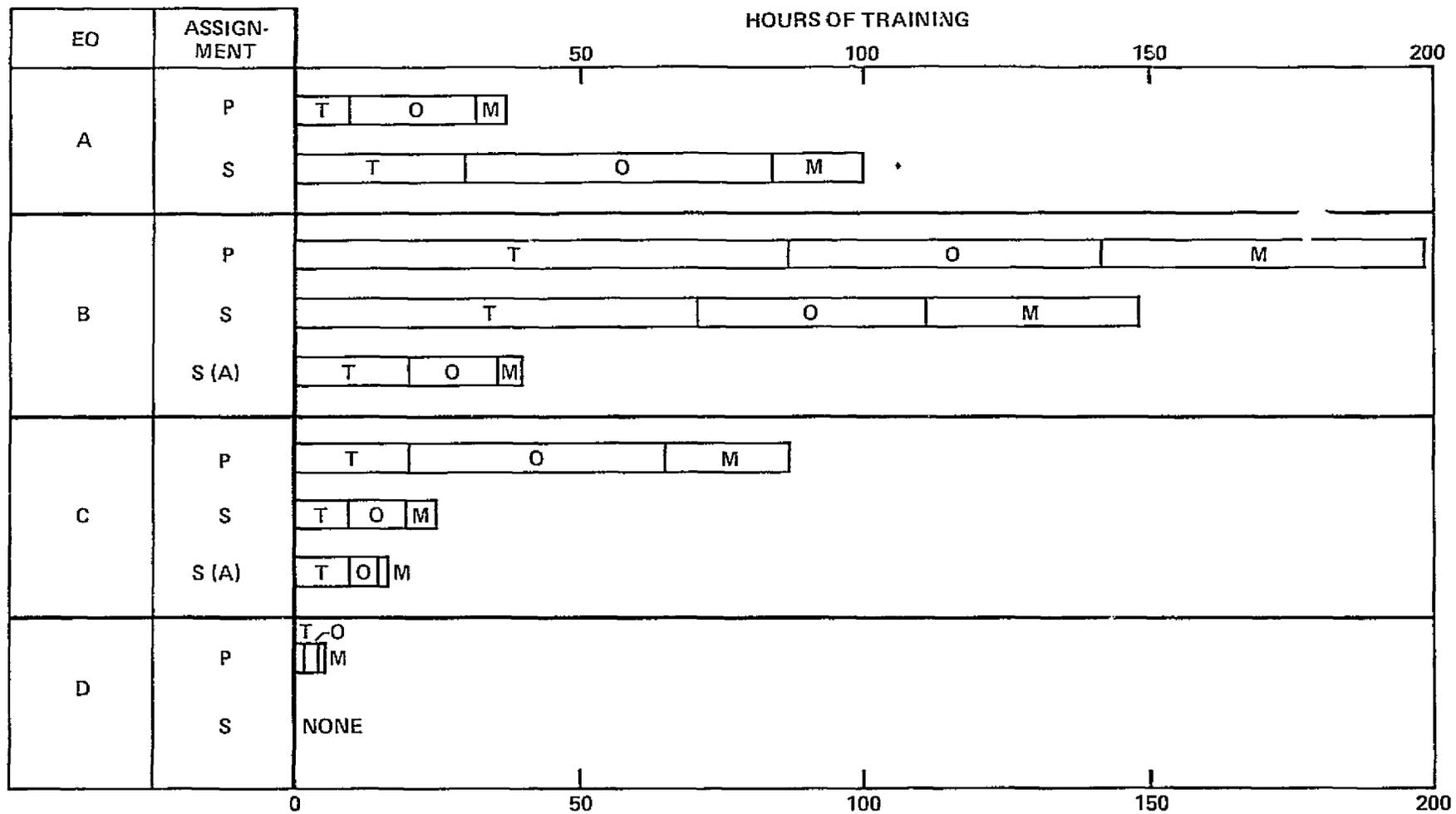
(c) By subject area: theory (T), operations (O), maintenance (M).

Figure A-2   Concluded.

TABLE A-3.- EO TRAINING AT PI HOME LABORATORIES, OPERATORS B, C, AND D

	Jet Propulsion Lab/Colorado		Alaska		New Mexico		Ames	
	Operator B	Operator C	Operator B	Operator C	Operator B	Operator C	Operator C	Operator D
Duration of training	JPL 8 days Colorado - none	JPL 8 days Colorado - none	12 days	6 days	4 days	4 days	3 days	1 day
% of time spent directly on EO training	90%	80%	95%	75%	80%	80%	65%	65%
% of time personally instructed	35%	60%	75%	45%	70%	70%	30%	65%
% of time with hands-on experience	25%	45%	20%	20%	30%	25%	10%	10%
Timeline procedure evolved & practiced	No	No	No	Started	Yes	Yes	No	No
Parts of experiment studied	Visible TAOI Prototype electronics (analog) 20-cm telescope	Flight electronics (digital)	Spectrometer Control & recording electronics Prototype data system	Flight data system EO procedures	Entire system EO procedures		Photometer & electronics (some prototype units)	
Parts of experiment not covered	UV TAOI Flight electronics (digital) Colorado experiment	———	External optics system Computer software Total system operations EO procedures Flight data system	——— ———	None		Telescope optics and control systems EO procedures	
Literature provided	Equipment inst. manuals TAOI theory papers JPL/Colorado proposal		Background scientific papers Notes on spectrometer		Operating procedures Background scientific papers		Background scientific papers	
Literature not provided	Material on Colorado experiment EO procedures		Guides to home-built units EO procedures		———		Technical guides & manuals for home-built units	

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least one of their secondary group.

Figure A-2(b) compares classroom training (lecture, study, observation) with hands-on activities by total hours on primary and secondary assignments. The former was the predominant mode of instruction at the PIs' laboratories, averaging about 70 percent of the time spent by individual operators on either assignment. Figure A-2(c) shows major subject areas — theory, operations, and maintenance. The first two were roughly comparable times and tended to outweigh the maintenance-related activity. On an average percentage basis, theory represented 36 percent of the total, operations training 43, and maintenance training 21 percent. There was little difference between primary and secondary assignments. Within subject areas, however, there was a two-to-one spread for different operators: theory from 48 to 23 percent of the total hours, operations from 62 to 27 percent, and maintenance from 28 to 14.

Operator training at the home laboratory was primarily a PI responsibility, and the individual programs made some allowance for operator experience and experiment complexity. Operator B was the least experienced and received nearly 400 hours of training, while A and C with more extensive backgrounds had about 135. Experiment E2 appeared more complex and required more operator attention than E3, and E3 more than US3, as apparently reflected in the training effort. But what of those cases where little or no training was done? Three reasons for these omissions can be identified. First, operators A and C had to forgo training on secondary experiments at overseas laboratories because of mission schedule and funding constraints. Second, experiments US1 and US2/Colorado were not accessible for training, nor had any meaningful training plan been developed; one was not assembled, the other was not on location at the PI's laboratory. Third, operator D decided not to train on his secondary experiments prior to arrival at Ames.

Training during Payload Integration and Checkout

The payload integration and checkout period at Ames afforded important training opportunities for the EOs. During the first two weeks, the PIs were fully occupied getting their equipment in working order and ready for installation; subsequently, they were busy with detailed checkout activities on the aircraft. The EOs assisted the PIs in readying the experiments, at the same time developing their knowledge of the equipment. Operator B, in particular, worked long hours with the Southampton group. Operator D worked many hours with the Ames group, and operator C assisted in setting up the Alaska 1-meter spectrometer.

Operator A organized a series of seminars with the PIs, at which each discussed his individual experiment for the benefit of all the EOs.

Meudon/Groningen

Operator A worked closely with the PI team in alignment and checkout of the telescope. He spent several days fabricating an alignment device to assure proper boresight. He assisted the PI team in balancing the telescope. Because of his facility with French, he acted as the contact with the PI team for operator D who also had to learn the operation of the telescope. Operator A spent about half time during the month of May on training activities on this experiment, including preparing much of the operational procedures.

Queen Mary College

During the presimulation period, operator C attended a lecture on the QMC system. A group EO run-through on the aircraft scheduled for May 23 was postponed by the PIs. A complete set of

operating instructions was not received until June 2, and in the opinion of the EO, they suffered general deficiencies, discussed later.

Ames Research Center

Presimulation training for operator D, the primary EO for the Ames experiment, began April 30 and continued on a four- to five-day-a-week basis (12 hours per day) until June 2 when the confinement period began. When he arrived at Ames, the ARC instrumentation was in a state of disarray. Some pieces were being redesigned (in particular an interface control panel) and other pieces were on the C-141 for a different series of flights. For the next two weeks, operator D participated in instrumentation buildup and troubleshooting. He was not involved in development since the instrument in various forms had already been flown on the Lear and C-141 aircraft. He found the opportunity to actively participate in experiment assembly and troubleshooting very useful in learning the instrument systems and operations, but also at times a bit inefficient. As part of this effort he wrote up almost all the switch and activity checklist with the expected result that by flight time he really did not need them.

A second major phase of the instrumentation for the Ames observation was the Meudon telescope. Here operator D relied heavily on operator A, the prime EO for the Groningen detector, who spoke better French and had had earlier training on the telescope in Paris. Operator D observed some of the testing of the telescope, especially the balancing of the telescope with detectors. He had no formal training on the telescope directly from the Meudon PIs, and although he became very much at home operating the telescope, he did not acquire nearly the depth of understanding of its systems that he had on the Ames detector (admittedly also a simpler system).

JPL/Alaska/Colorado

During the presimulation period at Ames, operator C assisted the PIs with equipment installation on the aircraft, and updated JPL and Alaska operating procedures to reflect modifications that had occurred since his visit to the PIs' laboratories in March and April.

He also arranged for a meeting (May 16) of the PIs for this group of experiments to discuss in concept the sharing of telescope time and EO time among the four instruments and three telescopes involved. Discussion included: the possibility of putting a TAOF on the 14 in. telescope; status of curtaining the area; observations of Venus and Saturn; switching from Alaska to Colorado during a flight; availability of the fourth EO to help mount the TAOFs and acquire objects; and the servicing of JPL by ADDAS.

During the period May 18-31, which operator C had expected would include major involvement in training activities, the major activity in fact was equipment modification and repair by the PI groups.

For JPL, hardware modifications were accomplished up to this point, and there was ground opportunity to run one TAOF. For the Alaska experiment, hardware and software modifications were still in progress. There was no opportunity to run a finalized procedure. Procedures were still being rewritten.

A basic run-through of the Colorado system was accomplished on the ground, but optics had not been completed so no ground run on a target was possible.

As of May 28, the 14 in. telescope that was part of both the Alaska and Colorado optical sys-

tems had not yet been used, although the PIs claimed it was now ready. System transfer optics had not yet been installed. Alaska write-up was still being revised. The Colorado instrument still couldn't be tested because of the lack of transfer optics. It should also be noted that the Colorado instrument was allocated little telescope time during this period.

Operator C requested a second meeting with the JPL group of experimenters to discuss more details of joint use of EO time and target priorities. The meeting was held May 24. At that time, a solution was devised to a problem involving the vignetting of the beam to the telescope's finding scope, which had precluded obtaining targets on previous evenings. Also, more detailed sharing of telescope time and target priorities was decided upon.

This and the meeting of May 16 apparently were the only meetings held to discuss confinement priorities with the JPL group of experimenters.

Operator D's training on the JPL experiment group (his secondary experiments) was concentrated during the last week before confinement. However, the timing of his training was due largely to his own choice of concentrating on his primary experiment until after his checkout flight. About one-half of his secondary experiment training consisted of reviewing switch lists, checklists, and other material provided by the PIs. The other half of the training was during evenings on the ram, with the PIs checking out their equipment and also giving the EOs a chance to operate it. By the beginning of the confinement period, operator D felt he had been adequately trained on these secondary experiments. He also felt, however, that if there were significant problems there would be a "primary" EO around who could help out, and therefore that his principal task was to learn "nominal" operations. In carrying out these nominal operations, he notes that EOs were noticeably more dependent on the checklists than when working on their primary experiments.

New Mexico and Southampton

New Mexico procedures were reviewed, a lecture was given on Southampton systems. Operator C participated in one complete run-through on the ground.

Summary of Onsite Experience

Operator training during the experiment integration and checkout period at Ames continued to be the responsibility of the PI. For the most part this activity was even less formal than the home-laboratory training, and much was left to the initiative of the EOs. Some PIs did not arrive at the start of the period (April 28), and once at Ames, they did not utilize EO time effectively.

Installation of experiments and GFE was scheduled for 13 working days of one-shift operation in a coordinated sequence of one-day time blocks for effective use of available time, space, and manpower. Depending on the experiment, the last 3 to 6 days of this period was for interfacing with the ADDAS (CDMS) and for final testing of the fully integrated equipment. Following this, EO training on experiments and two PI checkout flights were scheduled for the final two weeks before simulation began.

With one notable exception (operator D), the EOs were not fully involved with the installation activities. The PI depended on his team of specialists for this work, and apparently had not scheduled the EO into the activity flow. Nevertheless, there was frequent interaction during the two-week period between EO and PI while observing or participating in the work, in PI seminars, and in preparing experiment operating procedures. With one prearranged exception, all experiments were physically integrated and safety approved by the May 15 deadline. Checkout and testing con-

EO	ASSIGN-MENT	HOURS OF TRAINING*
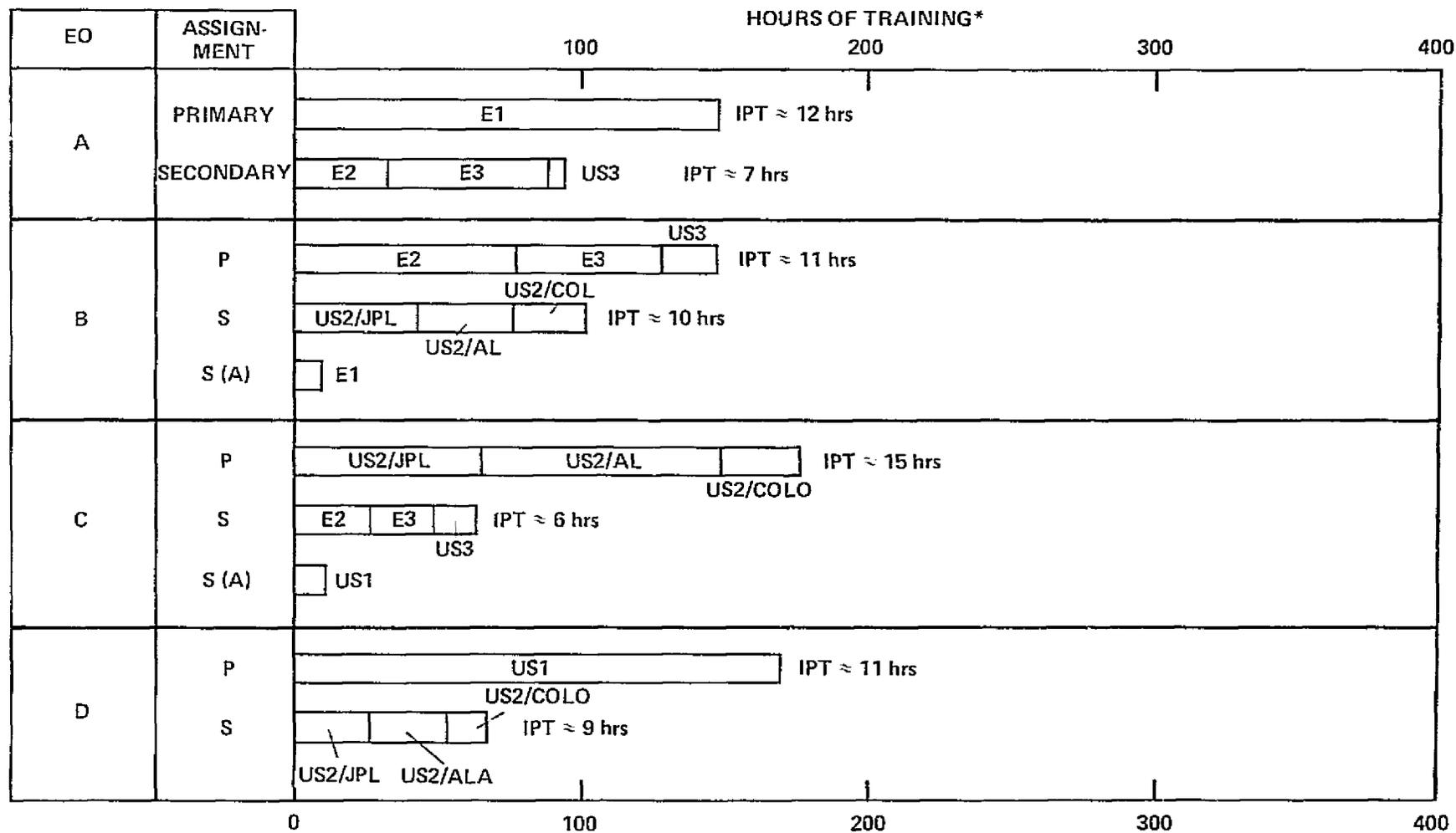
*INCLUDING INTEGRATED PAYLOAD TRAINING (IPT) ON GROUND AND IN FLIGHT.

(a) By experiment.

Figure A-3. Operator training experience at integration site (Ames).

EO	ASSIGN-MENT	HOURS OF TRAINING
A	PRIMARY	CR HO
A	SECOND-ARY	CR HO
B	P	CR HO
B	S	CR HO
B	S-A	CR
C	P	CR HO
C	S	CR HO
C	S-A	CR
D	P	CR HO
D	S	CR HO

Scale: 0 — 100 — 200 — 300 — 400
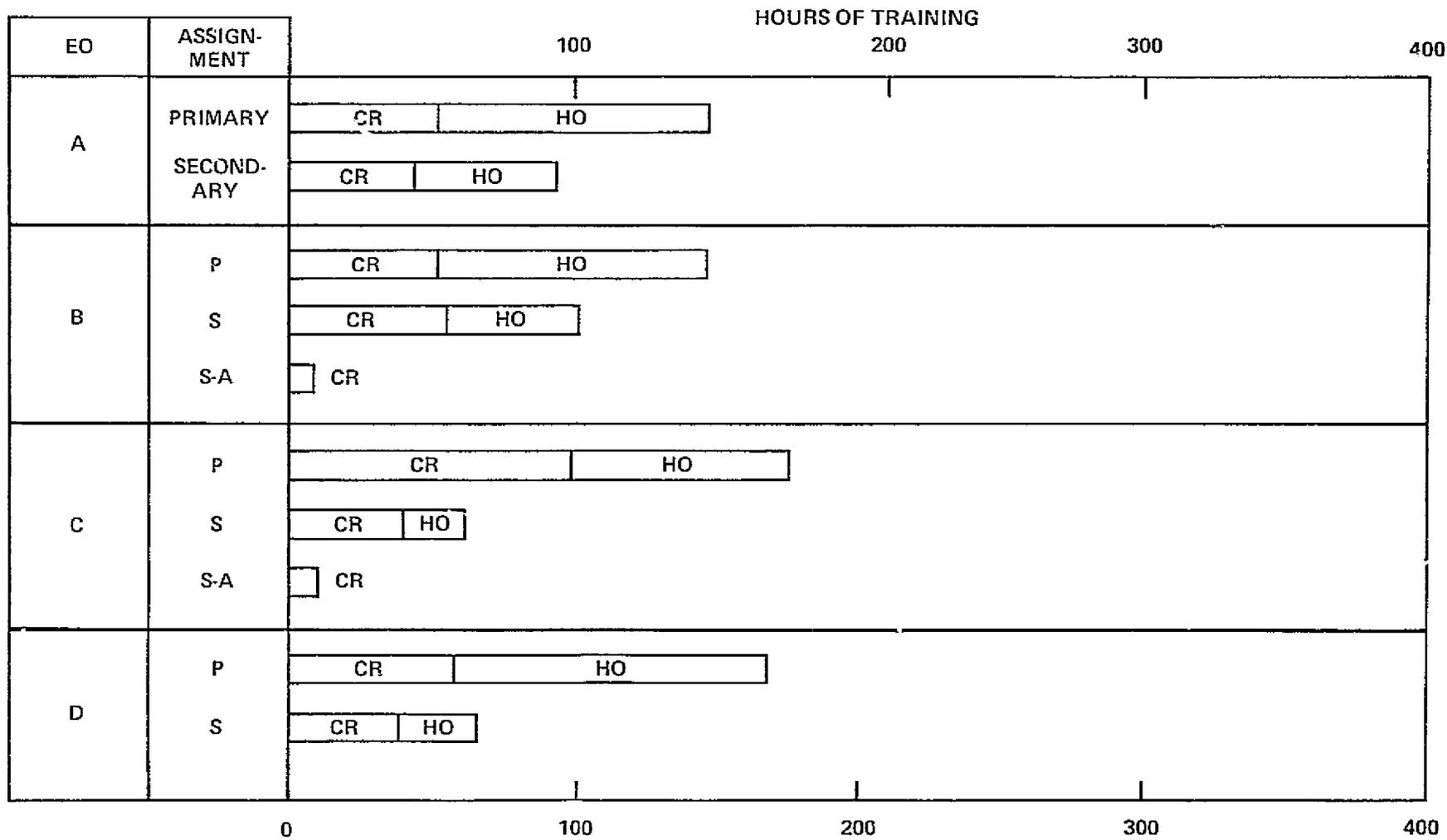
(b) By type of training; classroom (CR), hands-on (HO)

Figure A-3.   Continued.

HOURS OF TRAINING

EO	ASSIGN-MENT				
		100	200	300	400
A	P	I O M			
	S	I O M			
B	P	I O M			
	S	I O M			
	S (A)	M O			
C	P	I O M			
	S	O M			
	S (A)	M O			
D	P	I O M			
	S	I O M			

0   100   200   300   400
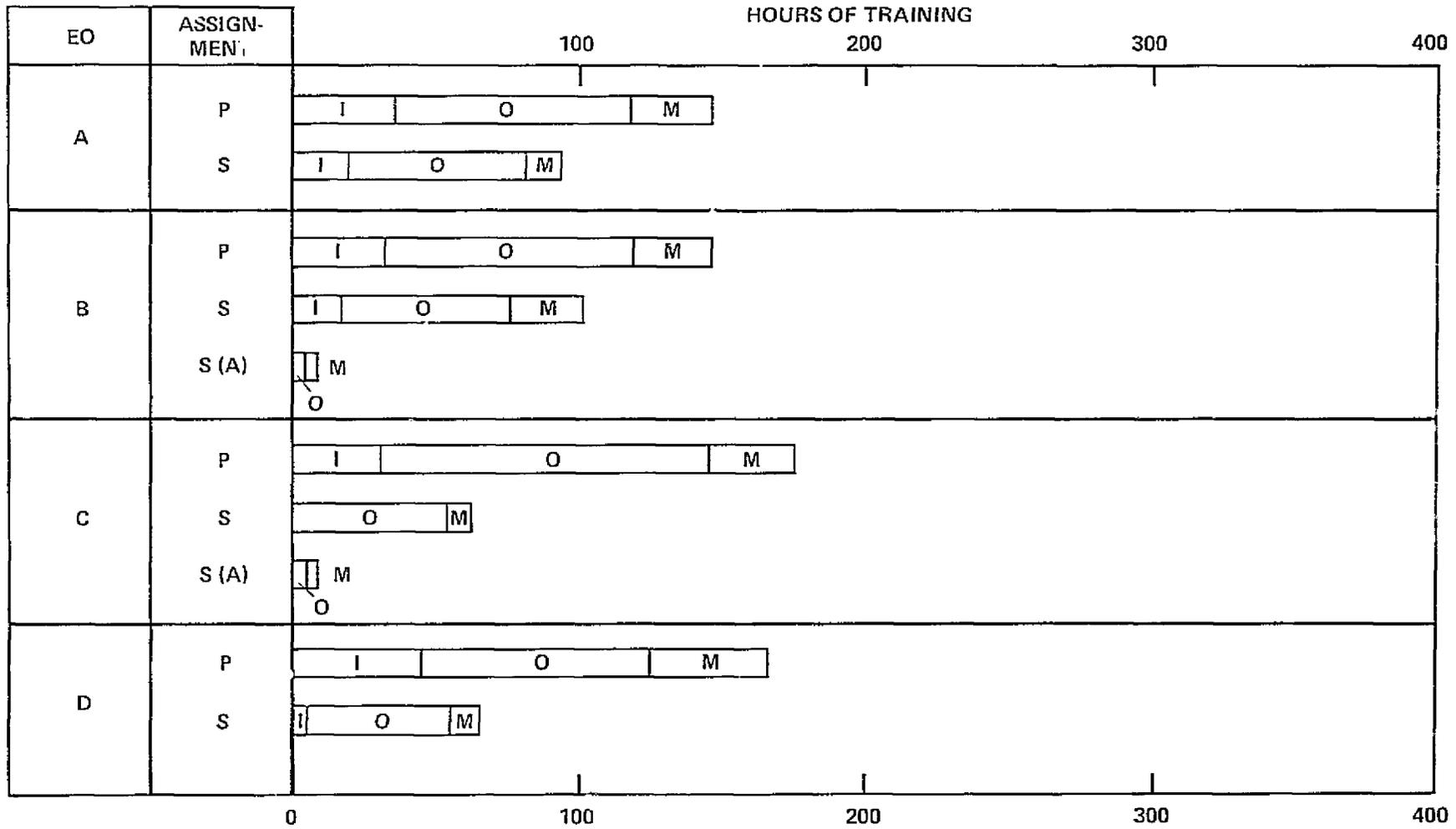
(c) By subject area; integration (I), operations (O), maintenance (M)

Figure A-3. Concluded.
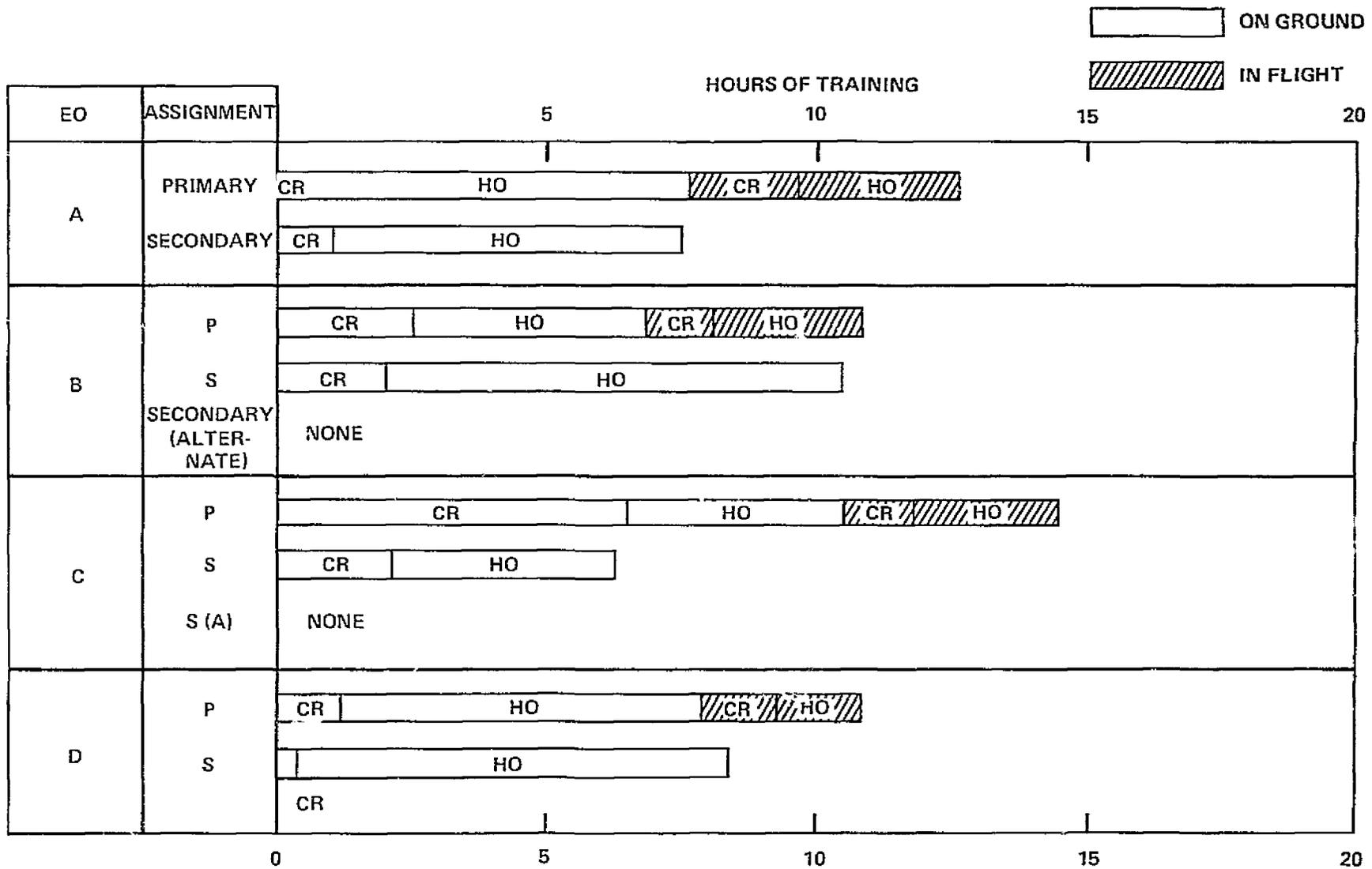
Figure A-4. Operator training experience; integrated payload simulation, cla room (CR) and hands-on (HO)

SPECTROMETER
CONTROLS;
OPERATOR D

PI (AMES)

TELESCOPE
CONTROLS;
OPERATOR D

PI (MEU)

TARGETS | VENUS | α-HERC | MOON |

TO   TD

2000   2200   2400   0200

TIME (PDT) HOURS

PRIMARY CONTROL

ASSIST

TROUBLESHOOT
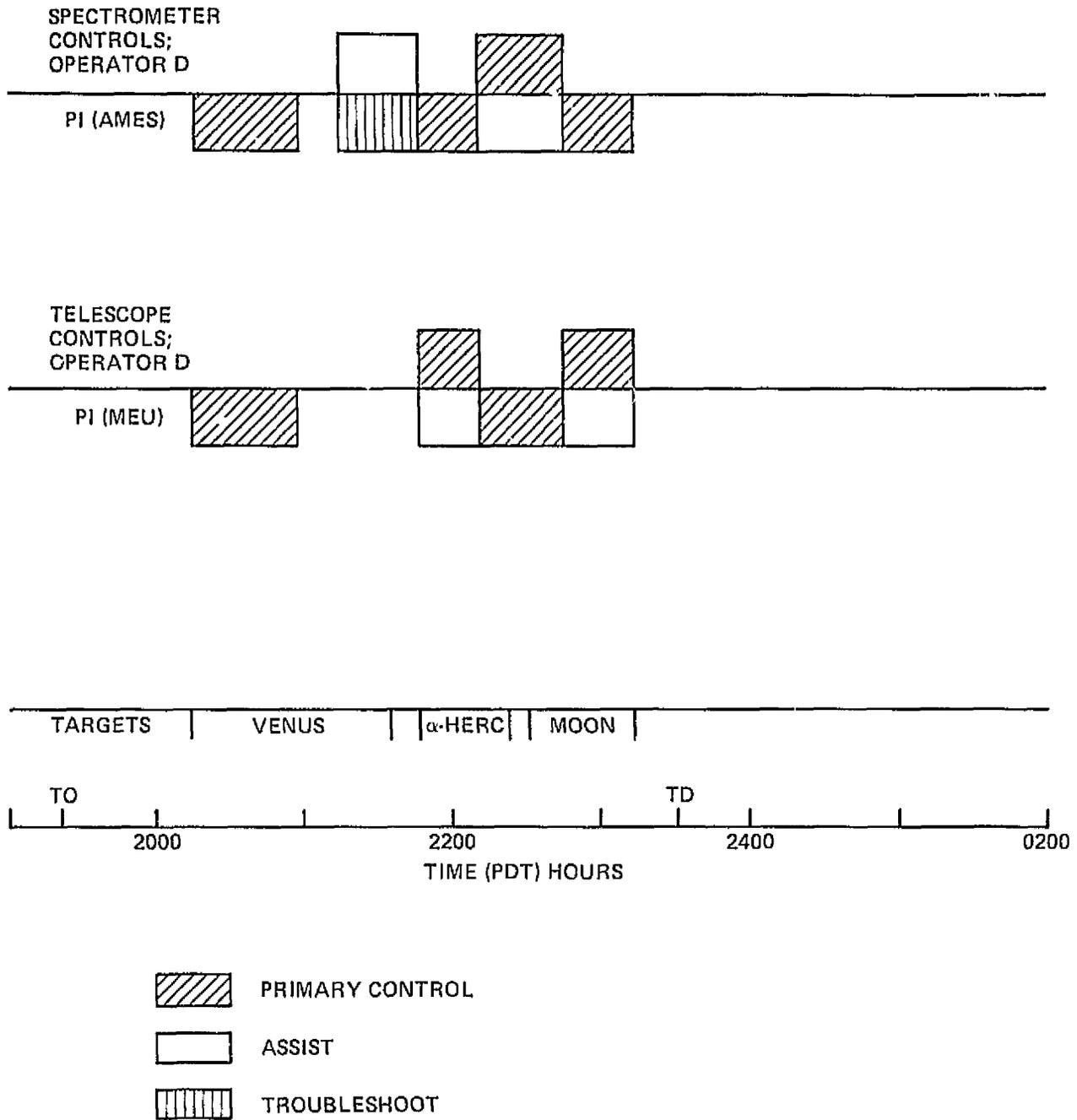
(a) Flight 2.

Figure A-5. Training-flight timeliness.

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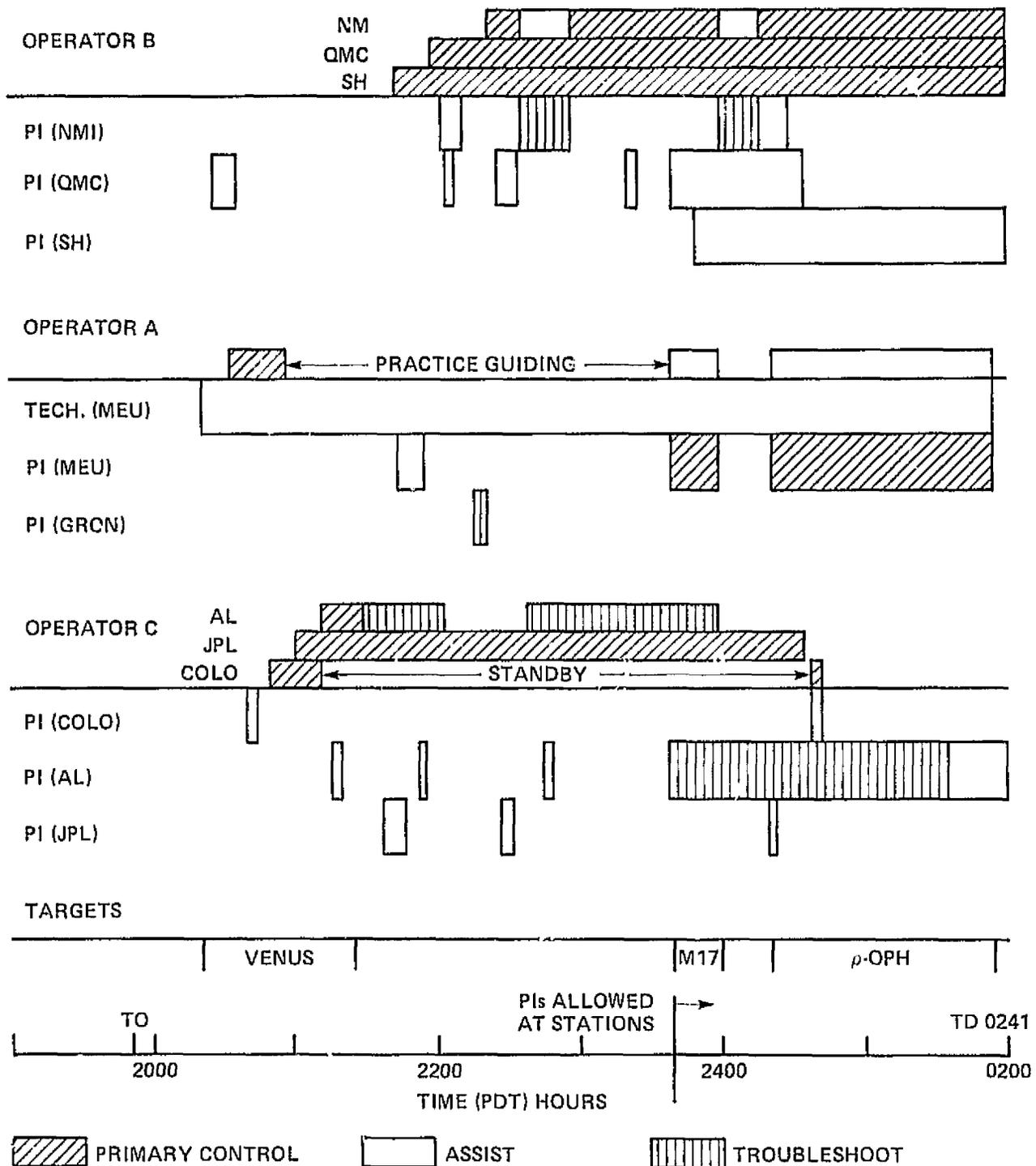
(b) Flight 3.

Figure A-5. Concluded.

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tinued on into the scheduled EO training period, however, and adversely affected both the amount and quality of EO experience on the full experiment. Here again the PI and his team did most of the work, with EO training at moments of opportunity rather than as scheduled.

In the final two weeks of preparation, increased activities of the aircraft maintenance crew to accommodate the scheduled checkout flights had an added impact on training opportunities. Further delay was caused by a chronic malfunction of the GSE ground air conditioner, that resulted in several over-temperature shutdowns of some experiment equipment and the abrupt termination of hands-on training sessions.

Training during these two periods totaled about 250 hours for all EOs and, except for operator B, significantly exceeded laboratory experience (fig. A-3). Primary assignments were emphasized, but coverage was complete. Hands-on experience varied from one-third to two-thirds of the total, with primary experiments on the high side, while operations training accounted for almost two-thirds of the time and integration/maintenance for the remainder. A small portion of this record is time spent in presimulation flight training, discussed below.

Presimulation Flight Training

Operator training on the integrated payload in a simulated mission environment (complete with input signals) occurred during seven night sessions on the ground and one in flight. Only two experiments were operated on all seven ground nights; the minimum was three nights. All were operated in flight, but only by primary operators. Figure A-4 gives the training hours and the amount of hands-on experience. Each operator had about 17 hours of ground simulation and 4 hours in flight, less than 10 percent of his total onsite experience. In some cases, the nonactive (classroom type) mode was still a sizable fraction of the total during the presimulation flight period, indicating that either the EO or the equipment (usually the latter) was not cleared for proxy operation. Furthermore, only in flight was a real effort made to follow a timelined operation. Nevertheless, all EOs agreed that this integrated payload experience was their most valuable training by far, and served a critical need as a reasonable analogue to integrated mission simulation for Spacelab missions.

Following flight 1, devoted to PI checkout of the payload, flights 2 and 3 afforded the EOs an opportunity for inflight experiment operations, in a full-up analogue of an integrated mission simulation for Spacelab. The flight schedule called for the primary Ames EO to receive this training on flight 2 and the others to operate their primary experiments on flight 3. It was planned that during the first half of the flight, the EO would start up and operate his prime experiment (or group of experiments) without direct assistance from the PI, who was available only via intercom from the rear of the aircraft. The EO would continue as primary operator during the second half of the flight, but with the PI available for direct hands-on assistance if requested by the EO.. No inflight training on secondary experiments was provided.

The effectiveness of EO flight training was limited by the marginal condition of some of the experiments. In particular, the Meudon/Groningen and University of Alaska experiments suffered from significant telescope and computer system problems, respectively. Actual flight training activities of the EOs are detailed in figure A-5, which indicates EO time spent operating their primary experiments, assisting another EO and troubleshooting the equipment. The astronomical targets also are indicated.

MPG flight guidelines were not followed on flight 2, in part as a result of experiment problems. During this flight, operator D observed experimental activities while the Ames PI guided on Venus. Between Venus and α-Here, he assisted the Ames PI in troubleshooting his experiment, and then alternately operated the telescope controls or the spectrometer controls while guiding on α-Here

and the Moon. He never operated all controls simultaneously and enjoyed constant assistance from the PI.

On flight 3 the participants attempted to follow the general EO flight operations plan. During the first part of the flight, the PIs were available (at station) only when requested by the EO. Such requests were made fairly frequently, mostly for advice but also for troubleshooting. Operator C spent a significant portion of this time troubleshooting the Alaska experiment (the computer frequently locked up). The JPL experiment was turned on but largely ignored, and finally was turned off by the PI because no obvious signal was being generated. After a short period at the controls, operator C left the Colorado experiment in standby and worked on the Alaska experiment. He and the Colorado PI attempted to guide on a star, but the star was too dim for the stabilization system so this experiment was shut down also. The Alaska PI (aided by an Alaska technician) was able to get his experiment up shortly before descent from altitude.

Operators A and B fared better. A Meudon technician was assigned to improve the balance and stabilization of the Meudon telescope during the flight. His activities affected the consistency of telescope pointing, but were otherwise relatively independent of operators A's operations of the experiment. After PIs were allowed at station, the Meudon PI became the primary operator on M-17 and ρ -Oph during the remainder of the flight. Operator B was in primary control of his experiments during most of the flight. The New Mexico PI did some troubleshooting of his 16-mm camera. The remainder of the equipment was operating satisfactorily.

Summary of Training Experience

Operator training for the Joint Mission is summarized in figure A-6. A 200- to 300-hour level of effort was expended on primary assignments, and on secondary assignments by operators A and B; C and D spent under 100 hours on their secondary experiments. Training at Ames was a large fraction of the total, particularly for the more experienced operators. This last result may be unique to this simulation exercise rather than a valid Spacelab analogy, since opportunity for training at the Spacelab integration/launch site may be limited by facilities and integration schedules.

TRAINING EVALUATION

Data on EO training effectiveness were obtained from EO notes and the responses of PIs and EOs to a questionnaire prepared by the ASSESS observer team covering a number of specific training areas.

EO Observations

EO comments on training at the PI home laboratories are briefly summarized below, by experiment. One observation appeared generally applicable across the entire experimental payload — namely, the tendency of the PIs to assume that their experiments would operate satisfactorily and according to an established checklist available to the responsible EO. Instruction therefore tended to emphasize equipment operation with little attempt to develop a working understanding of the experiment that would have facilitated troubleshooting and repair.

Meudon/Groningen

No structured training plan was followed, largely because of PI involvement with experiment development. Even on days designated for EO training, the PIs were not able to devote full attention to that activity. Technical explanations were good, but could have been more extensive. Overall, training for Meudon/Groningen experiment operation was just sufficient for normal operation.
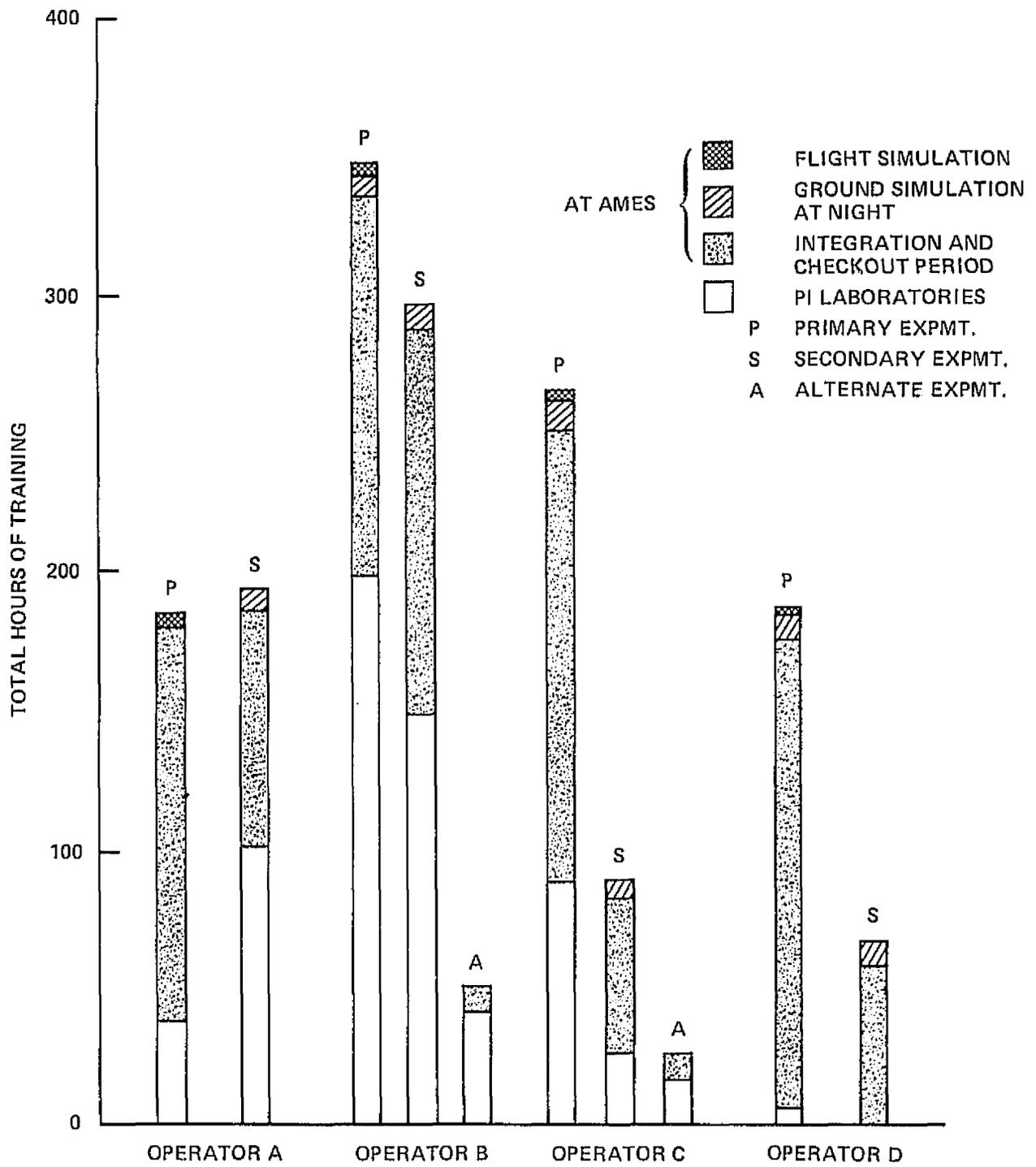
Figure A-6. Summary of training experience.

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An EO without the necessary background, given this level of training, would have been forced to operate essentially as a technician.

Queen Mary College

The EOs attended two meetings of the experimenter team at which scientific objectives and overall experiment planning were established. The EOs thus were involved relatively early in the experiment development period and on a scientific -- as compared with a merely technical -- level. Several members of the PI's team worked with the EOs on the days designated for EO training, and provided helpful explanations of experiment details. Overall, this phase of QMC training was satisfactory, although significant training time was lost early in the laboratory period due to lack of experiment readiness, and the preliminary operating procedures that had been established proved useless in the face of continuing changes in experiment configuration.

University of Southampton

No agreed-on training plan was established, and continuity of PI/EO interaction during the laboratory training period suffered as a result. Overall, the level of EO training was just about sufficient for a nonspecialist.

Ames Research Center

No training plan was established -- in fact the experiment was not ready until just before the flights. The prime EO participated in assembly, test, and checkout of the equipment in lieu of any formal training. Training on the telescope was received from the prime EO on the Meudon experiment rather than from the PIs.

JPL/Alaska/Colorado

Difficulties in experiment development and equipment availability, together with a lack of coordination among the scientists for this experiment group, seriously limited both the extent and quality of EO training. In particular, telescope timeshare arrangements and experiment operating priorities were not even discussed, despite their central importance to experiment data return.

University of New Mexico

EO training provided by the New Mexico PI was satisfactory. In contrast to the other experimenter programs, the New Mexico material included detailed operating procedures.

ASSESS Questionnaire

The ASSESS questionnaire (fig. A-7) was designed to elicit PI and EO estimates of training progress on each experiment in a number of significant areas. Ratings covered a range of perceived EO understanding expressed in the numerical values 0 through 10, with 0 indicating that no instruction had been provided and 10 indicating the respondent's estimate that full understanding of the area in question had been achieved. These values were used in calculating composite and average scores for purpose of analysis. Questionnaire responses were obtained at three points in the integration and checkout period at Ames: at the end of the first week (5/5), midway through the period (5/15), and just before the first flight of the simulation period (6/2). EO and PI responses are shown, by experiment, in figure A-8. Overall ratings of EO proficiency by PIs are given in figure A-9. Reference rating levels are shown for comparison, with 5 the threshold of adequate proficiency

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ESTIMATE OF TRAINING PROGRESS

Name _____   Experiment _____

PI _____   EO _____   Prime _____   Backup _____

Areas of Instruction	Well Understood			Adequately Understood			Need More Instruction			Little or No Instruction	
	HI	MED	LO	HI	MED	LO	HI	MED	LO	LITTLE	NONE
1. Research Objectives											
2. Relationship of experiment procedures to research objectives											
3. Experimental procedure: a. Sensing/Detecting Phase b. Signal Conditioning Phase c. Data Recording Phase d. Data Evaluation Phase											
4. Target-Mission selection procedure											
5. Assembly and installation of equipment											
6. Alignment and focusing of equipment											
7. System testing of equipment											
8. System calibration of equipment											
9. System maintenance and troubleshooting procedure											
10. Preflight checkout procedure											
11. Post flight communication with PI											
12. Reviewing and planning for potential problems											
13. Additional Comments:											
RATING SCALE	10	9	8	7	6	5	4	3	2	1	0

Figure A-7 Questionnaire used to evaluate training progress

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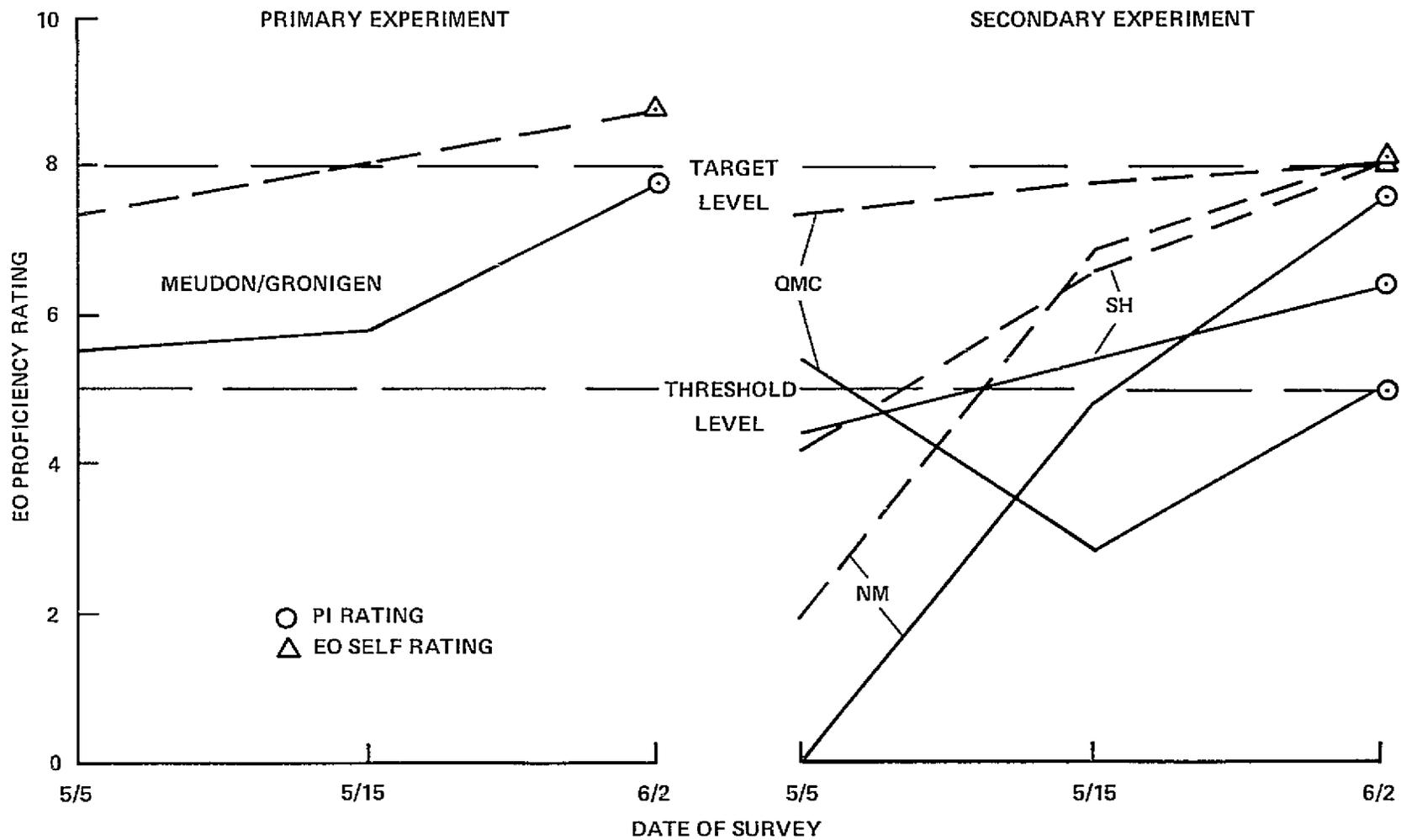
(a) Operator A.

Figure A-8.— Training progress of individual EOS.
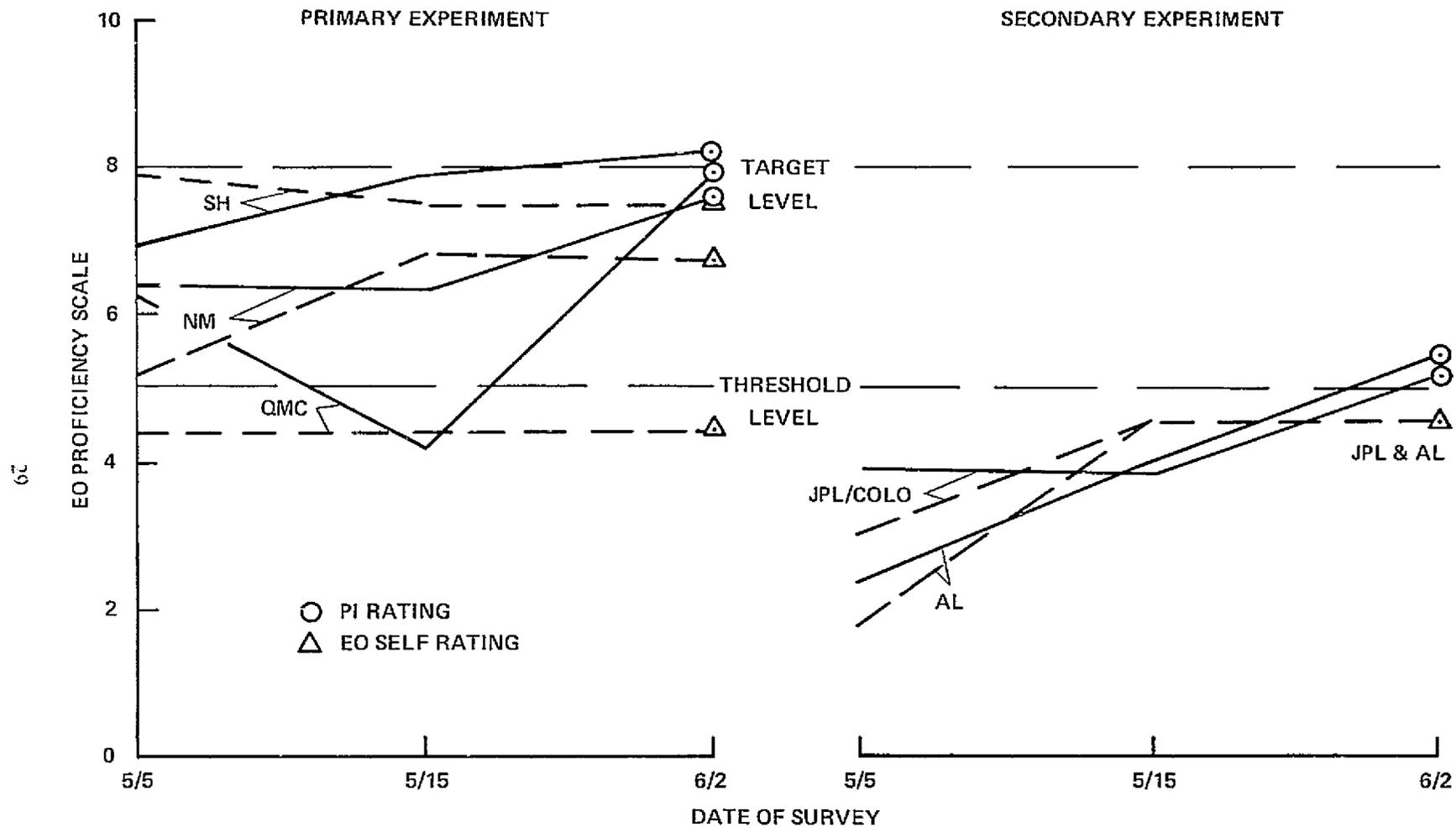
(b) Operator B.

Figure A-8. – Continued.
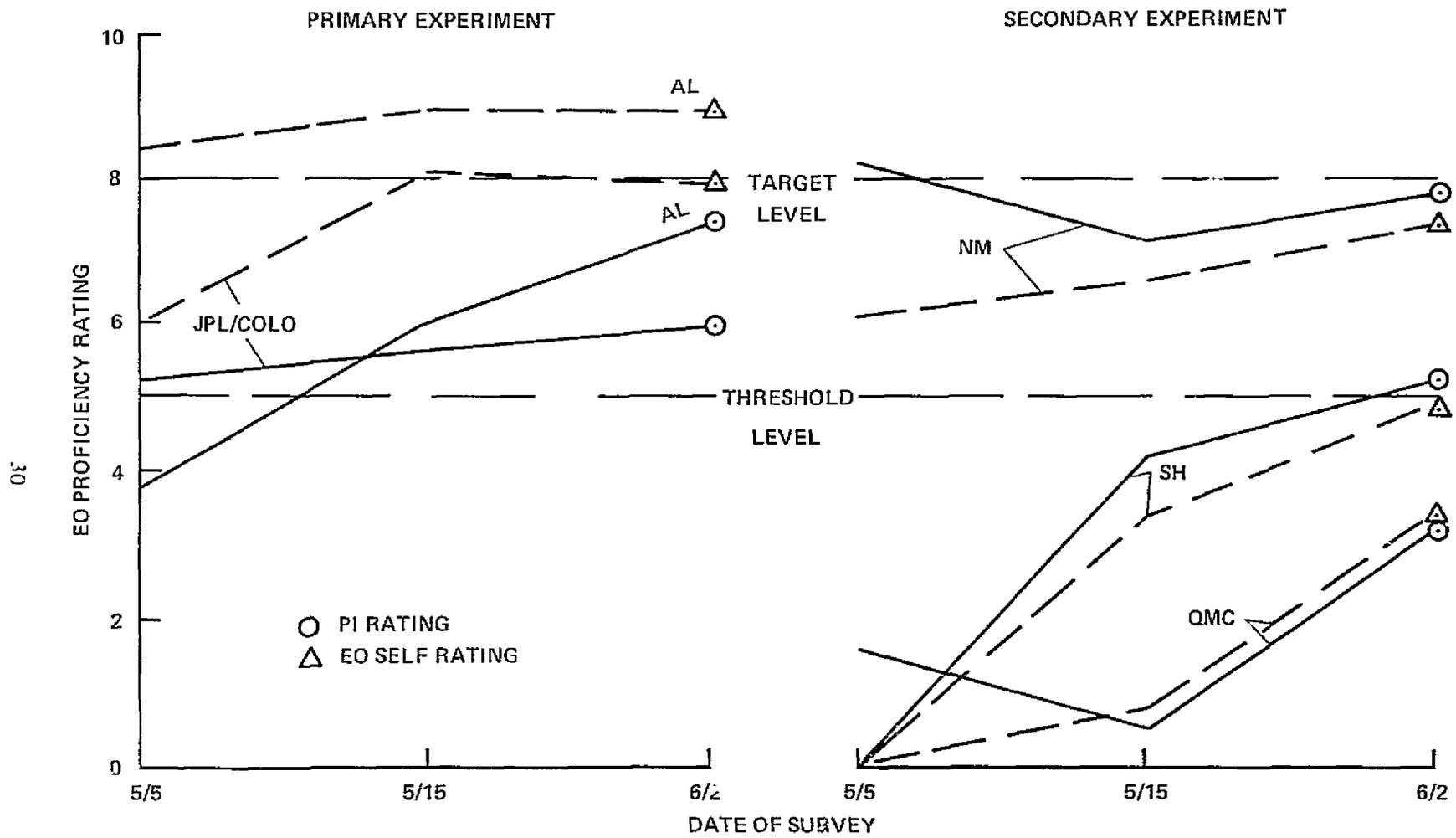
(c) Operator C.

Figure A-8.-- Continued.
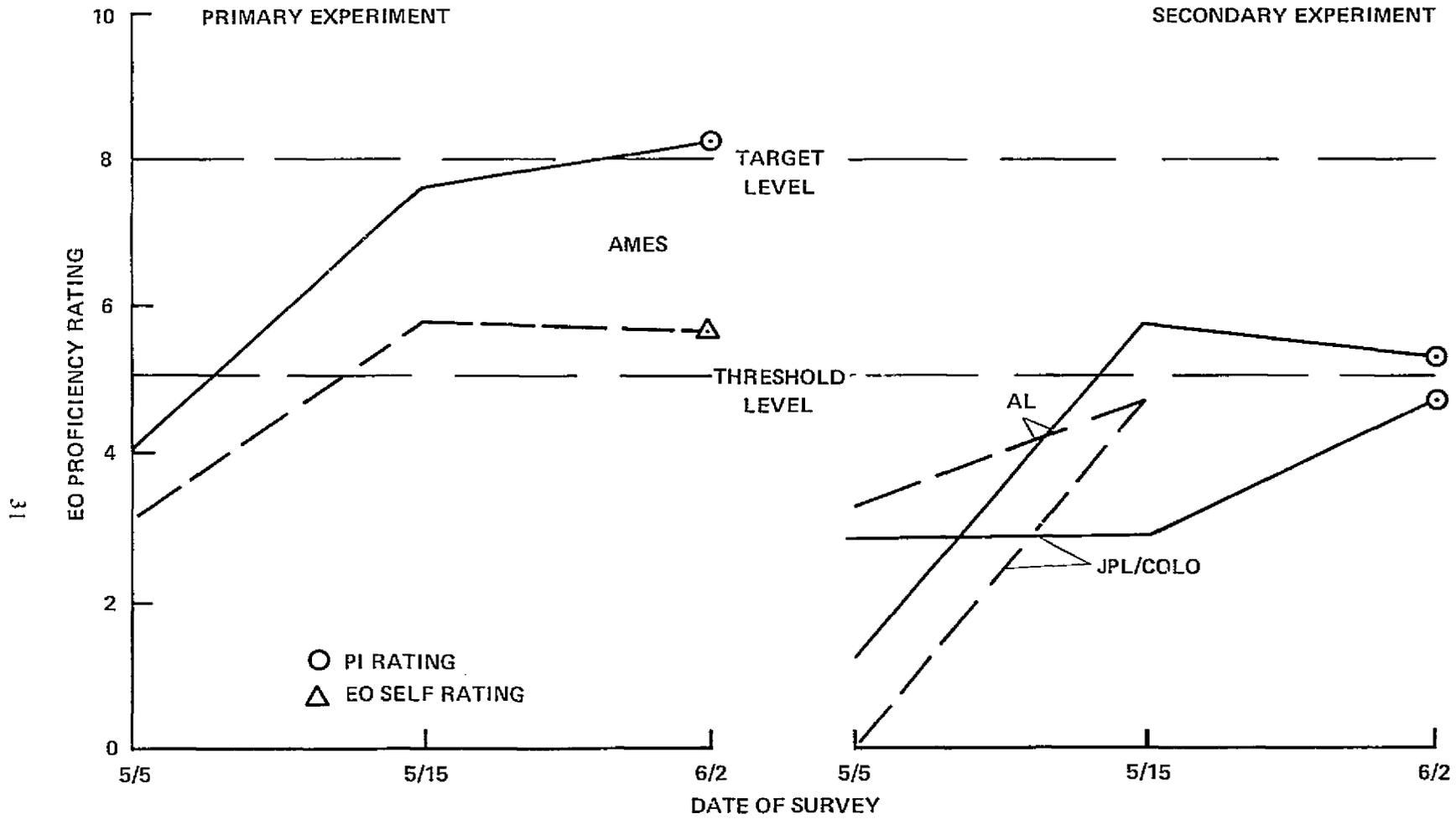
(d) Operator D.

Figure A-8. - Concluded.
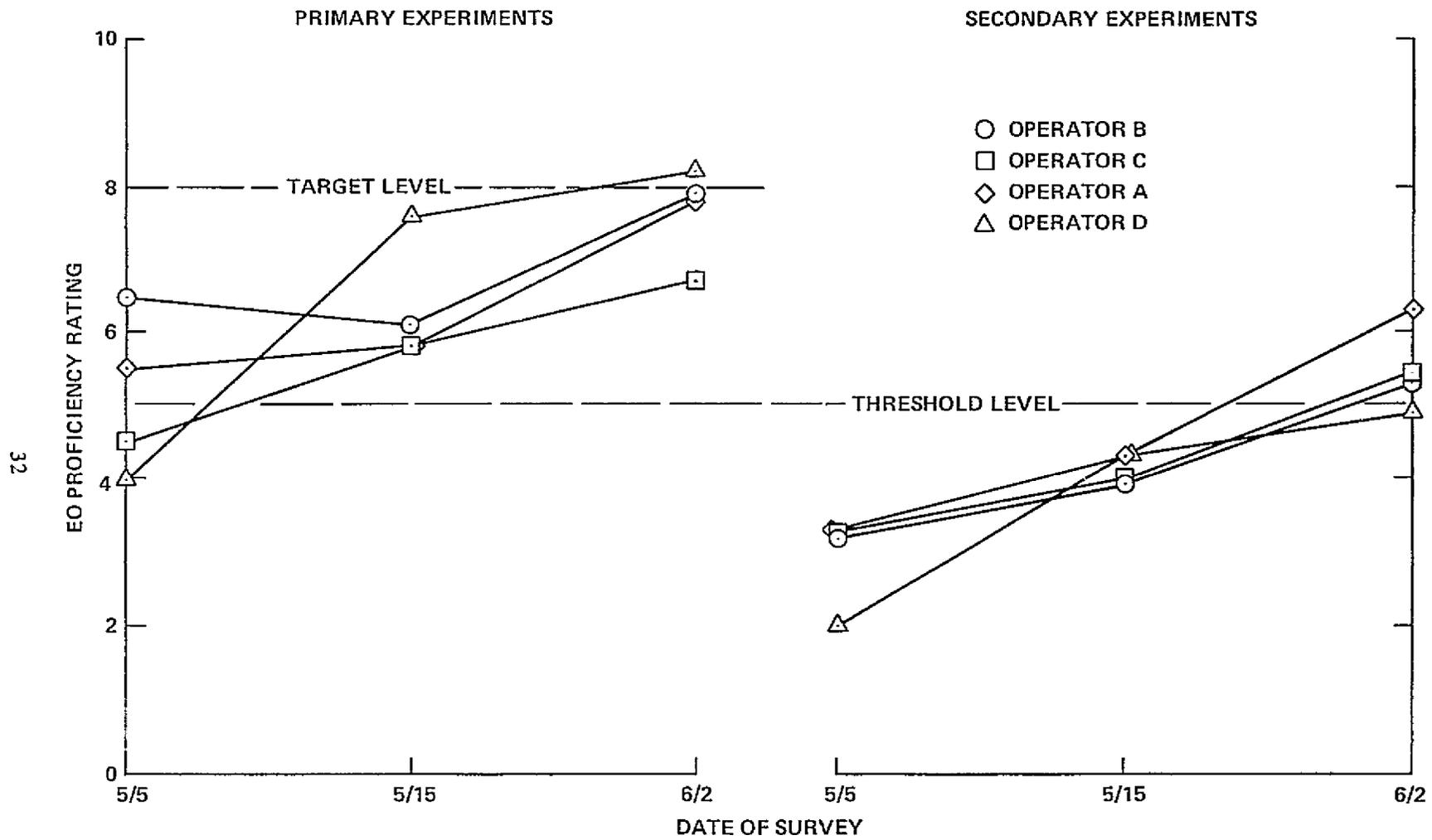
Figure A-9. – Summary of EO training progress, PI ratings.

and 8 the "target" level for a well-trained operator.

An interesting characteristic of the data shown in figure A-8 is that operators A and C were generally more confident of their ability on primary experiments than were the respective PIs, while the reverse was true of B and D. It appears that A and C had sufficient background experience and laboratory training to feel reasonably well prepared at the start of this period. On the other hand, operator B lacked experience, and D lacked laboratory training, to the extent that their starting proficiency was relatively low.

With relatively few exceptions, both EO and PI confidence improved substantially during the integration and checkout 4-week period, particularly on those experiments where little or no prior training was done. Notable exceptions from the PI's standpoint were QMC and JPL/Colorado. The QMC PIs' ratings of EO proficiency dropped appreciably at midpoint for all three prospective operators, indicating that prior training was less effective than expected, but recovered sharply in the final two weeks. The JPL/Colorado experiments made little progress at first and less than average thereafter, a definite reflection of integration and operating problems that delayed operator training. On the other hand, all the EOs indicated that their midpoint position on one or more experiments did not improve much, if at all, in the last two weeks, while all but one of the corresponding PI ratings showed a distinct improvement. Possibly EOs became aware of more gaps in their knowledge as the flight period neared, while the PI, already aware of such deficiencies, felt they were being corrected.

Both EO and PI ratings indicate that EO preparation for primary experiments was superior to that for secondary experiments, usually by a large margin. Although such a difference in operating proficiency is a normal consequence of the assignment guidelines (table A-1) and the training priorities followed for this mission, the extent of the disparity at the end of the training period, particularly as perceived by the PIs, is surprising (fig. A-9). On primary assignments, all operators were close to the 8 or "target" training level, while secondary assignment levels were about 5, the threshold level. These statistics were borne out during the simulation period, when primary operators usually handled equipment repairs and had to provide assistance, in some cases, to EOs operating their secondary experiments.

Figure A-10 is a composite look at areas of minimum EO proficiency identified by PI ratings on the ASSESS questionnaires. Deficiencies occurring most often are shown with their average rating values. For example, on May 5 area 9 was rated lowest on 11 of the 17 EO/experiment combinations, with an average value of 1.4 (out of 10). It is notable that (1) overtime, average ratings increased sharply and frequency decreased, thus indicating improved performance; (2) five of the original six deficiency areas carried through into the mission, and four of these were maintenance-related functions (the fifth was EO/PI communication); and (3) the significant addition midway in the period was "data evaluation," which except for "alignment and focusing" was the lowest rated area of performance for 6 of the 17 possible selections.

Table A-4 groups final questionnaire results under three major headings — planning, operations, and maintenance — to illustrate EO strengths and weaknesses at the start of the simulation period. PIs were generally more confident than EOs in the area of experiment operation, and about equally divided on maintenance and planning. Where large point spreads occurred either way, and this was not uncommon, there obviously was a difference of opinion as to the amount and depth of training required to develop a fully competent proxy operator. In one-third of the comparisons shown, the point spread was two or more.

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RATING AREA	DESCRIPTIONS	EO AVERAGE, 6/2	
		PRIMARY	SECONDARY
3D	DATA EVALUATION	7.7	4.3
4	TARGET SELECTION	7.9	4.8
5	ASSEMBLY & INSTALLATION	7.6	4.3
6	ALIGNMENT & FOCUSING	7.9	4.1
7	SYSTEM TESTING	7.1	4.4
8	SYSTEM CALIBRATION	7.6	5.4
9	MAINTENANCE & TROUBLESHOOT	6.3	4.6
11	POSTFLIGHT COMMUNICATION	5.9	5.9
12	POTENTIAL PROBLEMS	6.2	5.2
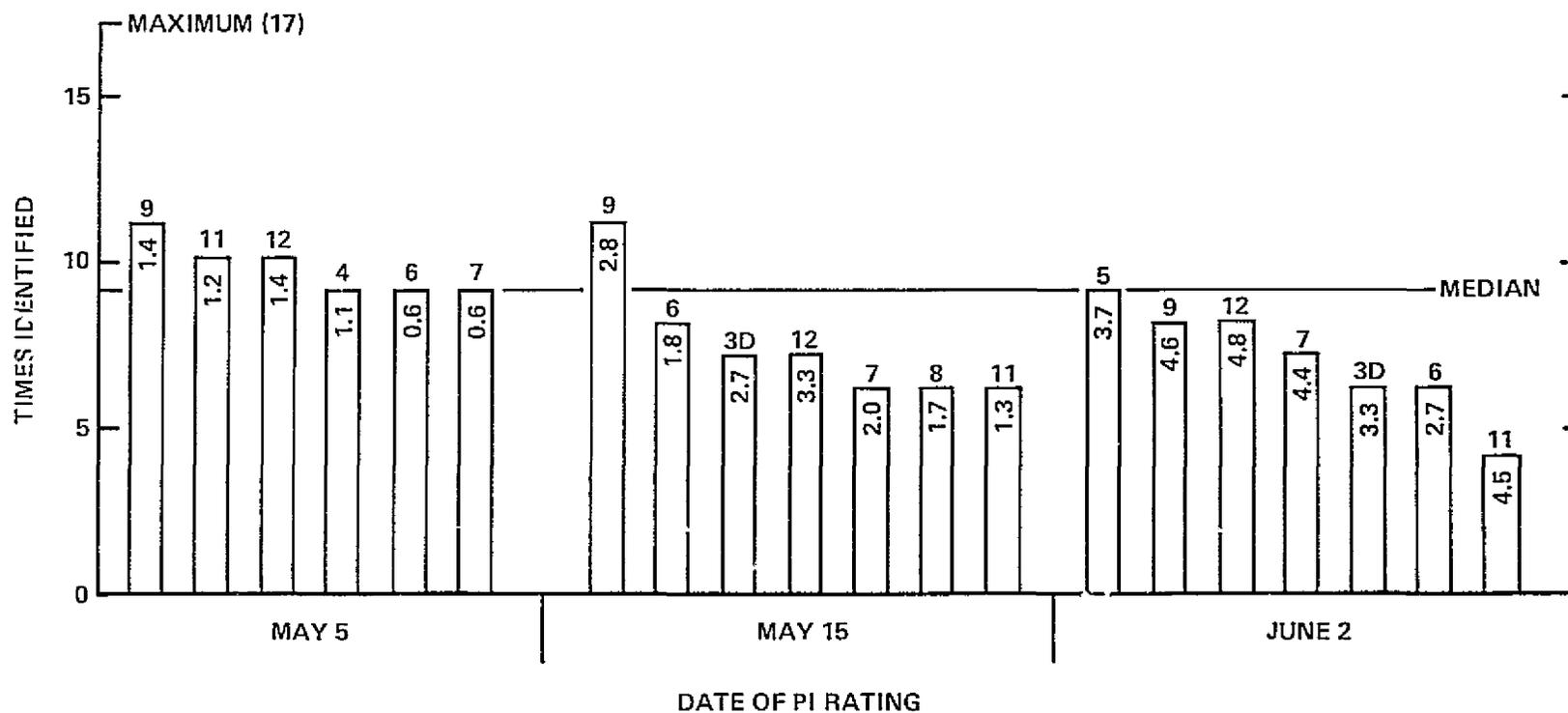
Figure A-10. Areas of minimum EO proficiency.

TABLE A-4 – PRESIMULATION TRAINING LEVEL, 6/2/75

EO	Expmts.	Planning (1, 2, 4, 11)		Operations (3, 10)		Maintenance (6, 7, 8, 9, 12)		All Functions (Avg.)	
		EO	PI	EO	PI	EO	PI	EO	PI
B	P	8.0	8.0	6.1	8.8	4.7	7.5	6.1	8.1
	S	4.5	5.3	5.4	6.1	3.7	4.3	4.5	5.2
C	P	9.0	6.7	8.2	7.7	8.4	5.7	8.5	6.7
	S	6.3	4.9	4.7	6.9	4.8	4.6	5.2	5.5
A	P	9.0	8.3	9.0	9.0	8.4	7.8	8.8	8.4
	S	8.3	7.4	8.6	7.2	7.9	5.4	8.3	6.6
D	P	6.0	6.8	5.2	8.4	5.4	9.0	5.5	8.2
	S	5.4	5.5	5.0	5.0	3.6	4.4	4.6	4.9
Avg.	P - S	1.9	1.7	1.2	2.2	1.7	2.8	1.6	2.3
Avg.	P	8.0	7.5	7.1	8.5	6.7	7.5	7.2	7.9
Avg.	S	6.1	5.6	5.9	6.3	5.0	4.7	5.7	5.6

INFLIGHT PERFORMANCE

Table A-5 describes EO assignments in terms of the scientific objectives of each experiment and the specific tasks associated with their attainment. Specific operating procedures involved are given in the final section of this appendix. A brief description of EO activities and significant events that occurred during the simulation week (flights 5 - 9) is given below, followed by a discussion of EO performance in terms of target acquisition, ability to resolve problems during flight or on the ground, and interactions among the EO across experimental assignment boundaries. Where appropriate, comparisons are made with PI performance in similar situations during postsimulation flights.

Flight Activities

Figure A-11 gives timeline information on EO activities during the five flights of the simulation week. Open blocks represent the periods during which an EO was attempting to collect data. The available time on astronomical targets is placed under the Meudon/Groningen or Ames operation timeline since all targets except Venus were of interest primarily only to these experiments. The Southampton timeline is separated into three components - the photometer, 180° FOV camera, and TV - because these elements (mostly accidentally) had somewhat different periods. The two modes of operation for the Alaska experiment, telescope and skyglow, are also shown on separate timelines. During flights 5 and 7 the Ames EO (operator D) was off duty and spent his time trouble-shooting the Ames dewar/detector. These periods of activity are shown above the Meudon/Groningen timeline. The Ames dewar was not attached to the Meudon telescope during these tests.

Flight 5

The assignments for flight 5 called for both Alaska and Colorado to obtain Venus data (fig. A-11(a)). However, the EO had difficulties acquiring Venus (no boresight). When he did acquire the target, he was unable to get the Colorado computer up so neither PI got Venus data. This EO then got JPL and Alaska up in skyglow modes and then intermittently tried to put the Colorado experiment into operation. During an aircraft-related deviation from the planned course (approximately 2300), the Meudon/Groningen EO conducted system noise checks. The Southampton EO forgot completely to turn on the 180° FOV camera. Finally, an interruption in the New Mexico data was caused by a lightning storm in its line of sight, and the EO turned the system off temporarily.

Flight 6

Flight 6 was less hectic than flight 5. However, Colorado and Alaska again both requested Venus data, and again the EO was slow in acquiring. Some Venus data were collected but for only one PI. The interrupted Colorado timeline shows the effect of conflicting operating priorities. The experiment was on standby for a good portion of the flight because the EO didn't have the time to set it up for data collection (airglow after Venus) as frequently as required by its operation. The interruption in JPL data was caused by ADDAS being down; since this meant no permanent record the EO chose to go temporarily to standby.

Flight 7

Flight 7 was only moderately successful. The Meudon/Groningen experiment had low sensitivity throughout the flight. Venus drifted out of the telescope's window, and the EO spent the next two hours trying to diagnose the cause. He developed some theories, but no solutions. The Colorado EO also had problems. The spectrometer kept stalling, and the EO devised a method to start it each time. This same EO was successful in switching the Venus signal from Alaska to Colorado during

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TABLE A-5. EO ASSIGNMENTS DURING THE SIMULATION PERIOD, BY FLIGHT AND OPERATOR

Flight	Operator	Experiment	Objectives and Tasks
5	A	Meudon/ Groningen	Obtain spectra of Venus; map area of S Cephi, M-17 and ρ Oph.
	B	Southampton	Obtain TV pictures of airglow; obtain airglow photographs with the Nikon camera in a prescribed sequence; operate the photometer (let it run).
		QMC	Run interferograms on atmospheric emissions in far IR.
		New Mexico	Obtain photographs of OH airglow in dark sky. Record sky parameters every 30 minutes. Operate the photometer (let it run).
	C	JPL	UV skyglow measurements on all legs.
		Colorado	Obtain Venus spectra; obtain airglow through 14° window during ρ Oph leg with star tracker off and heliostat tracking on.
		Alaska	UV spectral scans on Venus, scattered sunlight, O_2 Herzberg nightglow, OH Meinel nightglow.
	D		Off duty. Conduct microphonics tests on Ames photometer.
6	A	Meudon/ Groningen	Obtain spectra of Venus; map area of S Cephi, M-17 and ρ Oph.
	B	Southampton	Obtain TV pictures of airglow; obtain airglow photographs with the Nikon camera in a prescribed sequence; operate the photometer (let it run).
		New Mexico	Obtain photographs of OH airglow in night sky. Record sky parameters every 30 minutes. Operate the photometer (let it run).
		QMC	Run interferograms on atmospheric emissions in far IR.
	C		Off duty.
	D	JPL	UV skyglow measurements on all legs.
		Alaska	UV spectral scans on Venus, OH Meinel nightglow.
		Colorado	Obtain spectra of Venus; do airglow through 14° window during ρ Oph and M-17 legs with star tracker off and heliostat tracking on.
7	A	Meudon/ Groningen	Obtain spectra of Venus, NGC 7000; map area of ρ Oph.

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Flight	Operator	Experiment	Objectives and Tasks
7	B	JPL	UV skyglow on all legs.
		Alaska	Obtain spectral scans on Venus, nightglow O_2, nightglow 5517, nightglow OH.
		Colorado	Skyglow measurements on all legs except τ Scor. Attempt to track this star on ρ Oph leg.
	C	New Mexico	Obtain photographs of OH airglow in night sky. Record sky parameters every 30 minutes. Operate the photometer (let it run).
		Southampton	Obtain TV pictures of airglow and meteors; obtain airglow and meteor photographs with the Nikon camera in a prescribed sequence; operate the photometer (let it run).
		QMC	Obtain interferograms on atmospheric emissions in far IR.
	D		Off duty. Conduct microphonics tests on Ames photometer.
8	A	New Mexico	Obtain photographs of OH airglow during night sky. Record sky parameters every 30 minutes. Operate the photometer (let it run).
		Southampton	Obtain TV pictures of airglow; obtain airglow photographs with the Nikon camera in a prescribed sequence; operate the photometer (let it run).
		QMC	Run interferograms on atmospheric emission in far IR.
	B		Off duty.
	C	Alaska	UV spectral scans on Venus, scattered sunlight, O_2 Herzberg airglow, OH Meinel airglow.
		JPL	Try to get sunset airglow on Venus leg.
		Colorado	Obtain spectra on Venus and Alpha Virginis.
	D	Ames	Obtain spectra on Venus, Alpha Herculis, IRC-10216, α Vir (Spica), and α Cyg (Deneb).
9	A		Off duty.
	B	QMC	Run interferograms on atmospheric emission in far IR.
		Southampton	Obtain TV pictures of meteors; obtain meteor photographs with the Nikon camera in a pre-

38

Flight	Operator	Experiment	Objectives and Tasks
9	B	Southhampton (cont.)	scribed sequence; operate the photometer (let it run).
		New Mexico	Obtain photographs of OH airglow in nig sky. Record sky parameters every 30 minutes.
	C	Alaska	UV spectral scans on Venus, OH Meinel airglow.
		JPL	UV astronomy on Venus.
		Colorado	Obtain UV spectra on Venus, OH Meinel airglow.
	D	Ames	Obtain spectra on Venus.

QMC

SH
CAMERA
PHOTOMETER
TV
NO DATA ACQUIRED

NM

AMES

MEU/GRON
|←VENUS→| |←— S-CEPH —→|

COLO
(TELESCOPE)

JPL
TAOF (UV)

AL
TELESCOPE
SKY GLOW
NO DATA ACQUIRED

TO

TD
LAS VEGAS

2000   2200   2400   0200

TIME (PDT) HOURS

▨ TROUBLESHOOT   ▥ SYSTEM NOISE CHECK
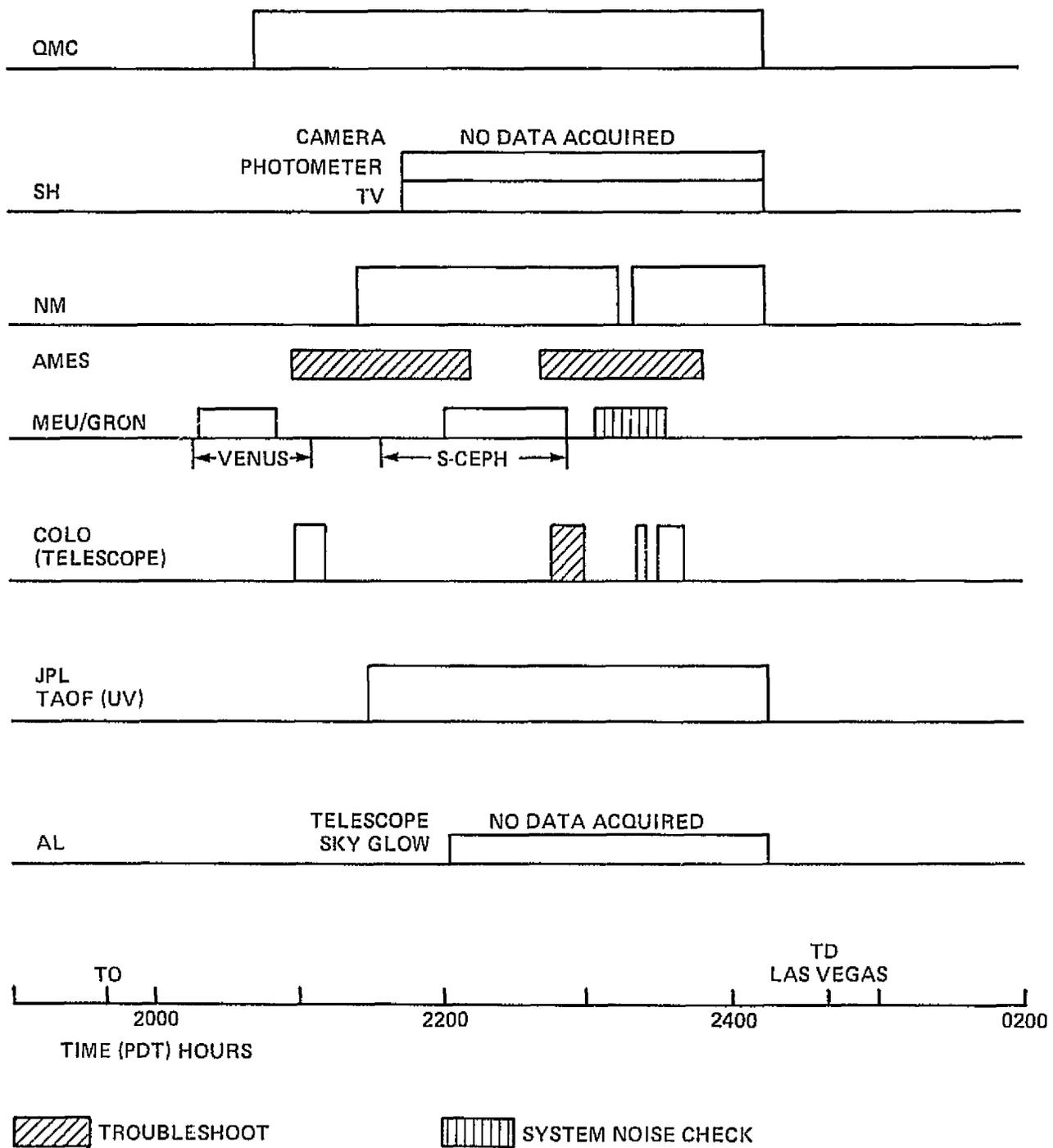
(a) Flight 5.

Figure A-11.   EO activities during simulation flights.

40

QMC

SH
    CAMERA
    PHOTOMETER
    TV

NM

MEU/GRON

VENUS   S-CEPH   M-17 ρ-OPH

COLO
(TELESCOPE)

JPL
TAOF (UV)

AL
TELESCOPE
AIR GLOW   NO DATA ACQUIRED

TO   TD

2000   2200   2400   0200
TIME (PDT) HOURS
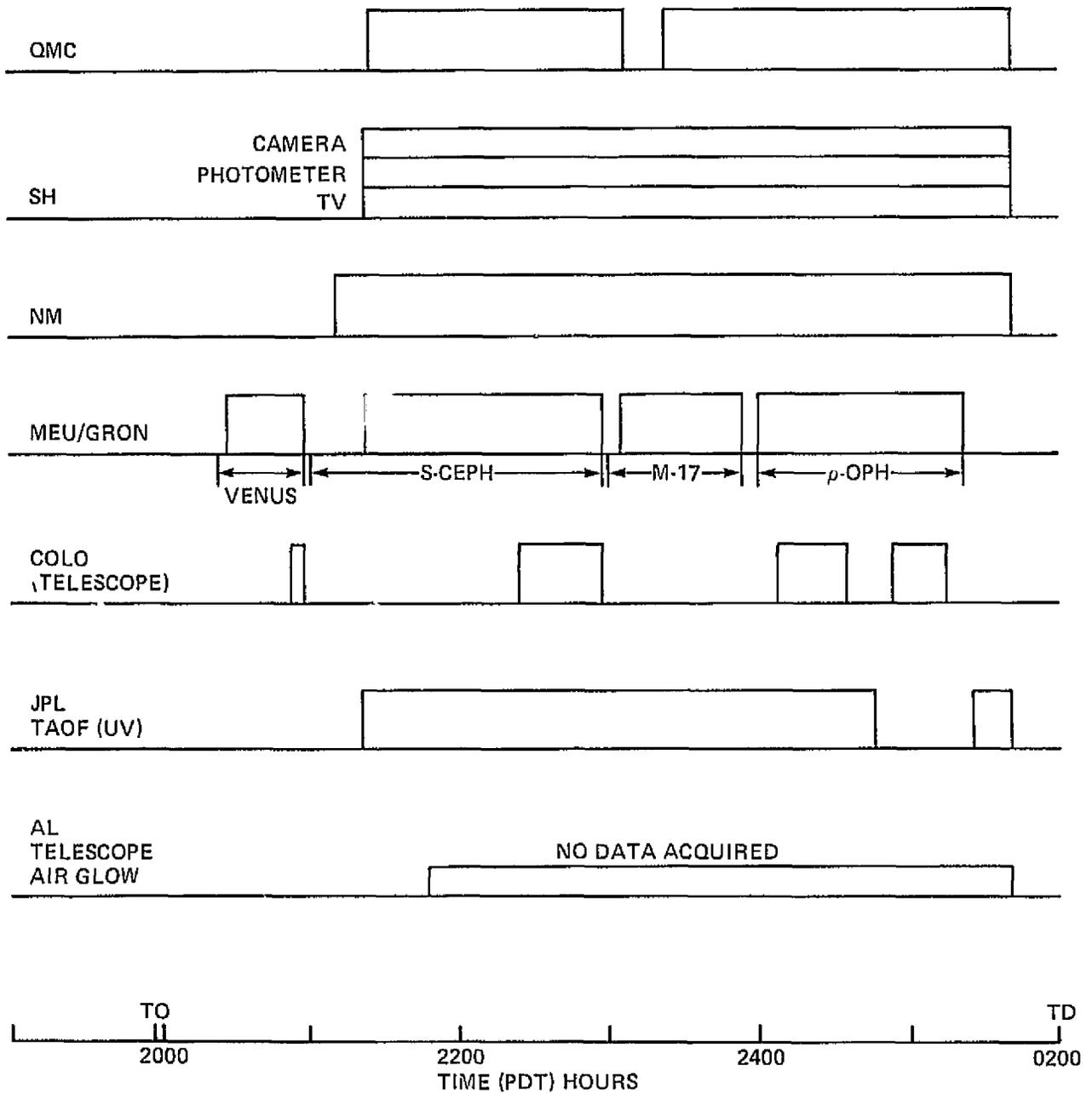
(b) Flight 6.

Figure A-11. Continued.

41

QMC

SH
         TV
PHOTOMETER
  CAMERA

NM

AMES

MEU/GRON
←——VENUS——→ →NGC7000 ←—|←———p-OPH———→

COLO
(TELESCOPE)

JPL
TAOF (UV)

AL
TELESCOPE
SKY GLOW

TO   TD
   2000   2200   2400   0200
TIME (PDT) HOURS

///// TROUBLESHOOTING
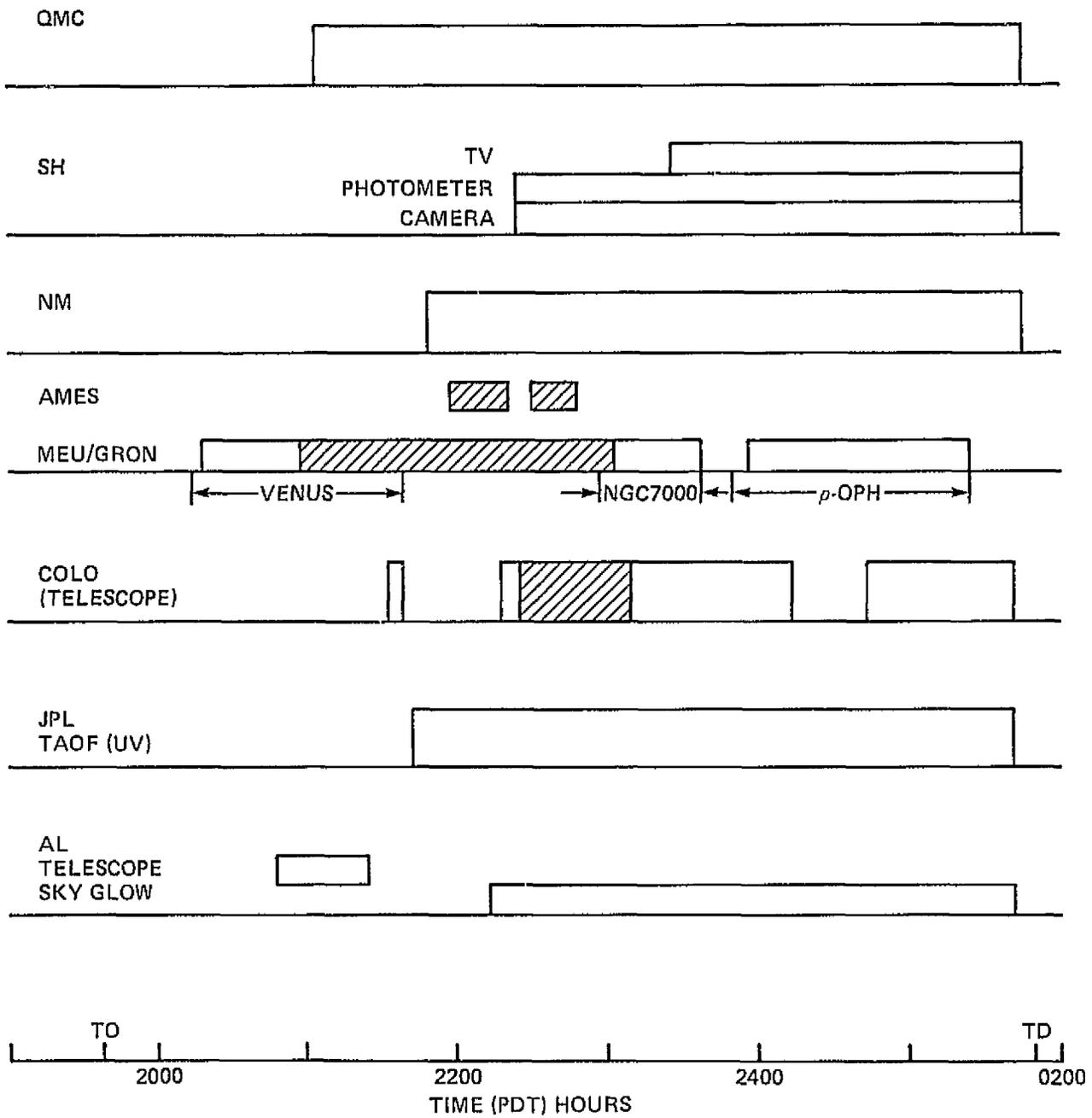
(c) Flight 7.

Figure A-11.— Continued.

42

QMC

SH
CAMERA
TV
PHOTOMETER

NM

AMES

TARGETS | VENUS | α-HERC | IRC +10216 | α-VIRGO | DENEB |

COLO
(TELESCOPE)

←———STANDBY———→

JPL
TAOF (UV)

AL
TELESCOPE
SKY GLOW

NO DATA ACQUIRED

TO

2000   2200   2400

TD

0200
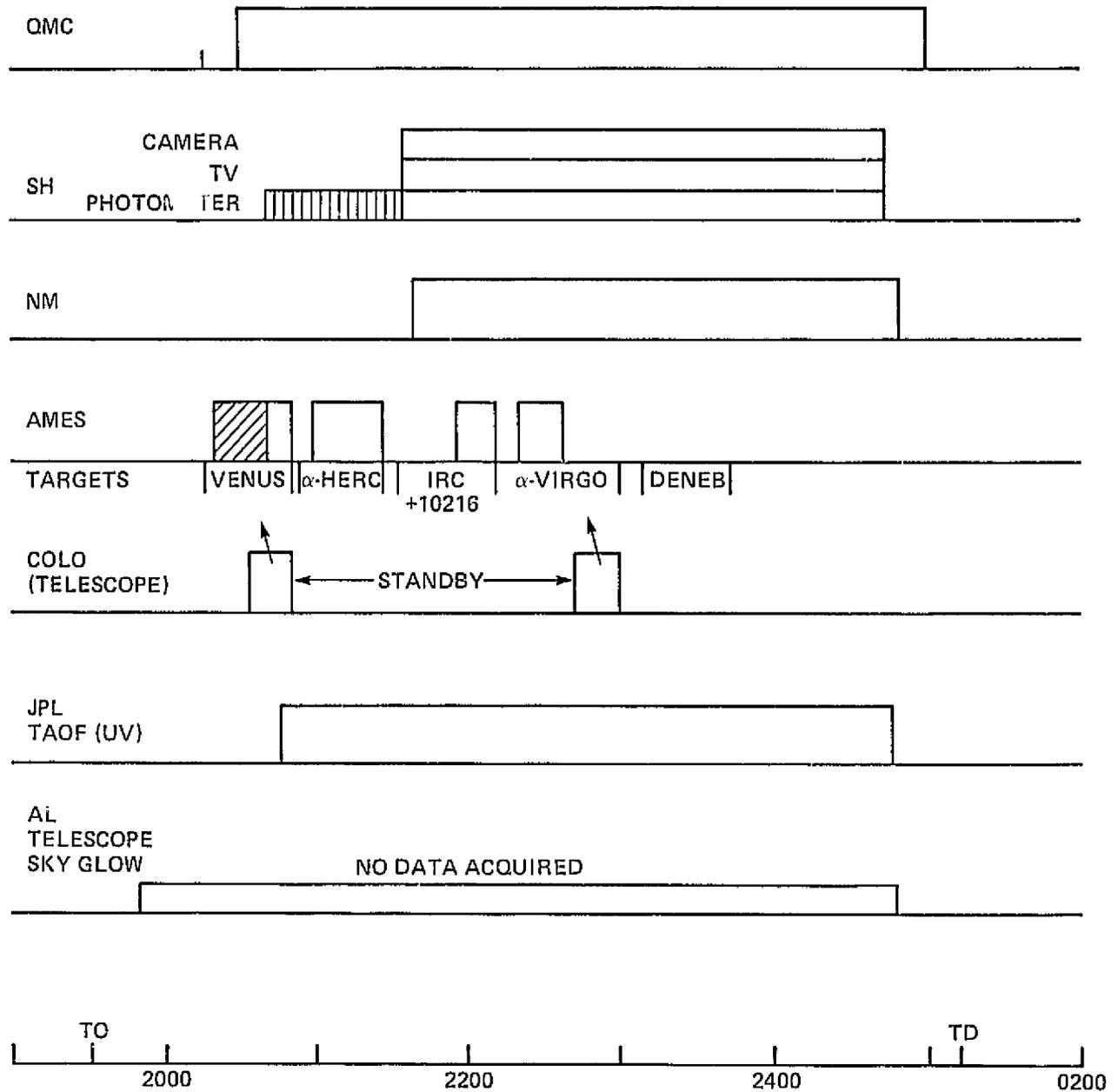
▨ ALIGN OPTICS   ▥ CALIBRATE

(d) Flight 8.

Figure A-11. Continued.

43
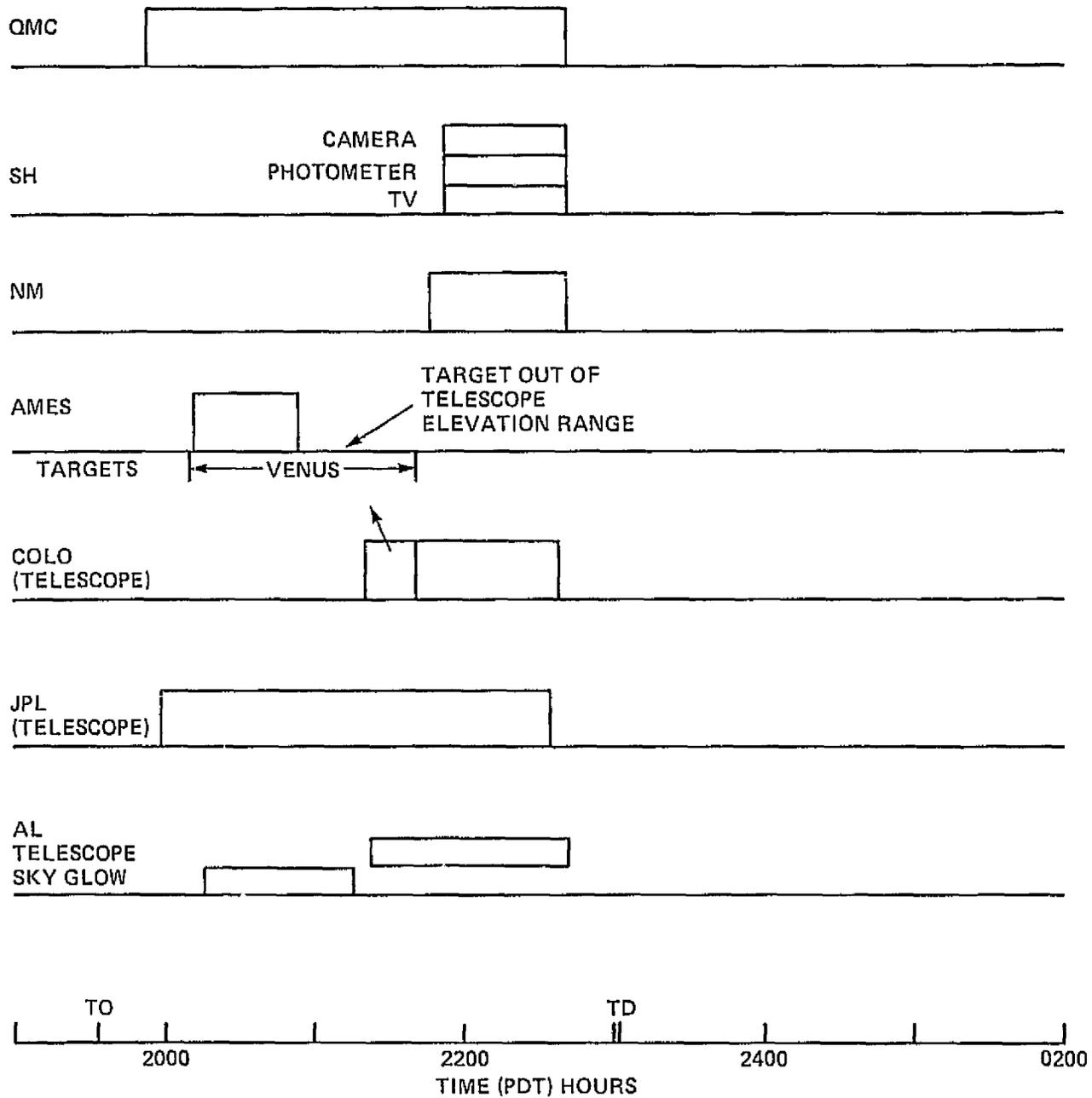
(e) Flight 9.

Figure A-11. Concluded.

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that leg of the flight. Finally, the Southampton TV tape recorder was set up incorrectly during the first hour of experiment operation.

Flight 8

During flight 8 a repeated request by the Southampton PI for photometer dark current was finally carried out: the photometer was turned on early, but with the lens capped to exclude external radiation. This flight was the first for the Ames experiment, and the EO spent much of the first data leg aligning optics. He also found that he could not guide consistently on α-Virgo and made no concerted effort to do so. He made no attempt to guide on Deneb. Both targets had been requested by the Ames PI, but were considered of less importance than the first three targets of the flight. The long standby period for the Colorado experiment between Venus and α-Virgo was as planned. Alaska also wanted Venus data on this leg, but the EO chose to set up Alaska for airglow and concentrate on getting the Venus data for Colorado.

Flight 9

Flight 9 was only about half the length of other flights, and included only a Venus leg and a reverse leg back to Ames. Until late in the flight, the sky was too bright for Southampton and New Mexico. The Alaska/Colorado EO acquired Venus early for Alaska, and later in the Venus leg he was able to switch the signal to the Colorado experiment. This had been done on flight 7 but not nearly as successfully. Operator C also had the JPL experiment on-line, but failed to acquire any useful scientific data. Operator D on the Ames experiment obtained some very good data on Venus until the target moved out of the elevation range of the Meudon telescope.

EO/PI Flight Events Comparison

For comparison purposes, figure A-12 shows the activities on a "typical" PI flight (12). The differences result basically from the availability of more PI operators with more time at their disposal. Calibration activities took place on every PI flight. Calibration had been possible on only two EO flights (5 and 8) owing to the tight timelines that characterized the confined flights. Again, because of time, such activities as reading data from magnetic tape onto strip chart took place on the ground during the EO operating period, while the PIs did these tasks in flight.

The availability of more operators on the PI flights also allowed more complex operations. New Mexico shifted some components to the right side of the aircraft under certain viewing conditions. Colorado, now a two-man operation if required, chose astronomical targets of opportunity (i.e., not scheduled).

Operational Effectiveness and Data Quality

Table A-6 summarizes EO inflight performance during the simulation period in terms of time effectiveness, expressed as a percent of available time (time on track) that the experiment was operated to acquire data, and data quality based on PI estimates made at the end of the simulation period. Figure A-13 shows EO performance in terms of data quality achieved for each experiment, by flight. It is immediately apparent in Table A-6 that results were better for all-sky observations than for astronomical targets involving acquisition and guiding functions, and depending on aircraft position and stability. Thus, EOs whose major assignment was astronomy usually scored lower than those making all-sky observations. When equipment was operating normally, the EOs produced average or better data; when problems occurred, the quality of their product dropped sharply. Overall, the results are distinctly favorable. Experiments were maintained in operable condition to produce useful quality data for nearly three-fourths of the time available to the EOs.

45
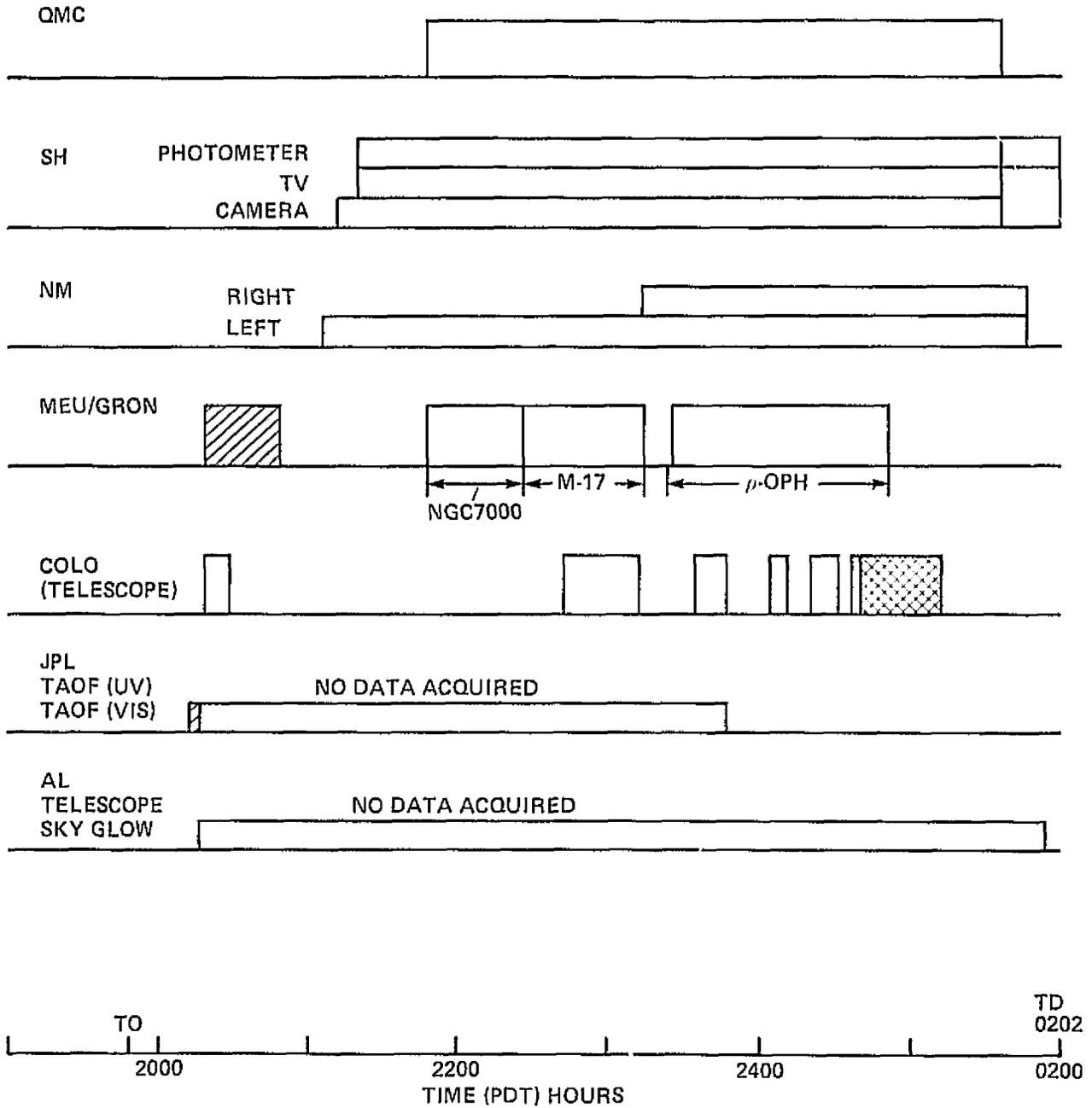
FLIGHT 12

Figure A-12. PI activities on a representative post-simulation flight (Flight 12).

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TABLE A-6.— EO INFLIGHT PERFORMANCE RATINGS

EO	Number of observation periods		Percent of available time utilized			Data quality estimates (PI)*					
						Type of observation		Average of all observation periods	Type of operation		
	Astron. targets	All-sky	All	Astron. targets	All-sky	Astron. targets	All-sky		Normal	Equipment problems
A	9	3	80	75	95	1.4	3.3	1.9	4.0	1.5
B	2	14	77	65	79	2.5	3.0	2.9	2.9	2.5
C	6	12	74	40	91	1.8	2.2	2.1	2.4	0.5
D	7	3	54	40	85	1.7	1.5	1.7	1.9	1.2
All	24	52	73	56	86	1.7	2.5	2.3		

*Data quality scale applied to PI estimates:

    4 = Excellent   11 times
    3 = Good   11 times
    2 = Fair   18 times
    1 = Poor   10 times
    0 = No data   6 times

47
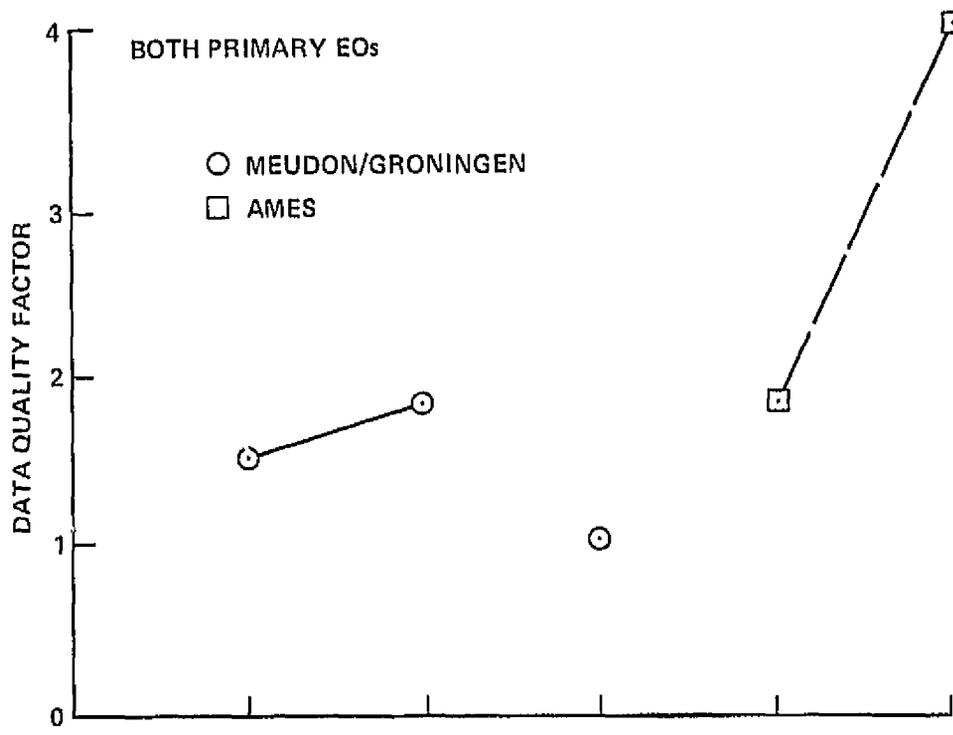
(a) Primary operators A & D
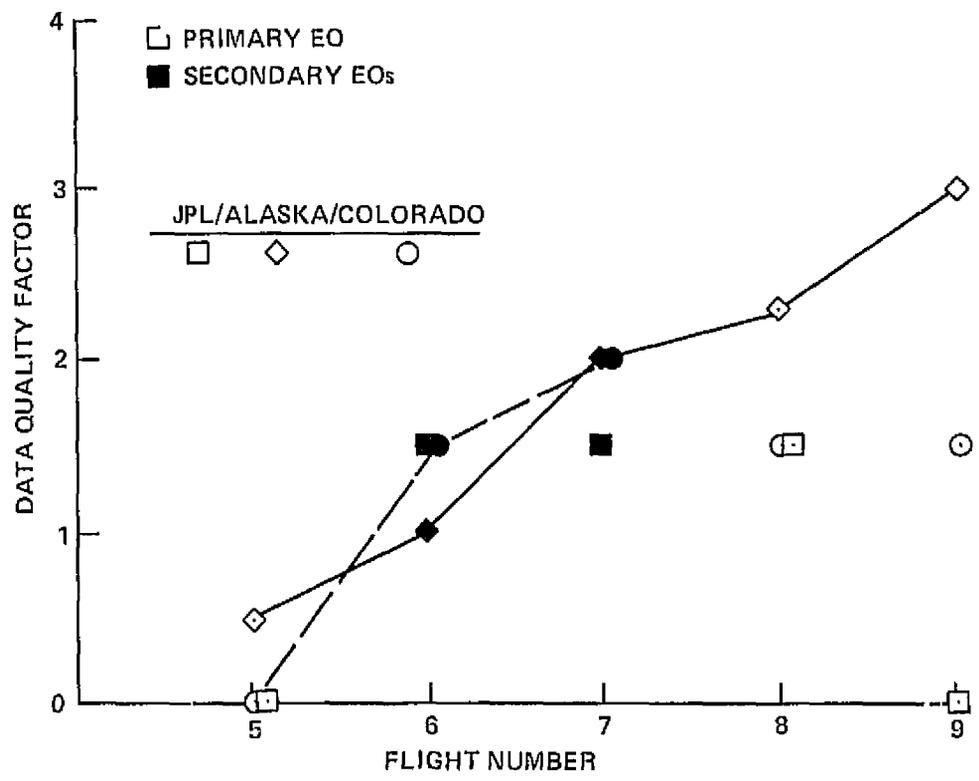
(b) Primary operator C

Figure A-13.   EO performance on simulation flights; data quality estimates by PIs.

(c) Primary operator B
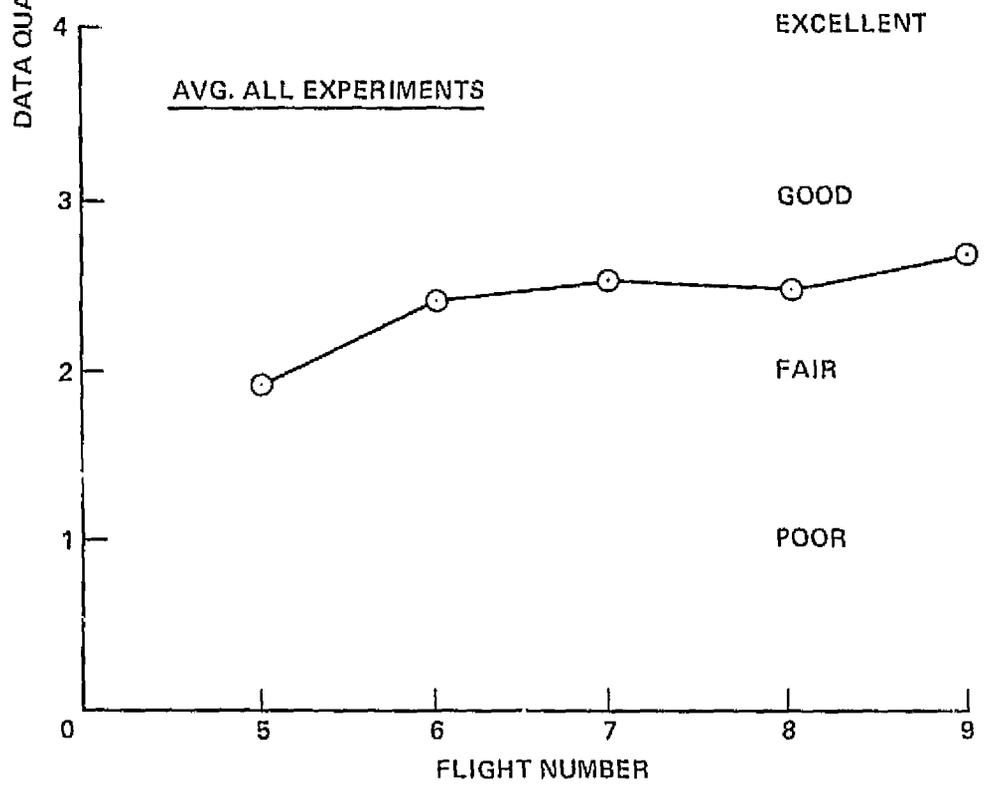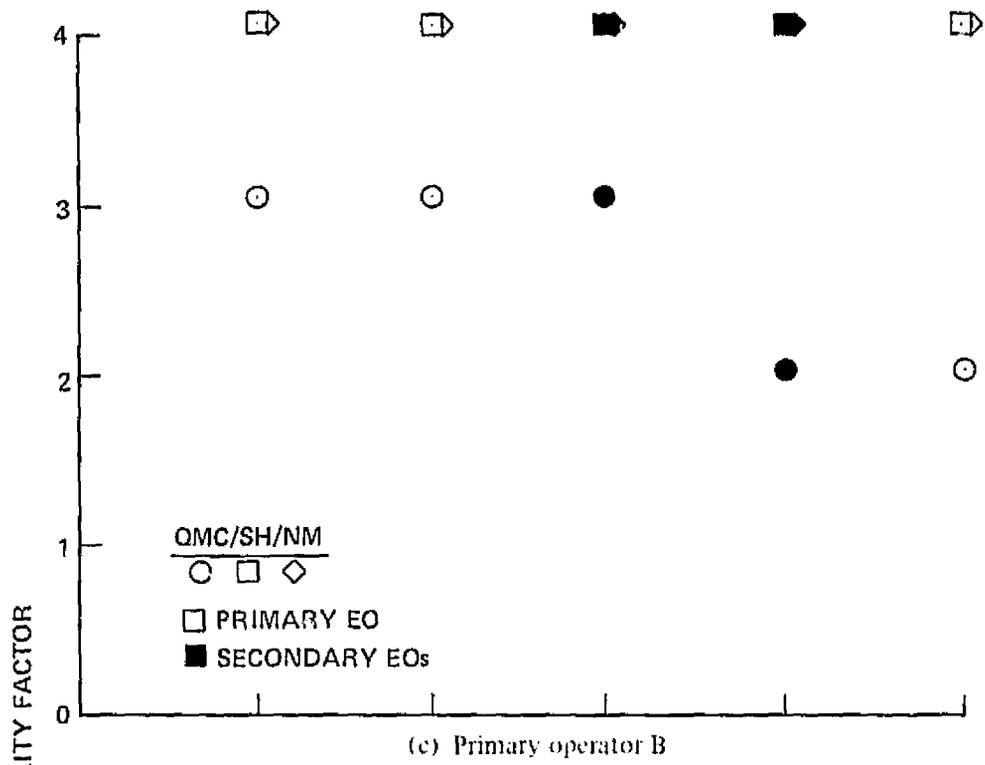
(d) Average for all EOs.

Figure A-13. Concluded.

Operator performance showed a distinct improvement as the simulation mission progressed, except when a serious equipment problem affected data acquisition (fig. A-13). The most notable examples are the Alaska and Ames experiments. It appears that secondary (or alternate primary) operators benefited from the experience of their associates on these same experiments, since their first-time operation was usually better than on the previous flight. Operators of the Queen Mary/Southampton New Mexico group performed well from the start; the latter two experiments were well automated and observed in a skyglow mode, which made their tasks somewhat simpler. The relatively poor results on Meudon for flight 7, JPL for flight 9, and QMC on both 8 and 9 were caused by equipment problems. Figure A-13(d) summarizes data quality for the entire instrument payload, for the five EO flights, and shows a general trend of improving performance.

Comparison of EO and PI Operating Performance

Differing modes of operation were employed in EO and PI data flights. During the PI flights, there was a large increase in manpower (from 3 to 14), which allowed operator specialization, and the experimenters had free access to equipment and outside support. In addition, significant changes were made on six of the eight experiments to improve data acquisition and quality. In combination, these factors should have created near-optimum operating condition for the PIs, within the normal constraints of airborne research, during the seven postsimulation flights. The following comparisons are made with this in mind.

Table A-7 gives manpower loading, observation time, and data quality by individual experiment for both flight periods. Data quality is again based on PI estimates rated on the 0 to 4 scale. Overall, the results for EO and PI operation are comparable, in itself sufficient reason to commend the EOs' performance. There are some other notable factors that require attention, however. First, during the PI flights there was a substantial calibration effort for four experiments, as opposed to a modest effort for only one during the simulation period. This effort combined with actual observation times gives seven of the eight experiments a significantly longer period of operation by the PIs, clearly a reflection of the greater manpower loading. On the other hand, the data quality achieved by the PIs is not generally superior to that of the EOs. Of the three apparently significant improvements in data quality during the PI flights, two (Meudon and Colorado) were influenced strongly by experiment changes that would have similarly benefited the EOs. Of the remaining five experiments, three achieved slightly better data quality during PI operation and two (New Mexico and Southampton) suffered some reduction in quality due to sky brightness from various sources (e.g., the Moon) that interfered with their observations.

The overall comparison at the bottom of table A-7 shows PI performance some 30 percent better in operating time and 20 percent in data quality, but about the same in utilization of available observing time. If the PIs were operating at near peak effectiveness for the given conditions, then the EOs were able to achieve about 75 percent of this level with less than one-fourth the manpower. Without question, this was an outstanding accomplishment.

Payload data quality for the three mission flight periods is compared in figure A-14, again on a 0-4 rating scale. Both PIs and EOs were significantly better on their second flight (flights 2 and 6, respectively), and continued to improve with experience at about the same rate. Postsimulation flights benefited from experiment improvements and increased manpower at first, but then were adversely impacted by sky brightness and flight constraints to accomodate specific experiments.

To further clarify the relative performance of the two groups, table A-8 ranks experiments in order of improvement on PI flights and indicates the primary reasons for the observed differences. Results are given in terms of observation time and data quality. Again, manpower loading

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TABLE A-7. COMPARISON OF EO AND PI PERFORMANCE

Experiment	Operator	Average manpower loading	Target observation time per flight (avg)*		Data quality estimates (PI)		Calibration time per flight, minutes
			Minutes	Percent of available	No. obser. periods	Overall rating	
Meudon/ Groningen	EO (P)	1	155	72	9	1.4	6
	PI	3-1/2	121	77	14	2.9	79
Queen Mary College	EO (P)	1/3	80	47	3	2.7	0
	EO (S)	1/3	185	74	2	2.5	0
	PI	1-3/4	222	66	7	2.6	29
Southampton	EO (P)	1/3	200	100	3	4.0	0
	EO (S)	1/3	240	89	2	4.0	0
	PI	1-3/4	218	99	6	2.8	4
Ames	EO (P)	1	59	48	5	1.7	0
	PI	3	60	48	2	2.0	38
JPL	EO (P)	1/3	190	100	3	0.5	0
	EO (S)	1/3	233	93	2	1.5	0
	PI	2	215	63	9	1.0	39
Alaska	EO (P)	1/3	190	92	7	2.1	0
	EO (S)	1/3	233	93	6	1.7	0
	PI	1-3/4	278	87	13	3.5	6
Colorado	EO (P)	1/3	39	44	5	2.0	0
	EO (S)	1/3	104	65	4	1.8	0
	PI	1	109	33	16	3.4	0
New Mexico	EO (P)	1/3	158	90	3	4.0	0
	EO (S)	1/3	193	98	2	4.0	0
	PI	2	263	100	5	3.8	0

*Not including calibration periods.
(P) Primary assignment
(S) Secondary assignment
   Overall ratios:

   • Manpower loading, PI/EO = 14/3 = 4.7
   • Operating time (incl. calib.)/expmt. flight, PI/EO = 205/158 = 1.3
   • Utilization available observing time/expmt. flight,
      PI/EO = 0.74/0.76 = 1.0
   • Data quality rating/expmt. obsv. period, PI/EO = 2.8/2.4 = 1.2
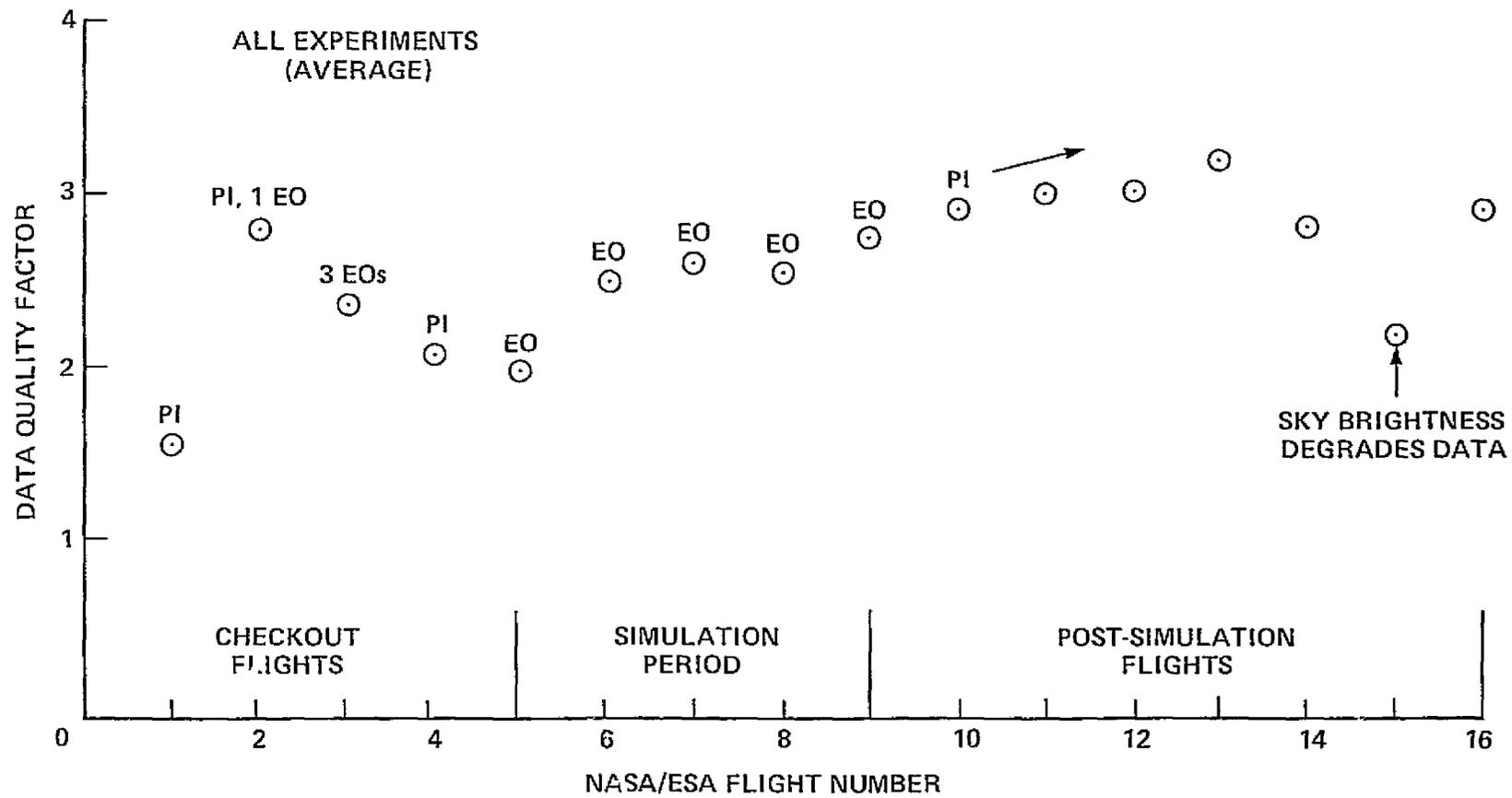
Figure A-14.— Overall performance of EO team compared to PI teams.

TABLE A-8. RATIOS OF PI TO EO PERFORMANCE BY ORDER OF IMPROVEMENT

Experiment	Ratio of observing times, PI/EO, per flight	Primary reasons for change in performance
QMC (1)	1.81	Full attention of PI
Colorado (2)	1.60	Full attention of co-investigator; no time sharing of Alaska telescope
UNM (1)	1.52	PI observations both sides of aircraft, so more time available
Alaska (2)	1.34	No time sharing with Colorado; full attention of co-investigator
JPL (2)	1.04	Automated skyglow measurements for both EOs and PIs
Ames	1.02	Limited PI experience with system; some calibration
Southampton (1)	1.01	Experiment required little attention
Meudon/Groningen	0.78	Extensive calibrations by PI
Group (1) average	1.45	Available manpower
Group (2) average	1.33	No time-sharing manpower or equipment
Single experiments average	0.90	Calibration requirements

(a) Observing time.

Experiment	Ratio of data quality, PI/EO, all observations	Primary reasons for change in performance
Meudon/Groningen	2.07	Increased signal strength
Alaska (2)	1.84	Automated skyglow measurements (PI)
Colorado (2)	1.79	Much improved optics for co-investigator
Ames	1.19	Experienced telescope operator (Meudon); increased signal strength
JPL (2)	1.11	Greater experience of PI with unproven instruments
QMC (1)	1.00	RFI and ADDAS problems for both EOs and PIs
UNM (1)	0.95	High-quality data for both
Southampton (1)	0.70	Reduced by sky brightness for PI
Group (1) average	0.88	Environment and support problems
Group (2) average	1.58	Improved input signal
Single experiments average	1.63	Improved input signal

(b) Data quality.

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and equipment changes account for the longer time periods and better data quality, respectively.

Responses to Operating Problems and Experiment Malfunctions

EO response to experiment and enviro.mental problems is a primary element in the total performance equation. The capability to evaluate and resolve problems will be vital to the success of a Spacelab mission, as it was to the Joint ASSESS Mission. In this respect the present experience was a realistic analogue. Both the physical isolation and the means of communication were designed to duplicate the essential constraints of the Spacelab.

Problems encountered and EO responses are summarized in table A-9. (Appendix A in the final report volume provides more descriptive information and analysis.) Sixty-nine events were identified, of which almost three-fourths were in the experiment, less than one-fourth were caused by the operator, and the remainder by the vehicle and/or its support systems (GFE). More than two-thirds occurred while an EO was operating his primary experiment. Corrective measures resolved 29 problems during flight, 10 of which involved assistance from another EO or the Mission Manager. In another 25 cases, the EO took positive action to troubleshoot the malfunction or to adjust his procedures to "live with" it. Only 15 problems were deferred for resolution after flight, and of these there were only two that caused experiment operations to cease (one each on Ames and Colorado).

An interesting general finding, evident in table A-9, was the relatively greater incidence of problems with the operation of the grouped experiments. Operators B and C were responsible for grouped experiments (three) on both their primary and secondary assignments, while operators A and D operated a single experiment on their primary assignment and one of the groups of three as secondary. The amount of electronic equipment each EO had to contend with was roughly the same. The multipurpose aspect of the grouped experiments may account for the larger number of problems; three or more times as many simultaneous measurements were being made.

Table A-10 compares the frequency and resolution of only experiment malfunctions for the simulation and postsimulation periods. The total number was similar for both periods, but during the PI flights, over two-thirds of the malfunctions were concentrated in the QMC and JPL experiments (RFI was a major problem for both, as it had been earlier). The significant conclusion from the data in table A-10 is that the EOs were able to solve a larger number and proportion of problems than the PIs, most notably in flight without PI support. Some of the more serious problems required assistance from the PIs after flight, but postflight aid of this kind was an accepted mission guideline and does not detract from EO performance. In addition to the EOs' competent handling of normal experiment operations, they also responded effectively, by PI standards, to equipment malfunctions. It should be noted, however, that both EOs and PIs were unable to solve a substantial number of problems. In a few cases, the impact of these unresolved problems on scientific accomplishment was significant, indicating the need for a more positive management input to the experiment development process.

Operating Errors

Of the 13 operator errors made during the simulation period (table A-9), five were serious (i.e., involving data loss) or potentially serious errors in experiment setup or operation. Four occurred during flight operations, and the fifth occurred on the ground just before takeoff. The latter would have been serious had it not been corrected before the start of the first data leg. No operating errors were observed during PI flights 10-16 following the simulation period.

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TABLE A-9. - PROBLEMS IMPACTING EXPERIMENT OPERATION DURING SIMULATION FLIGHTS

EO	Primary or Secondary	Source and Number			EO Responses				
		Expmt.	GFE	Operators	Corrected in Flight		Other Actions		
					Self	With help	Live with	Troubleshoot	Fix on ground
Operator A	P	6	0	3	0	0	5	3	1
	S	2	0	0	0	1	0	1	0
Operator B	P	14	1	1	6	1	1	3	5
	S	4	1	2	1	4	1	0	1
Operator C	P	11	3	2	7	3	4	0	2
	S	6	0	1	3	1	0	1	2
Operator D	P	3	2	1	0	0	6	0	0
	S	3	0	3	2	0	0	0	4
All	P	34	6	7	13	4	16	6	8
	S	15	1	6	6	6	1	2	7
	All	49	7	13	19	10	17	8	15
	%	71	10	19	28	14	25	11	22
		100%			42%		58%		

TABLE A-10.— MALFUNCTIONS OF EXPERIMENT EQUIPMENT

Experiment	Number of malfunctions		Problem solved				EO required assistance	Problem not solved	
	Simulation flights	Postsimulation flights	In flight		On ground			solved	
			By EO	By PI	By EO	By PI		By EO	By PI
Meudon/ Groningen	4	1	0	0	1	1	0	3	0
QMC	15	16	7	3	2	5	3	6	8
Southampton	4	3	2	0	2	3	1	0	0
Ames	2	1	1	0	0	0	0	1	1
JPL	4	16	0	1	0	1	0	4	14
Alaska	8	2	4	3	3	0	2	1	0
Colorado	11	2	7	2	3	0	3	1	0
UNM	1	3	1	3	0	0	0	0	0
All	49	45	22	12	11	10	9	16	23
Percent	100	100	45	27	22	22	18	33	51

Thirteen errors are not a large statistical sample, but it is instructive to point out certain trends in their occurrence. For example, they were about equally distributed among the EOs, and occurred in similar numbers on primary and secondary experiments. Nine of the 13, and all of the five serious errors were associated with the operation of the grouped experiments, suggesting that a multiplicity of operational goals is considerably more distracting than the operation of one complex experiment with several centrally directed peripheral activities.

With few exceptions, errors occurred the first time an EO operated an experiment in flight. Subsequently, and always on their primary experiments, the EOs were in command of the situation. This same observation has been made for other ASO flight programs. Experimenters who periodically fly the same experiment on the ASO Lear Jet have commented that they must do a certain amount of relearning of inflight operational techniques with each repeat of their mission cycle, particularly if the time between missions is more than a few months.

EO Interactions

The plan to have only three EOs directly involved in experiment operation at any one time was largely successful. Interactions among EOs on duty were not precluded by mission guidelines, and a helpful working relationship developed during the simulation period. On the other hand, interactions with the off-duty EO (except verbally) were at first prohibited and then later allowed, to the extent of simulating the one hour overlap planned for Spacelab.

During the first simulation flight, when each experiment was being operated by its primary EO, there was little need for EO consultation. On subsequent flights, however, when one or more experiments were being operated by secondary EOs, there was considerable interaction among all EOs, including the off-duty EO who had little else to do. As the simulation mission progressed, the EOs began to operate more as a four-man team than as three EOs and a backup, and unsolicited help was frequently offered.

Details of EO interactions are given in figure A-15. The rectangles above the time axis indicate experiment operation, including data collection as well as interruptions for troubleshooting and repairs. Breaks in the operating period indicate a standby condition for an experiment. Blocks below the time axis indicate interactions with the operator cited.

During flight 5 (fig A-15(a)), all experiments were operated by prime EOs. There was no notable interaction. Operator D (off duty) did some troubleshooting of Ames equipment at the Meudon/Groningen station but gave the prime EO no specific assistance.

Late in flight 6 operator C, scheduled to operate QMC/SH/NM on flight 5, obtained several minutes of verbal instruction from the prime EO (B). Again operator A ran his experimental equipment without assistance. Operator C provided considerable assistance to operator D, principally in connection with the Colorado/Alaska guide optics (lack boresight) and target acquisition (poor method in bright sky).

In flight 7 operator B helped C turn on SH (he probably would have had difficulties without this aid). Operator B checked later and found that the SH tape recorder was set wrong, and he again aided in righting the situation. On this flight, operator A could have used some assistance in troubleshooting, but no one knew the system well enough to aid him. Operator D (off duty) mounted part of the JPL experiment for B just after takeoff; subsequently, he gave liberally of his time throughout the flight. The aid provided operator B by operator D, beginning at approximately 0018 hours, was in indentifying the star field of τ-Scorpio and attempting to guide on it. Operator C
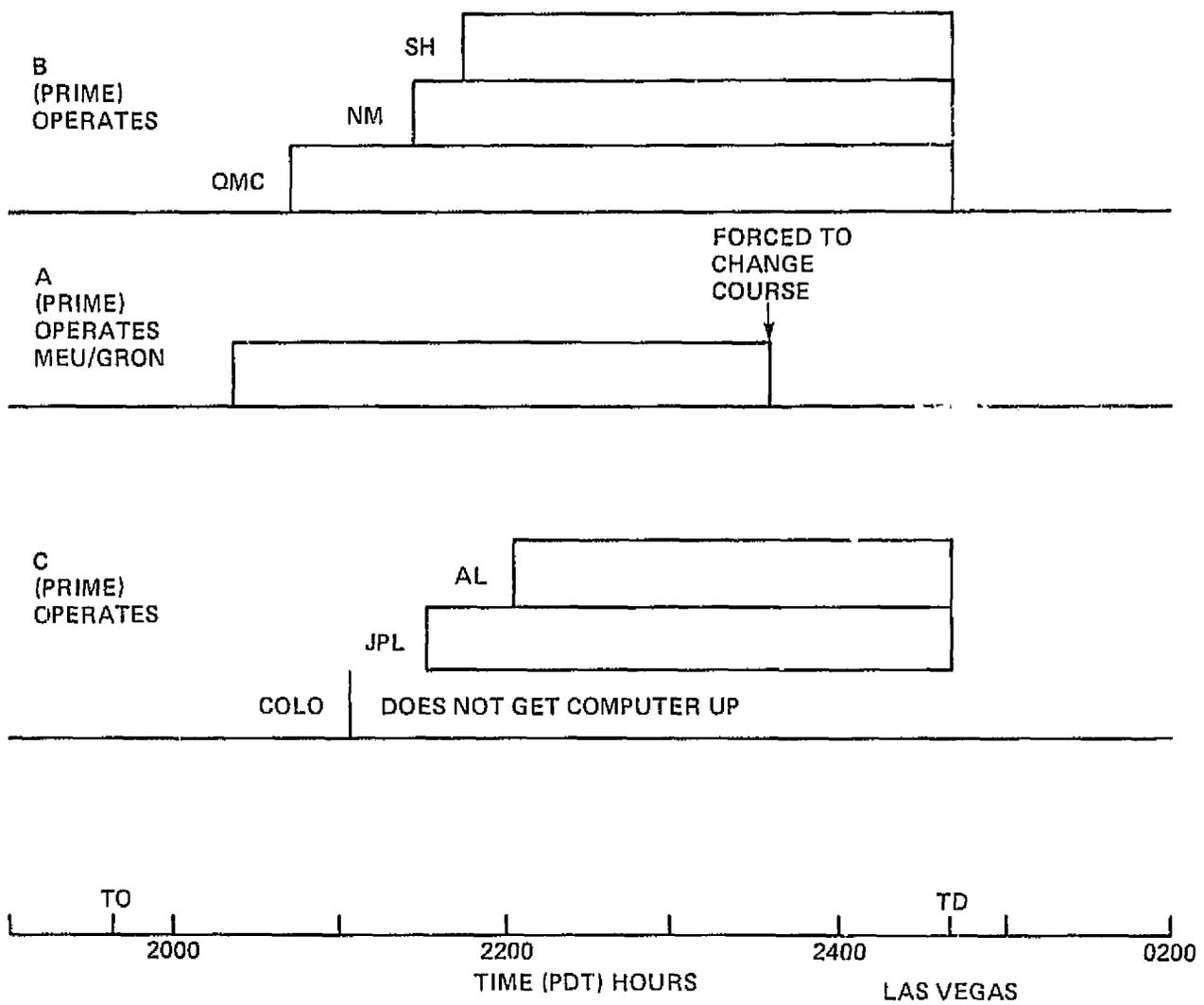
(a) Flight 5.

Figure A-15.— EO interactions in flight.

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B
(PRIME)
OPERATES

QMC

SH

NM

C (OFF DUTY SECONDARY INSTRUCTED BY B)

A
(PRIME)
OPERATES

MEU/GRON

D
(SECONDARY)
OPERATES

AL

JPL

STAND
BY

COLO

←STANDBY→

←STANDBY→

C
(OFF DUTY PRIME)
ASSISTS

TO

TD

2000

2200

2400

0200

TIME (PDT) HOURS
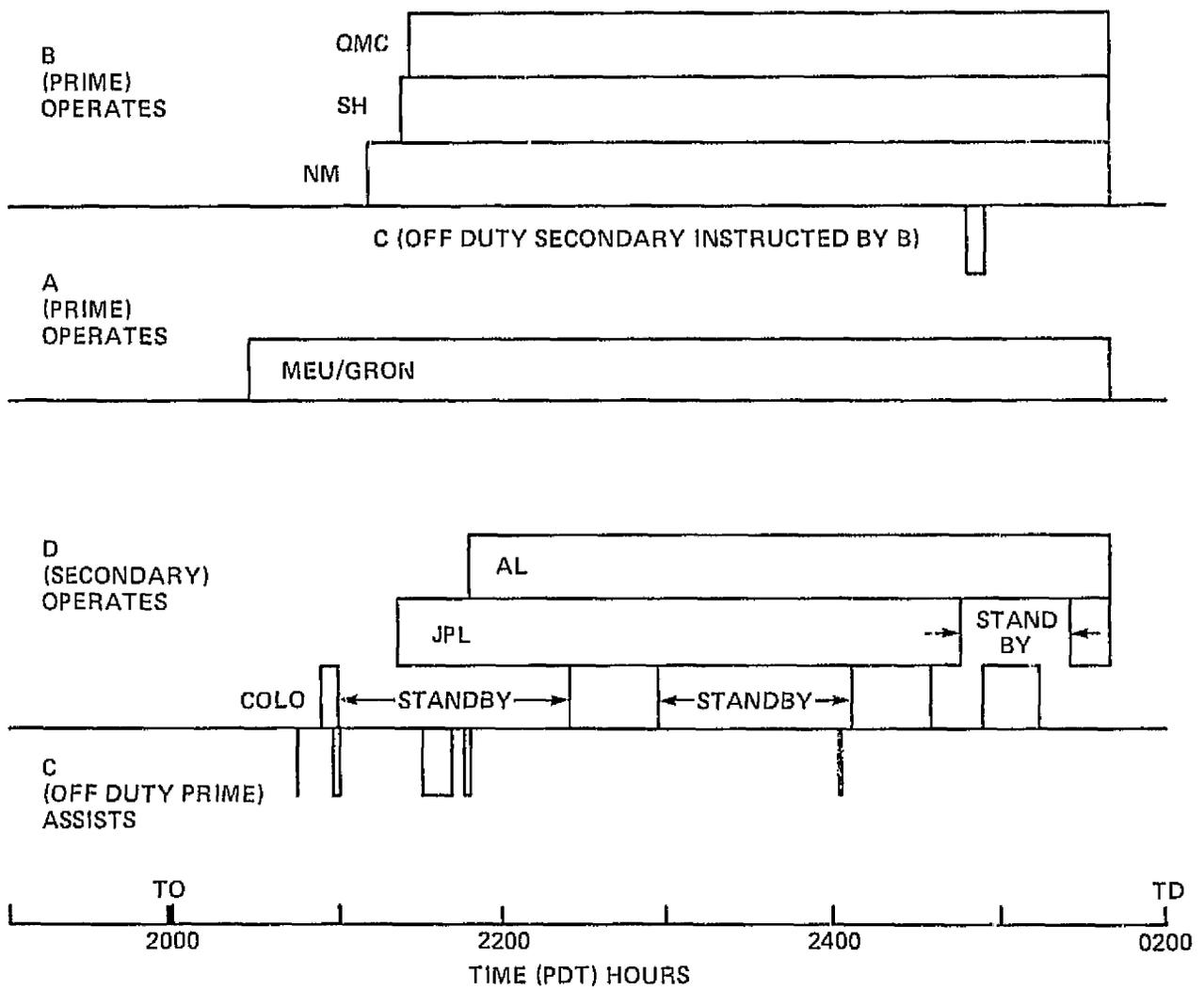
(b) Flight b.

Figure A-15. Continued.

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OPERATOR C
(SECONDARY)
OPERATES

SH

NM

QMC

OPERATOR B (PRIME) ASSISTS

OPERATOR A
(PRIME)
OPERATES

MEUDON/GRONINGEN

OPERATOR B
(SECONDARY)
OPERATES

JPL

COLO

STAND
BY

STAND
BY

AL

OPER. C (PRIME)
ASSISTS

OPER. D (OFF-DUTY
SECONDARY) ASSISTS

TO

TD

2000   2200   2400   0200

TIME (PDT), hr
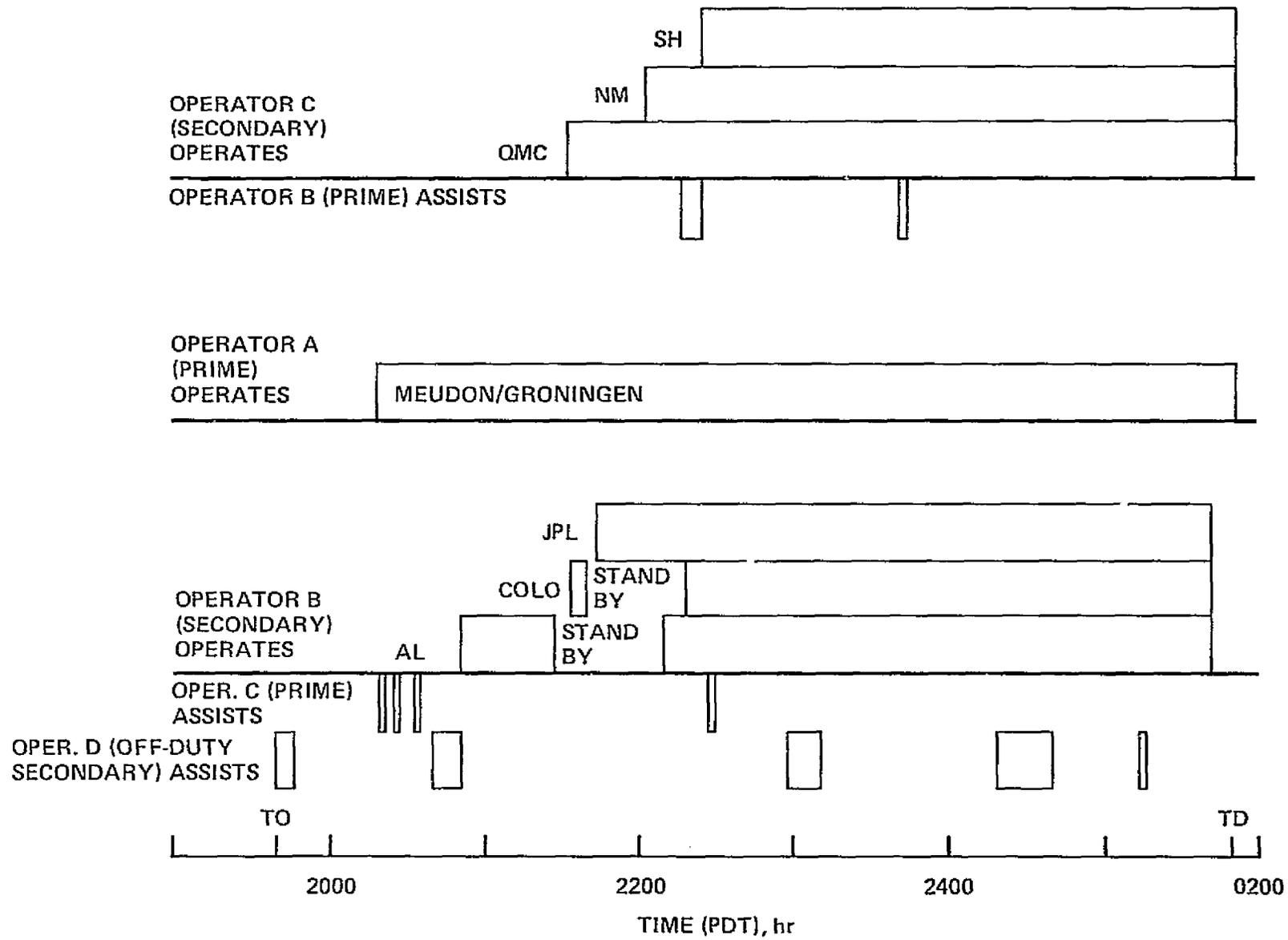
(c) Flight 7.

Figure A-15.—Continued.

OPERATOR A
(SECONDARY)
OPERATES

NM

SH

QMC

OPER. B (OFF-DUTY
PRIME) ASSISTS

OPER. C (SECONDARY) ASSISTS

OPER. D
ASSISTS
OPER. B

OPERATOR D
(PRIME)
OPERATES

AMES

OPERATOR A (PRIME ON
MEUDON/GRONINGEN)
ASSISTS

JPL

OPERATOR C   COLO
(PRIME)
OPERATES   AL

STAND
BY

OPER. B (OFF-DUTY
SECONDARY) ASSISTS

TO

TD

2000   2200   2400   0200

TIME (PDT), hr
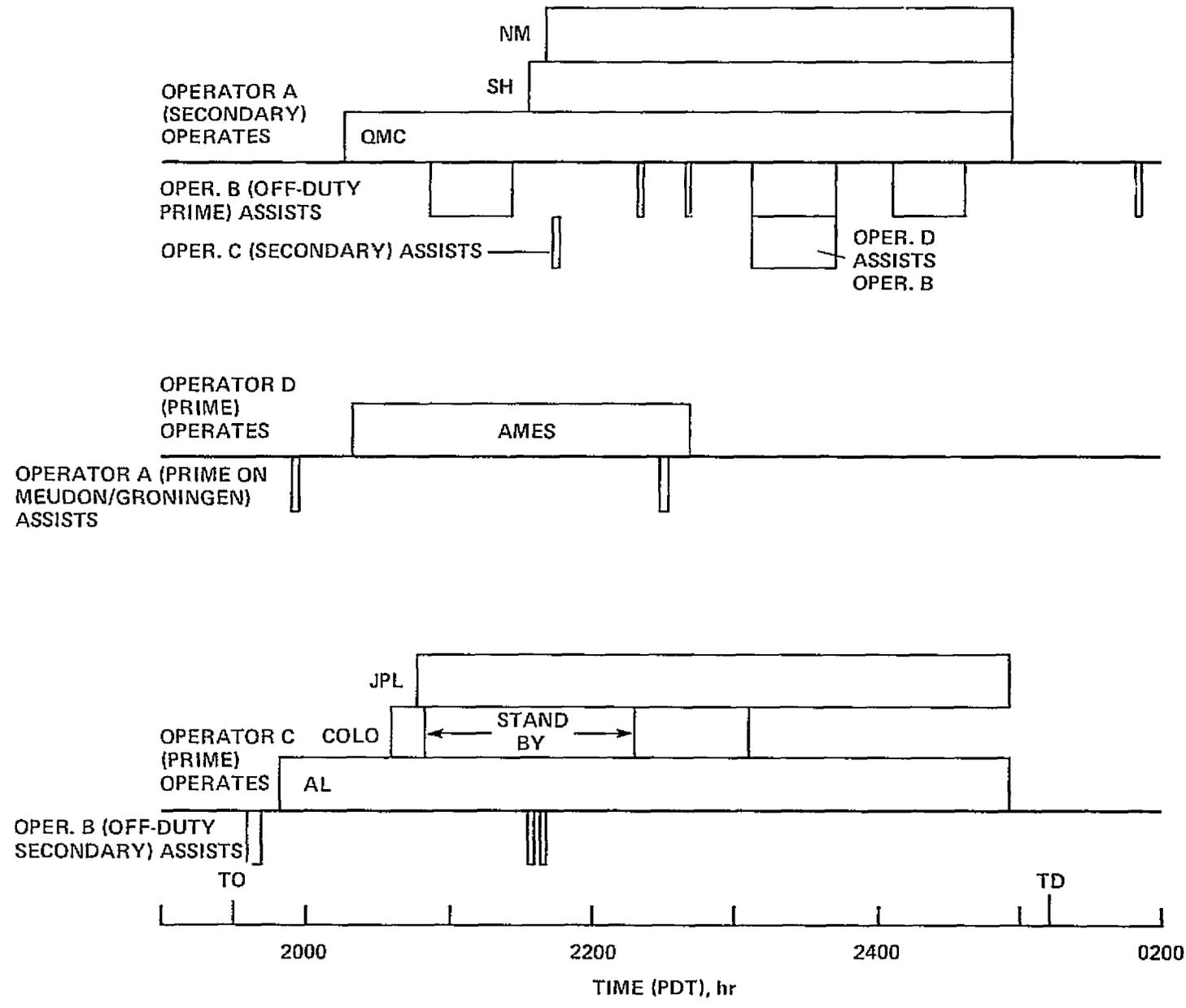
(d) Flight 8.

Figure A-15.   Continued.

B
(PRIME)
OPERATES

SH

NM

QMC

A
(OFF DUTY SECONDARY) ASSISTS

D
ASSISTS

D
(PRIME)
OPERATES

AMES

A
(OFF DUTY PRIME) ASSISTS

C
(PRIME)
OPERATES

COLO

AL

JPL

D
(SECONDARY)
ASSISTS

TO

TD

2000   2200   2400   0200

TIME (PDT) HOURS
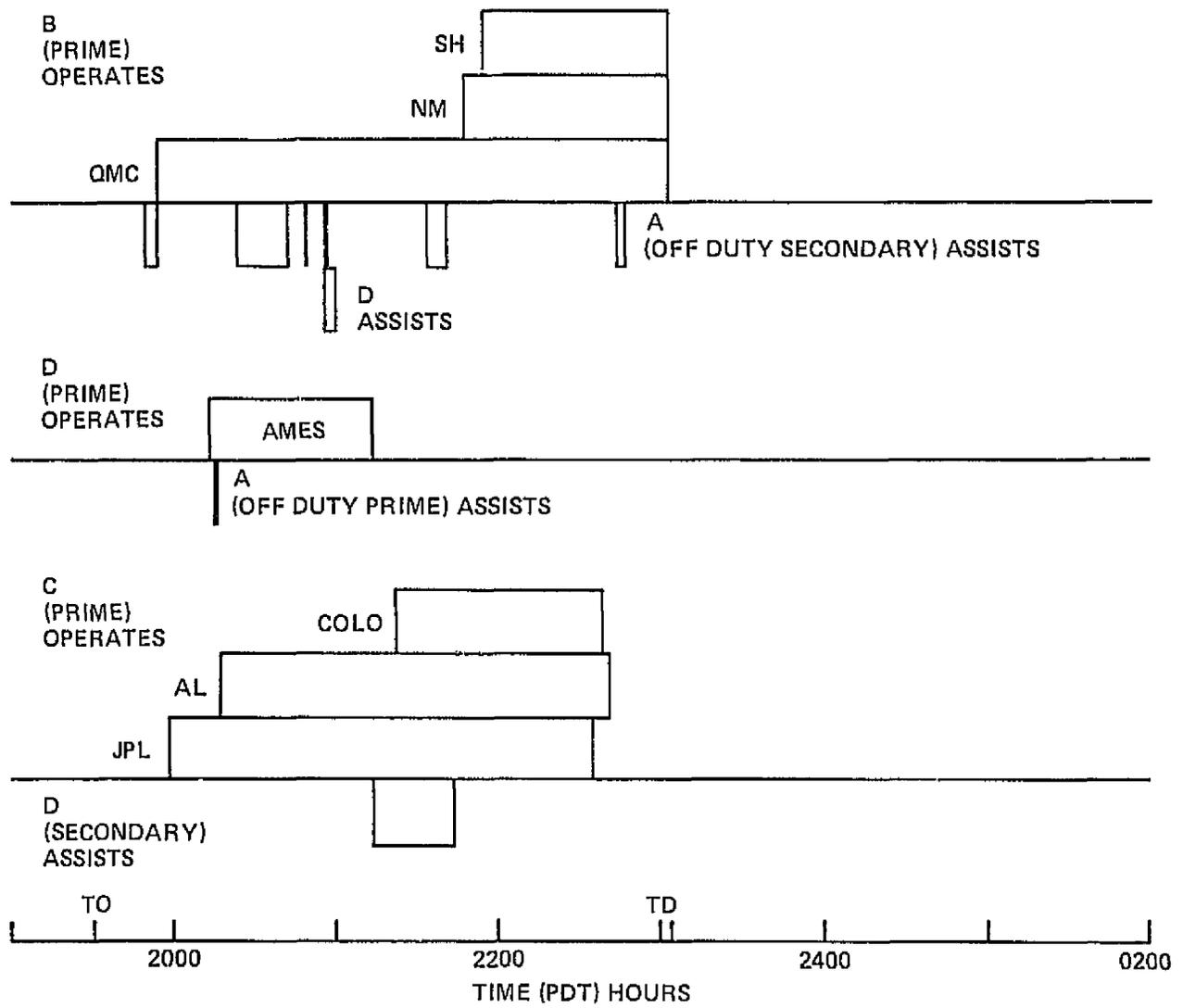
(e) Flight 9.

Figure A-15.-- Concluded.

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was busy elsewhere, but he too assisted operator B briefly on several occasions, primarily on guide optics and target acquisition.

The off-duty EO (B) on flight 8 (fig A-15(d)) spent very little of his time in the rear of the aircraft. He first mounted a portion of the JPL experiment (approved by The NASA/ESA Panel to lighten the EO turn-on workload) then donated generously of his time to operator A. The two long blocks of time after 2300 hours involved the repair of the QMC strip chart recorder and its reinstallation on the equipment rack. Operators B and A (primarily the latter) diagnosed the QMC EMI problem during the flight. Operator B's aid after touchdown was to let helium gas into the system. Operator A, with three nights of experience, aided operator D in turning on the Meudon telescope and briefly consulted with him later in the flight. At approximately 2333 and 2339, operator B aided operator C in troubleshooting JPL.

QMC had strip chart problems again during flight 9. Operator A helped operator B with that problem until approximately 2057, when Venus moved out of the telescope window, at which point operators B and A patched a strip chart from the Ames station (used to record aircraft roll) into the QMC experiment, about 20 feet away. Operator A again assisted operator D briefly during Venus acquisition. After operator D finished operating the Ames experiment (the only scheduled target was Venus), he spent about a half hour troubleshooting the JPL experiment. This experiment never worked well, and all people who had to operate it tried to diagnose its problems as time allowed.

EO interaction times are summarized in figure A-16 and compared with experiment operating time (average) and flight time. A trend toward increasing mutual assistance was observed as the EOs developed working relationships for effective handling of their secondary experiments. On flight 8, the off-duty operator spent more than one hour in troubleshooting and repair on one of his prime experiments, as mentioned above, while all the on duty EOs assisted one another for short intervals. On flight 9, all operators were at their prime experiments and the need for interaction with the off-duty EO was less. It should be noted, however, that on both these flights the total of interaction times was about 10 percent of the total of experiment operating times; this may represent a normal level of interaction for an experienced crew.

PI Commentary on Proxy Operation

Following the simulation period, each PI was asked to provide a written evaluation of the performance of the EOs who had operated his experiment. In addition, interviews were held with each PI and EO to discuss EO performance. The interviews were conducted near the end of the mission so that data quality could be taken into account. The evaluation forms called for both qualitative and quantitative responses from the PIs, including time spent by the EO in operating the experimental equipment versus the amount of time available to do so, and a subjective evaluation regarding the quality of data obtained. It was intended that the PI evaluate the EO's accomplishment relative to what the PI could have accomplished under the same conditions.

Not all the PIs were able to provide such an evaluation. Their efforts were hindered by difficulty in determining the ratio of EO time operating their experiment to the time available, insufficient processed data to allow an assessment of data quality, and in some cases, malfunctioning of experimental equipment or degradation of its performance due to turbulence of the atmosphere or excessive aircraft roll. The following comments represent the best judgment of the responding PIs at the close of the mission and are, necessarily, somewhat subjective. Available EO observations are included.
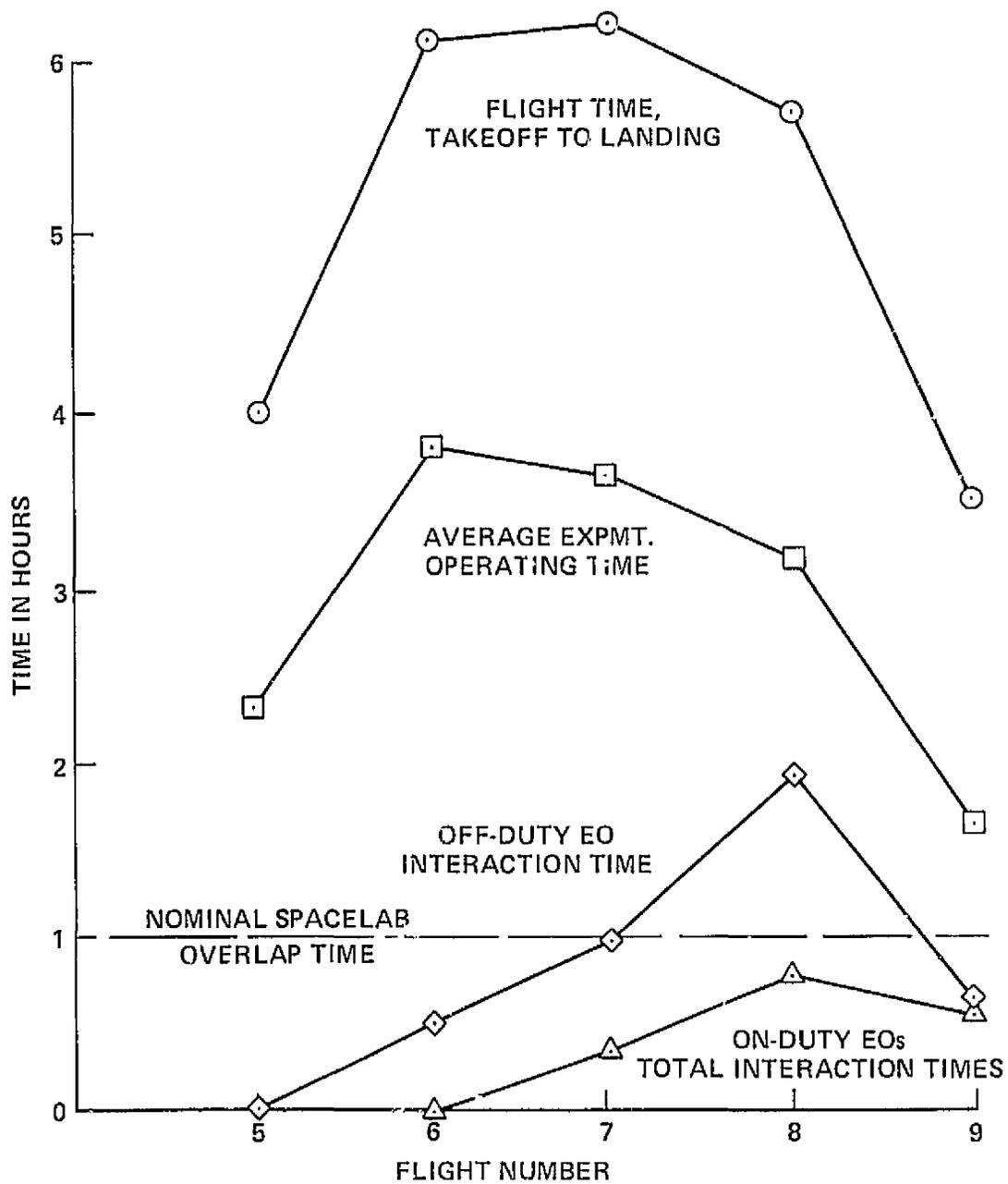
Figure A-16. — Comparison of EO interaction times with experiment operating and flight times.

It should be noted that the EOs in particular felt any comparison among them or with the PIs in terms of performance is significantly compromised by (1) the absence of the PIs on the confined flights and therefore their inability to evaluate first hand the responses of the EOs to their experimental requirements, including malfunctions, and working environment; (2) the availability of more manpower to operate the experiments during the PI flights; (3) improvements in equipment performance resulting from its operation and maintenance by the EOs in the aircraft environment during the confined mission; and (4) the operational know-how gained during the confined mission. These factors so significantly influence the conditions under which the EOs and PIs worked that a direct comparison of their performance in terms of data quantity and quality is impossible. Taken together, in fact, the advantages inherent in PI experiment operation, with the greater PI working knowledge of their own experiments, imply superior overall performance by the EOs.

Meudon/Groningen

The PI acknowledged that his training of the prime EO (A) was delayed by problems during the premission period. However, he felt that the deficiency was made up by the hands-on training at Ames before the simulation period.

The PIs felt that EO performance during simulation week was not nearly as good as the PIs would have been. The first flight resulted in little data during the time the aircraft was on an observational track. The second flight was very good. Early in the third flight, cooling was lost because of insufficient coolant in the cryostat (or an excessive loss rate). During two of the PI data flights following the simulation period, operator A acted as tracking operator, providing an opportunity for the PI to evaluate his work first hand (not possible for the other EOs). On these flights, EO performance was rated by the PI as equal to his own. However, this rating is not directly comparable to the EO's performance during the simulation period, because three people p   med the same operations on the PI data flights as the EO had done by himself on the confir   ts.

Queen Mary College

PI Comments. -- A persistent RF interference problem kept the EOs from doing too much. It took a number of flights before the problem was even identified (by the secondary EO), and the PI would have found it sooner. The EOs were about 50 percent as efficient as the PI would have been. Operation of this experiment requires that the display be monitored constantly, which is not possible if three experiements are to be operated by one man. The secondary EO, operator A, picked up on the RF interference quickly because he had flown before and recognized the symptoms. The PI said that, because of his flying experience, operator A was better than either he or operator B, and that the PI and B were about even.

The data obtained by the EOs are satisfactory but will need considerable evaluation. Since none of the EOs marked the strip chart recorder, the PI will have to inspect the interferograms to pick out spikes, instances of known noise, etc. This would not have been necessary if the PI had been monitoring the equipment.

There was no apparent difference in the performance of the three EOs. Operator B had the most training on repairs, but all three had the same amount of operational training. Operator A got many interferograms and he and C impressed the PI with their abilities. C probably could not have repaired a malfunction, but he operated the equipment very well.

If the PI had it to do over again, he would make the experiment more reliable and easier to operate by one man. This would be far more beneficial than more training or repair work. The PI feels that the operators should not be asked to make repairs.

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EO Comments. The EO lost many interferograms because ADDAS went down many times. The EO forgot to turn off all the switches several times before starting up and left ADDAS on. This affected the number of interferograms he got.

The EO claims he could have used the LN$_2$ black body if the filling system had been properly designed.

The EO repaired the pen recorder once, but it broke again later. He noted that the proper tools were not available on the aircraft.

After the first flight, the EO marked what he thought was necessary on the strip chart, and he felt that if it wasn't enough the PI should have told him what he wanted. This problem suggests a deficiency in the premission flight training period.

The EO complained about ADDAS failures during his flights. He felt the binary display was no help at all and that a chart recorder would have done as well.

On the last flight, the spare chart recorder failed and the EO patched onto the Southampton experiment, the New Mexico experiment and used a spare aircraft recorder to keep the equipment going. The PI was not aware of this and the EO received no credit for doing it. Without operator B, operator C would have had difficulties obtaining data due to lack of training.

University of Southampton

PI Comments. — All the data obtained by the various EOs, primarily airglow, were of excellent quality, the only difference between EO and PI in performance being the quantity of data obtained. The prime EO (B) operated the experimental equipment on the first, second, and fifth flights, and he obtained 100 percent of the data feasible.

The EO on the third flight was operator C, who obtained 80 percent of the data feasible. Operator A, assigned to the fourth flight, obtained 100 percent of the data feasible.

No malfunctions occurred, so there was no opportunity to compare EO and PI repair performance. The PI stated that the equipment was not laid out for ease of fault-finding while in the air. He was willing to make the following estimates: Operator B had the most experience with the equipment and was the best prepared of the EOs to make repairs. Operator A would have caught on quickly because of his background and experience, but his ability to accomplish repairs was unknown. Operator C had no training in trouble-shooting and repairs on this equipment (his secondary experiment) and therefore probably would have had difficulty in making repairs had any been needed.

Two EO mistakes led to a loss of data that the PI felt he could have obtained.

For lack of time, the EOs were not able to reflect very much on the training material. The PI complained that he spent a month, at ESA insistence, writing up training procedures for equipment that had yet to be built. Then, after the equipment was finished, the detailed procedures had to be rewritten.

For the first few days of the simulation, the EOs were under pressure and concentrated on getting the equipment to work. After that, they started taking an interest in looking at the data, making plans for the next flight, etc.

The PI suggested that the EOs' handwritten comments should be incorporated into a new master instruction list.

EO Comments. Operator C asked the primary EO (B) for help in getting a picture on the TV camera. The EO also gave operator C other tips on how to prepare the equipment.

The primary EO looked at the data after the first flight and then lost interest because he didn't see any structure. He became discouraged by the lack of results.

Without the assistance of the prime EO, operator C would have had difficulty obtaining data on this (his secondary) experiment owing to his lack of training.

Ames Research Center

The ARC experimental equipment was operated only on the fourth and fifth flight of the confined period. While the prime EO, operator D, was able to obtain about 75 percent as much data as was feasible in the allotted time, some data were poor, due to excessive aircraft roll during the fourth flight. When the problem was overcome, the data quality improved to good. During the fifth flight, data quantity improved to 85 percent and the quality was judged excellent by the PI.

The mission PI himself had never operated the equipment before, and had been provided only a brief review by the original PI concerning target acquisition, tracking, and calibration procedures. He and operator D assembled the experiment, providing the EO with r ost of his training in the process.

The mission PI felt that the EO operated the equipment better than the original PI could have and that the EO was more capable and willing to make changes.

At the time of the confined mission, the original PI was attempting, without success, to acquire the same target (IRC 10216) while flying on the C-141 as the EO was able to obtain on the CV-990. The EO-obtained data will be used by the PI. Also, Venus data obtained on the two aircraft are being compared.

Jet Propulsion Laboratory

PI Comments. -- Each EO had specialized knowledge in one or two areas and in some cases more than the PI. However, none had the across-the-board knowledge that was needed to operate the experiment successfully. Operator B was better on RF interference and actually helped the PI solve problems in this area. But he was not up on atmospheric molecular spectroscopy and, in some cases, he could not determine which was spectra and which was noise. Operator C was much better on spectra, but was less capable of operational changes to fit the situation, while D was very adept at picking up on star fields and the use of the telescope. In all cases, the PI felt that there was not enough time to train anyone to operate the equipment properly.

During the last 3-4 days of the confined period, the PI cut down on the number of variables for the EOs. He also felt that no one operator could possibly handle all tasks during periods of peak activity, such as turning on all three experiments at the same time to train on a given target.

The PI estimated that the EOs performed at about 70-80 percent of the PI level. They did not have the in-depth knowledge at the component level to change "Oz boxes," etc. In view of the amount of training he received, operator D performed much better than the PI expected.

The EOs helped prepare the training procedures by providing comments on the material that the PI first submitted. Operator C contributed most to this effort.

Because both TAOFs had problems with RFI it is difficult to judge the EOs' accomplishments. Although both of the EOs had spectrometer experience, it was along the lines of more classical instruments, whereas the TAOF was a new device approaching a "black box." Therefore, their intuition for modifications and variations was limited. Operator B seemed to feel at home with the electronics and the concept of the TAOF operation. Unfortunately, time did not allow any of the EOs the opportunity to really work with the instrument. With responsibilities for three separate experiments, all requiring detailed attention, the EO on duty did not have the time to concentrate on the TAOF. In most cases it was turned on very late (in one case, approximately 1-1/2 hours <u>after</u> take-off), and the operation mode was severely simplified by the PI to accommodate an overloaded work schedule. Assuming ADDAS was properly recording the data, the PI may be able to extract some useful data was recorded. <u>In most cases, however, the EO documentation (of test parameters) was insufficient to restructure the events and conditions of a recording.</u>

<u>EO Comments.</u> - The EO did not think the PI could tell noise from spectra himself, because of the poor equipment. In fact, the EO thought everything was noise. Despite the lack of training time, the EO felt that the equipment was simple to operate and understand. It just didn't work.

The displays were pointless, even after following the PI guidelines. The PI provided no criteria for changing chopping frequency, etc. This experiment was discouraging to the EO because it never operated properly, and he tended to concentrate on the other experiments that worked.

<u>Alaska</u>

The prime EO (C) operated the Alaska experiment on the first, fourth, and fifth flights. The targets were generally Venus, scattered sunlight, O_2 Herzberg, and OH Meinel radiation. He obtained between 80 and 100 percent of data feasible, and the data quality was divided fairly evenly between fair and good.

Operator D was the EO on the second flight. He obtained no data on Venus and 90 percent of the data feasible on the other target, nightglow OH, which was of fair quality.

Operator B was the EO on the third flight, during which the targets were Venus, nightglow O_2, nightglow 5517, and nightglow OH. No data were obtained on OH. Essentially 100 percent of data feasible was acquired on nightglow O_2 (fair quality) and on nightglow 5517 (good quality). Good data were obtained on Venus, but only about 40 percent as much as feasible.

In all cases, the quality and amount of hard-copy data were less than the PI obtained. Operator C did quite well and improved as the mission went on. The other EOs learned from him after his first flight. One EO did not change the amplitude setting when he should have, so it is very difficult to pick out the signal. The other data will be needed before results from that flight can be evaluated.

The EO contributions to the written procedures provided the PI with an indication that they knew what was going on.

<u>University of Colorado</u>

The primary EO operated the Colorado experiment on the first, fourth, and fifth flights of the confined mission. He obtained between 80 and 85 percent of data feasible, and the quality was

good when the target was Venus, dropping to fair when the target was Alpha Virginis (much fainter) on the fourth flight.

Operator D was assigned to the Colorado experiment on the second confined flight. He obtained about 25 percent as much data as feasible, viewing Venus (fair data quality) and sky background (poor quality).

Operator B operated the Colorado experiment on the third confined flight, obtaining about 80 percent as much data as feasible viewing Venus. The data were rated fair.

All the EOs did a good job. C did the best job even though the display unit wasn't operating during his tour. D forgot to turn on the tracker switch one night, which cost about 1/2 hour of data. It took him longer than the others to restart the instrument and he had to restart it several times.

Due to the lack of EO training time, the PI limited equipment operations to only two variables, which the EOs handled well. Many other variables would have been used, however, had the PI operated the experiment.

The only real malfunction that occurred was a loose wire in the spectrometer itself. This could only be repaired in a sterile atmosphere, and the PI had to do it on the ground. The PI commended operators B and D for locating a blown fuse in the power supply that went out due to an aircraft power surge. The fuse was well hidden, and the fault had never occurred before. The PI actually had to call an engineer back at Colorado to diagnose the trouble, but by that time, the EOs had remedied it.

Operator D had relatively little time on the equipment and was generally outperformed by operators B and C. Some of the EO observations of Spica were made at a different angle than any that the PI had ever made. Operators B and D also made good observations of Venus, and obtained some useful data.

The PI felt that the operational training was sufficient for the time allotted to him on the Alaska telescope. There were too many things that could have gone wrong for malfunction training to have been adequate. Operator C provided considerable help with the training procedures and did some of the writing.

University of New Mexico

The primary EO (B) operated the New Mexico experiment on the first, second, and fifth confined flights. He obtained between 90 and 100 percent as much data as was feasible, and the data was excellent. Operator C worked the experiment on the third flight, obtaining the same results, quantitatively and qualitatively, as the prime EO. Operator A, assigned to the fourth flight, obtained the same results as the two other EOs. The PIs were pleased with the data obtained by the EOs and will be able to write a scientific article based on it.

Operator B had some problems the first night, but the PIs would have had them also, and the EO could not be faulted. About 4 percent of one night's data was lost because operator C had difficulty reloading a strip chart recorder pen.

Accommodations made for the EOs were:
1. Observations were confined to the camera station on the left side of the aircraft; the alternate station on the right side was not used.

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2. An angle iron was used to align the movie camera with the image tube.
3. Dials were fastened down to set positions for camera focus.

No real malfunctions occurred, but operator B probably could have made any necessary repairs, since he was the best trained. When the other EOs had trouble loading the cameras, etc., they went to him for help.

The PIs felt the training material was adequate and benefited by the EO comments made before the confined period began.

PERFORMANCE EVALUATION

EO performance compared favorably with that of the PIs, despite much lower manpower loadings and the constraints associated with certain major experiment elements. It remains to establish relationships among the premission factors that could be indicators of performance — background experience, training experience, and operator proficiency ratings.

Operator proficiencies were shown earlier (fig. A-9) to be roughly comparable, in the opinion of the PIs, with primary assignments at or near the target level of 8 (well understood) and with secondary assignments at the adequate level (5). These were in general agreement with the training guidelines for operator capability, namely, operation and maintenance of primary ̣ ̣ ̣ments, and only normal operation of secondary experiments. With this in mind, figure A-17 cu ̣ ̣ ̣ EO performance in flight against premission proficiency ratings, both the data quality fac ̣ ̣ ̣rsus a composite operations rating (from table A-4) and EO inflight problem response versus a composite maintenance rating. The data do not show any particular trends when plotted in this manner: data quality varies widely at the same proficiency rating, while problem response is relatively independent of rating. Thus, by itself, the premission evaluation of readiness by the PI was not a clear indicator of operator performance, except perhaps in a qualitative sense to indicate PI confidence in the EO's capability.

EO Training and Performance

<u>Inflight Problem Response.</u>

Consider now the relationship between operator training experience and in-mission performance. Figure A-18 compares operator performance in terms of inflight problem response with the number of training hours, by assignment. The three "learning curves" approximate the improvement with hours of training. It appears that the EOs developed to about the 90 percent level of response to inflight problems with about 30 hours of maintenance training (data plotted), 75 hours of hands-on training, and 150 hours of total training. Operator B's below-average performance on his primary experiments is largely due to events on the first simulation flight, where his effectiveness was reduced by a lack of familiarity with the environment (no flight research experience prior to ASSESS).

By way of comparison, the operator training experience in one previous ASSESS mission on the ARC Lear Jet aircraft (ref. 2) is shown, with the present results, in the block on figure A-18. The combined time for the two proxy operators of a single complex experiment is roughly comparable to ASSESS I times, and was found adequate for normal experiment operation, but less than sufficient for maintenance and repair. Apparently neither operator had sufficient depth of training (roughly half the time shown) to be fully qualified.

70
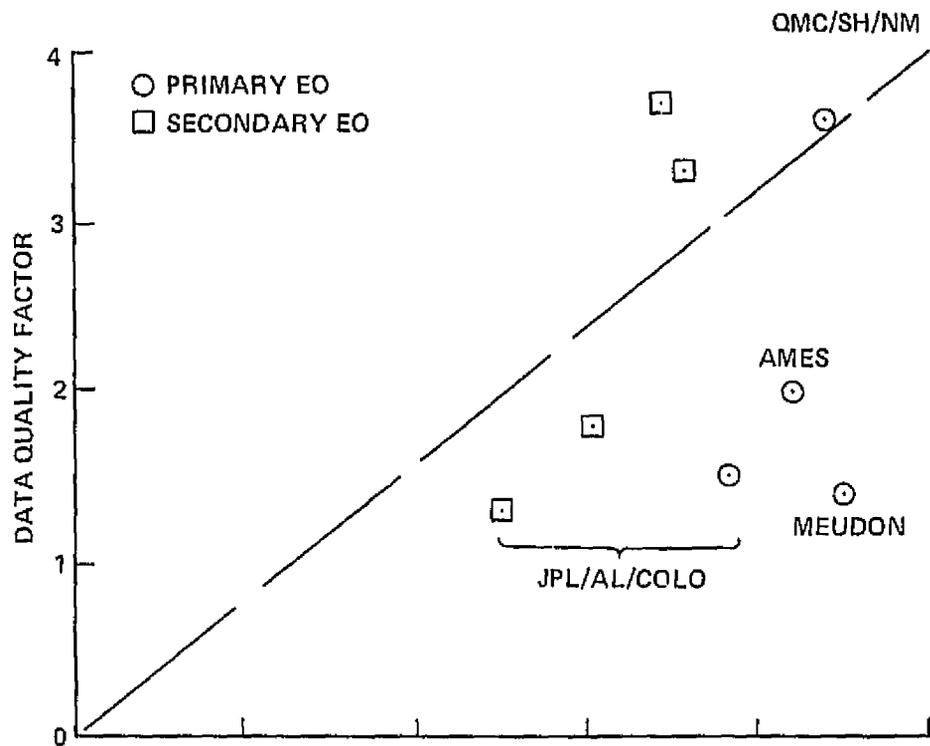
(a) Experiment operations.
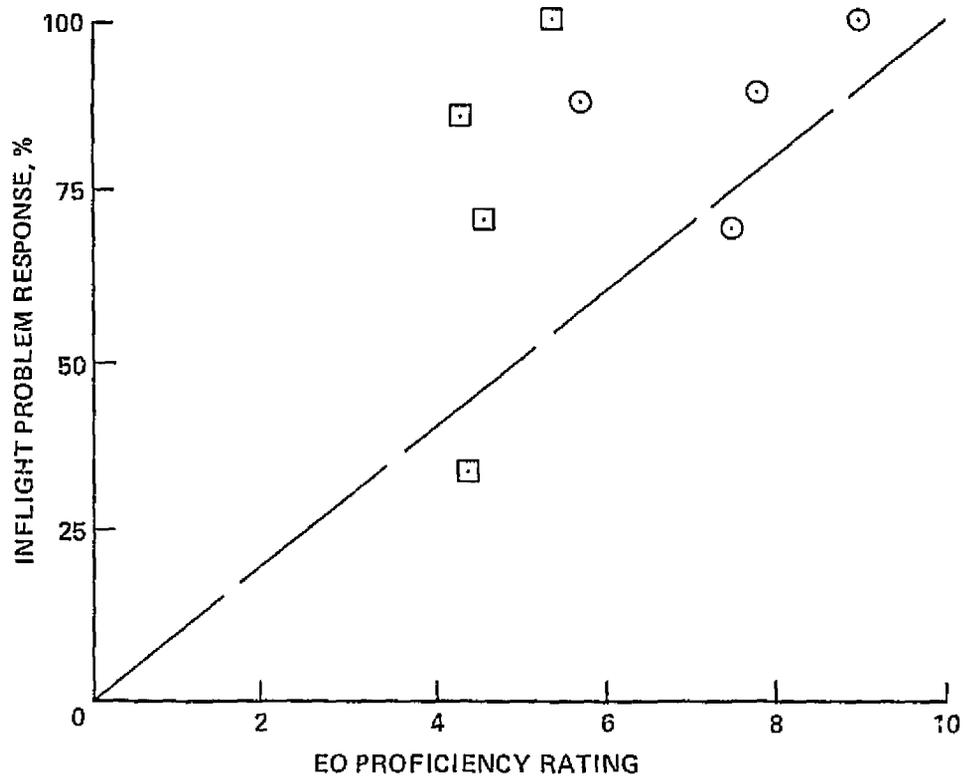
(b) Experiment maintenance.

Figure A-17.— Comparison of EO performance with PI estimates of proficiency at end of training (Table A-4).

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EO INFLIGHT PROBLEM RESPONSE, %

AVERAGE LEARNING CURVES

MAINTENANCE HANDS-ON TOTAL

100

80

60

40

20

0   20   40   60   80   100   120   140   160   180

TRAINING HOURS BY EO ASSIGNMENT

72

OPERATOR	ASSIGN-MENT	TRAINING HOURS		
		MAINT.	H-O	TOTAL
A	P	32	106	178
	S	27	83	197
B	P	89	149	333
	S	62	90	307
C	P	49	120	266
	S	18	32	114
D	P	45	107	169
	S	10	32	71
REF. 2 TWO EOs	—	38	11/	224
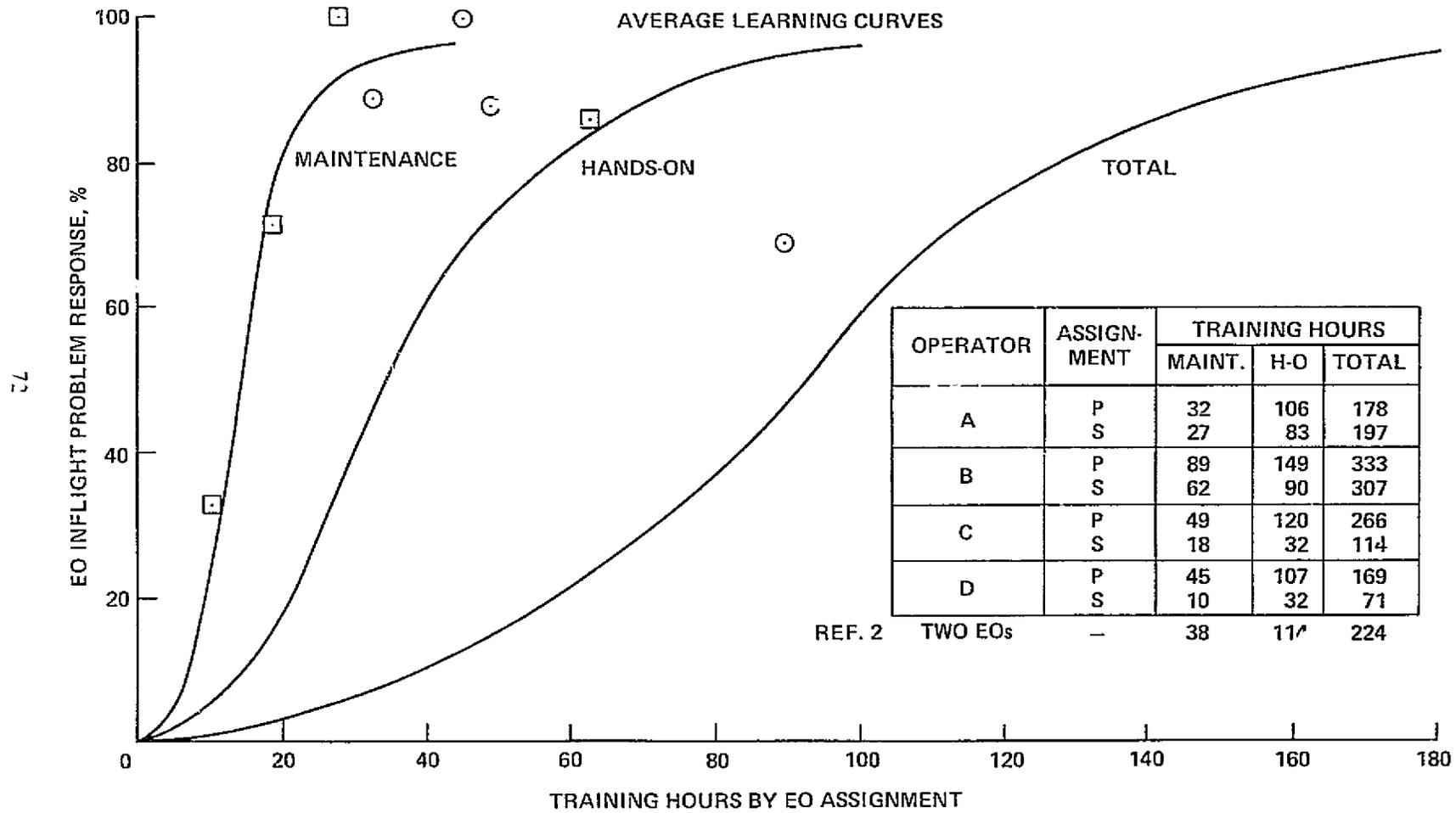
Figure A-18. — EO problem response as an indicator of training required.

<u>Data Quality Factor</u>

Figure A-19 shows the relationship between operator training time and inflight performance in terms of the quality of data acquired. No significant trend is indicated, on the basis of EO assignment; operators with about 100 hours did as well as those with two or three times as much training. There is, however, a notable difference between experiments, somewhat along the same lines noted earlier the those observing astronomical targets and those viewing in an all-sky mode. Here the latter were operated with significantly better results, regardless of the amount of operator training with no target acquisition requirements, the operator's task was much simpler.

Experiments then were ranked in order by five factors that could impact EO performance automation, complexity, readiness, design constraints, and malfunction severity (as observed during the mission). The results are shown in table A-11. A composite factor including three of these five factors was used as the independent variable in figure A-20, where a significant increase of data quality occurs as experiment operation becomes less difficult. In brief, it is apparent that EO performance was dependent on overall experiment design, both the physical equipment and the operational procedures. Thus, in the context of present results, operator training to the extent practiced here is not sufficient to assure good science; the experiment itself must be brought to a level of development compatible with the research environment.

EO Real-Time Experience

Operator performance on individual experiments for each simulation flight (fig. A-21) illustrates improvements made as the result of real-time experience during the mission. Presimulation training hours, overall EO performance (data quality factor), and po   ission PI performance are shown for comparison. Figure A-21(a) - (d) indicates notable improvement was shown by EOs of the more difficult experiments as the mission progressed, while those on the less difficult experiments generally stayed at their initial high level of performance. In a few cases, for example Meudon, JPL, and QMC, performance dropped on later flights when equipment problems surfaced.

The best example of EO improvement is the Alaska experiment, where the primary operator made remarkable progress on his own. At the same time he was also improving on the campanion experiments in his assigned group, JPL and Colorado. Even so, it took some 65 hours of work, of which 14 were in actual operation, to achieve something like the full science potential of these three experiments. This clearly shows the penalty that may be incurred on a short mission if the experiment preparation and operator training tasks are not fully implemented.

Two other points should be noted here. First, in four of the eight experiments the primary operator did not do as well on his first solo flight as during the training flight: on two his performance was the same, and on two it was better. This makes the point for a better exercise of integrated payload training. Second, in 11 of 12 comparisons secondary EOs did as well or better on their one flight experience than the corresponding primary operator on his first try. This is a strong indication of experience carryover from primary to secondary roles.

EO performance on the more difficult experiments, those on the lower line of figure A-19, is summarized in figure A-22. A distinct improvement was observed in quality of scientific results as the mission progressed, and with few exceptions the EOs attained the average level of PI performance in postsimulation flights on this group of experiments. It is fair to say that almost all of this improvement was in EO ability to cope with the experiments, rather than in hardware changes that simplified the operation. To the extent that such experience could be acquired before flight, the scientific return from such a relatively short mission might be substantially upgraded.
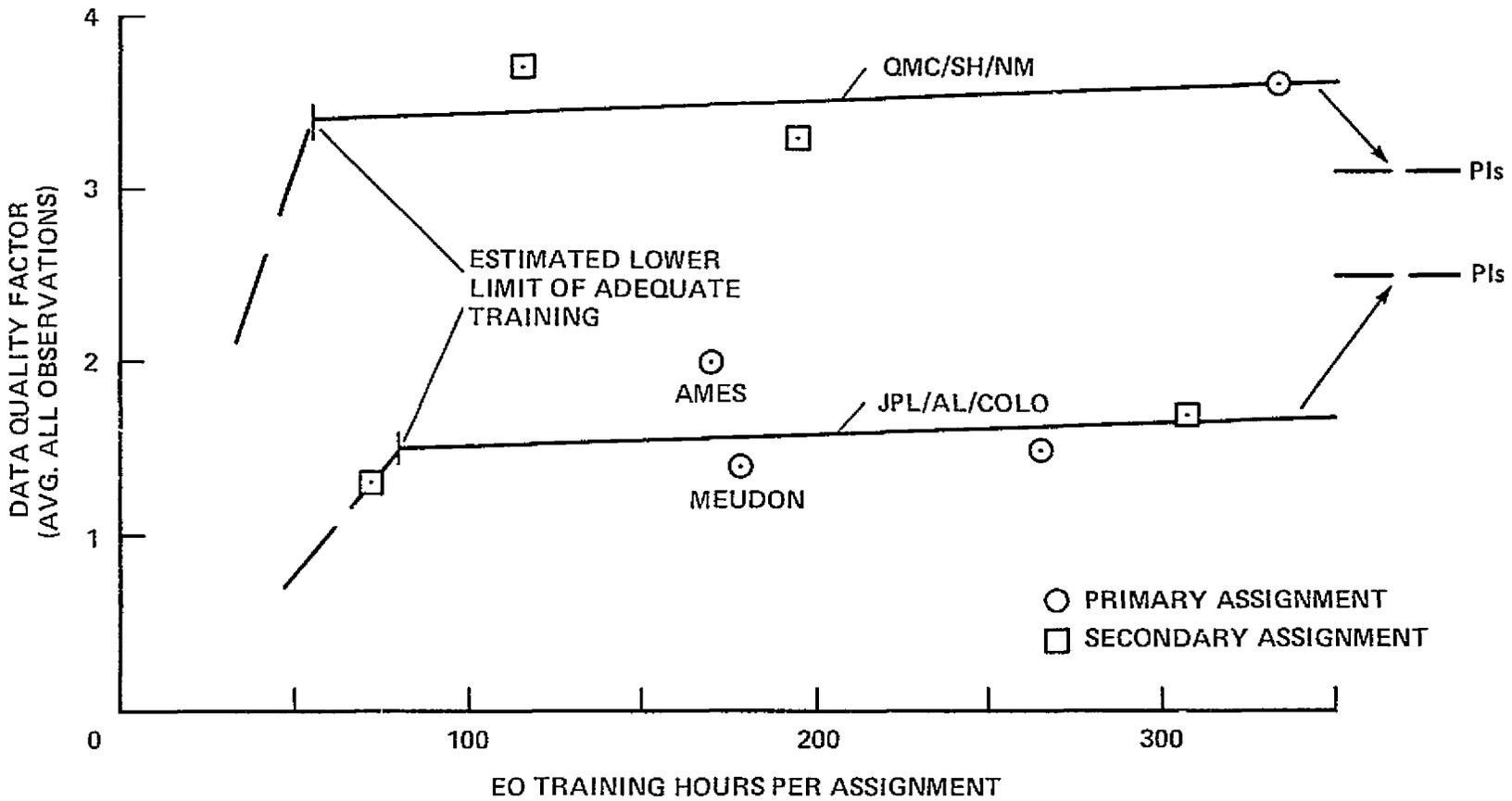
Figure A-19.— Data quality factor as an indicator of training required.

TABLE A-II.   EXPERIMENT RELATED FACTORS THAT CAN IMPACT EO PERFORMANCE

| Experiment | Experiment Ranking Factors* | | | | |
	Functional Automation 1 = Low 8 = High	Operating Complexity 1 = High 8 = Low	Demonstrated Readiness 1 = Low 8 = High	Design Constraints 1 = High 8 = Low	Malfunction Severity 1 = High 8 = Low
Meu/Gron.	7	1	8	2	5
QMC	1	2	5	6	6
SH	3	7	6	8	7
Ames	2	6	2	7	3
JPL	4	4	1	1	1
Alaska	5	3	3	4	2
Colo.	8	5	4	3	4
NM	6	8	7	5	8
	①	②	③	④	⑤

(a) Ranking by Individual Factors

| Composite Rankings | | | |
| All Factors (Avg.) | | Factors 2, 4, 5 (Avg.) | |
Expmt.	Rating	Expmt.	Rating
JPL	2.2	JPL	2.0
Alaska	3.4	Meu/Gron.	2.7
Ames	4.0	Alaska	3.0
QMC	4.0	Colo.	4.0
Meu/Gron.	4.6	QMC	4.7
Colo.	4.8	Ames	5.3
SH	6.2	UNM	7.0
NM	6.8	U. of S.	7.3

← Least Favorable Rating

← Most Favorable Rating

(b) Composite Rankings by Order of Benefit to EO

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EO	Rating of Experiment Groups					
	Primary Assignment			Secondary Assignment		
	All Factors	Factors 2, 4, 5	Factor 5	All Factors	Factors 2, 4, 5	Factor 5
B	5.7	6.1	7.0	3.5	3.3	2.3
A	4.6	4.7	5.0	5.7	6.1	7.0
C	3.5	3.3	2.3	5.7	6.1	7.0
D	4.0	5.3	3.0	3.5	3.3	2.3

(c) Experiment Ratings by EO Assignment

* Definition of Ranking Factors:

① Functions done without EO attention

② EO activity required after turn-on

③ Completed experiment available for EO training

④ Science potential (data quality) limited by design

⑤ Impact of inflight malfunctions on data acquisition
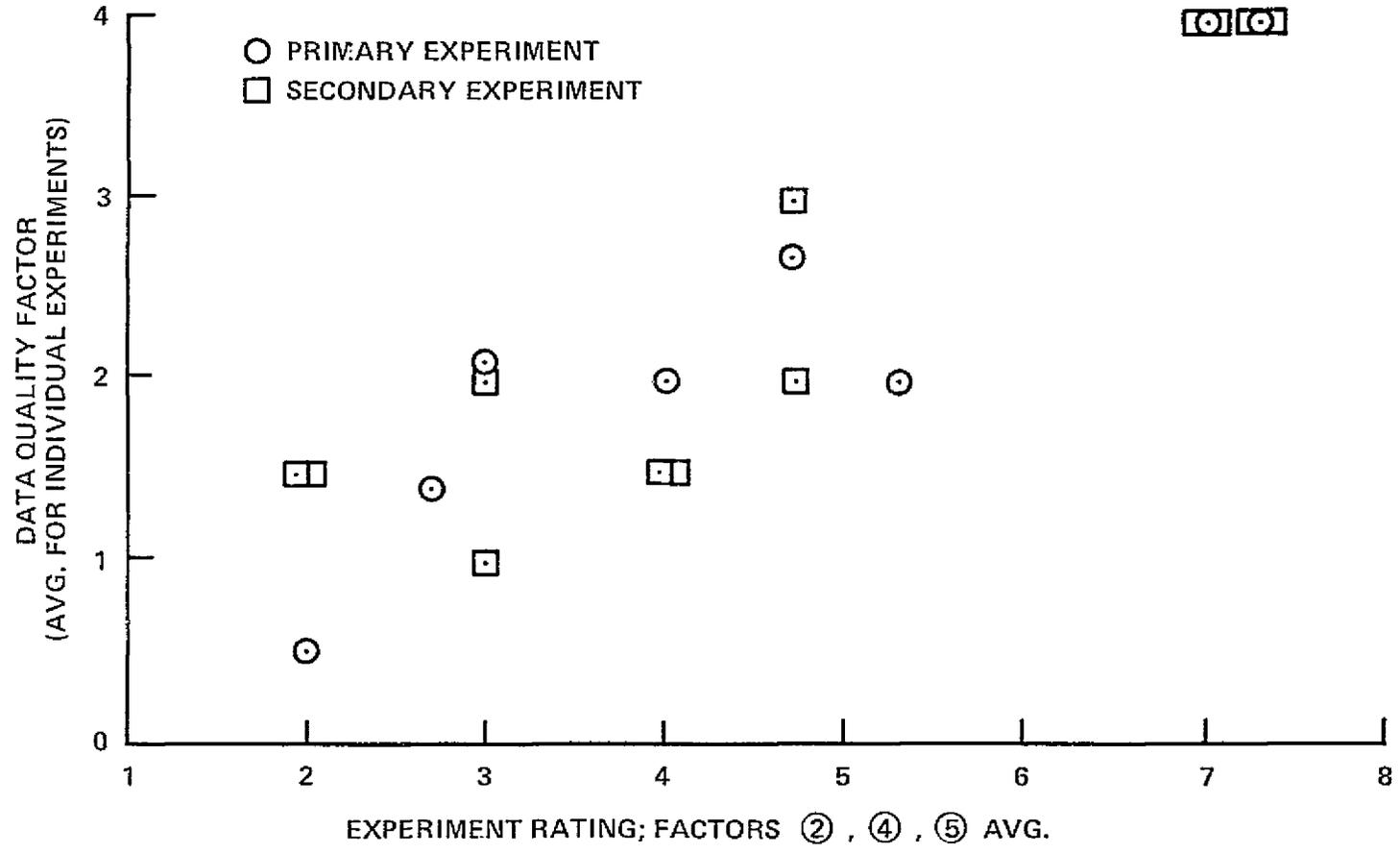
Figure A-20.– Variation of data quality with experiment evaluation factors.
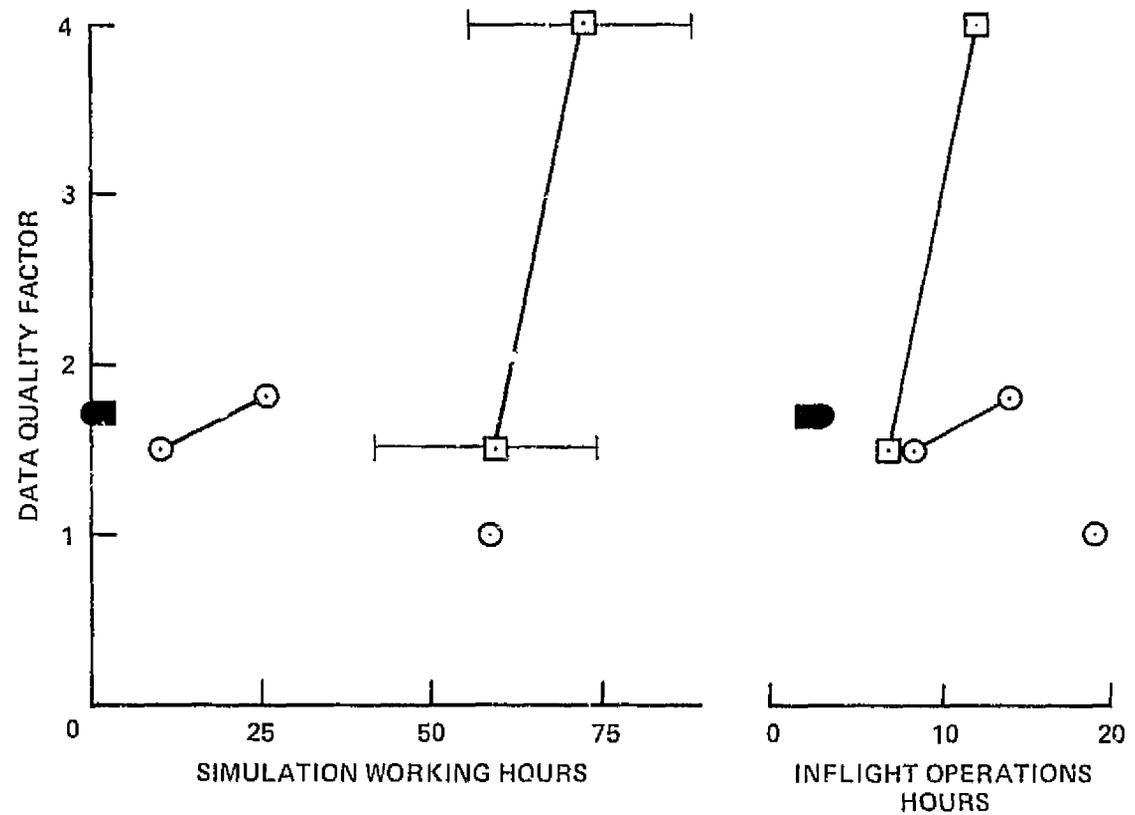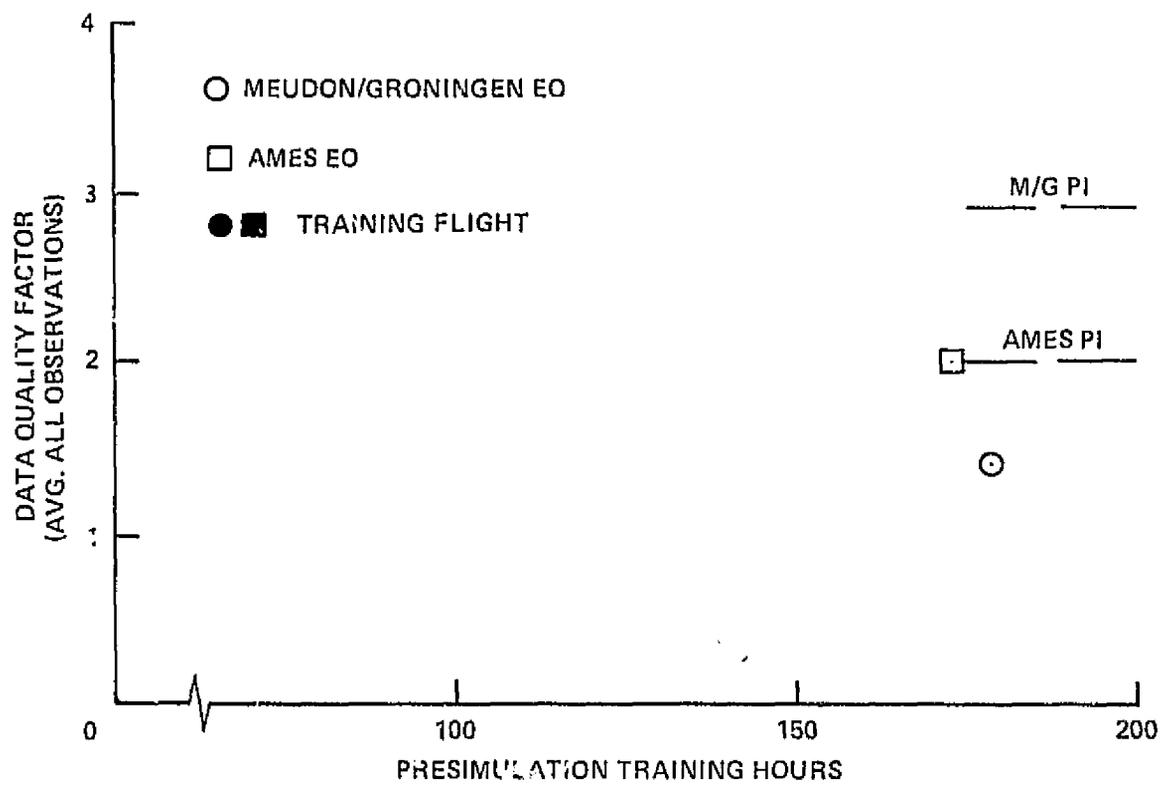
(a) Meudon/Groningen and Ames experiments.

Figure A-21. Effect of real-time experience on operator performance.
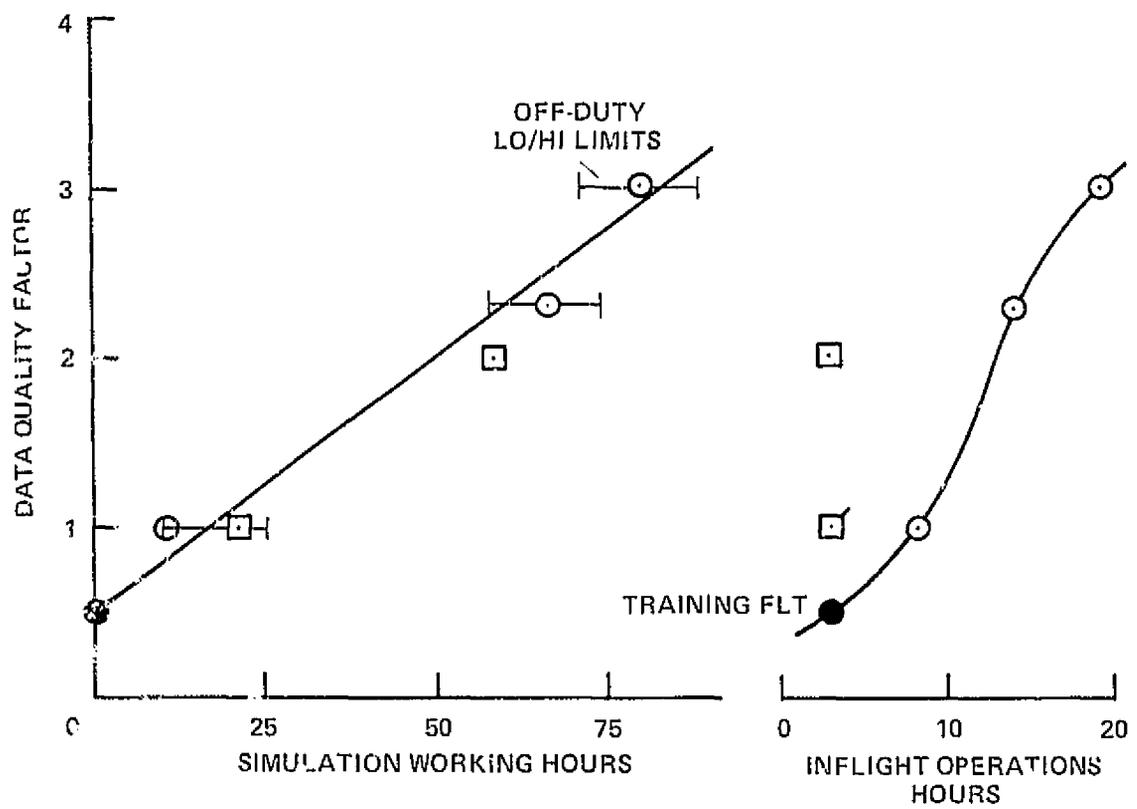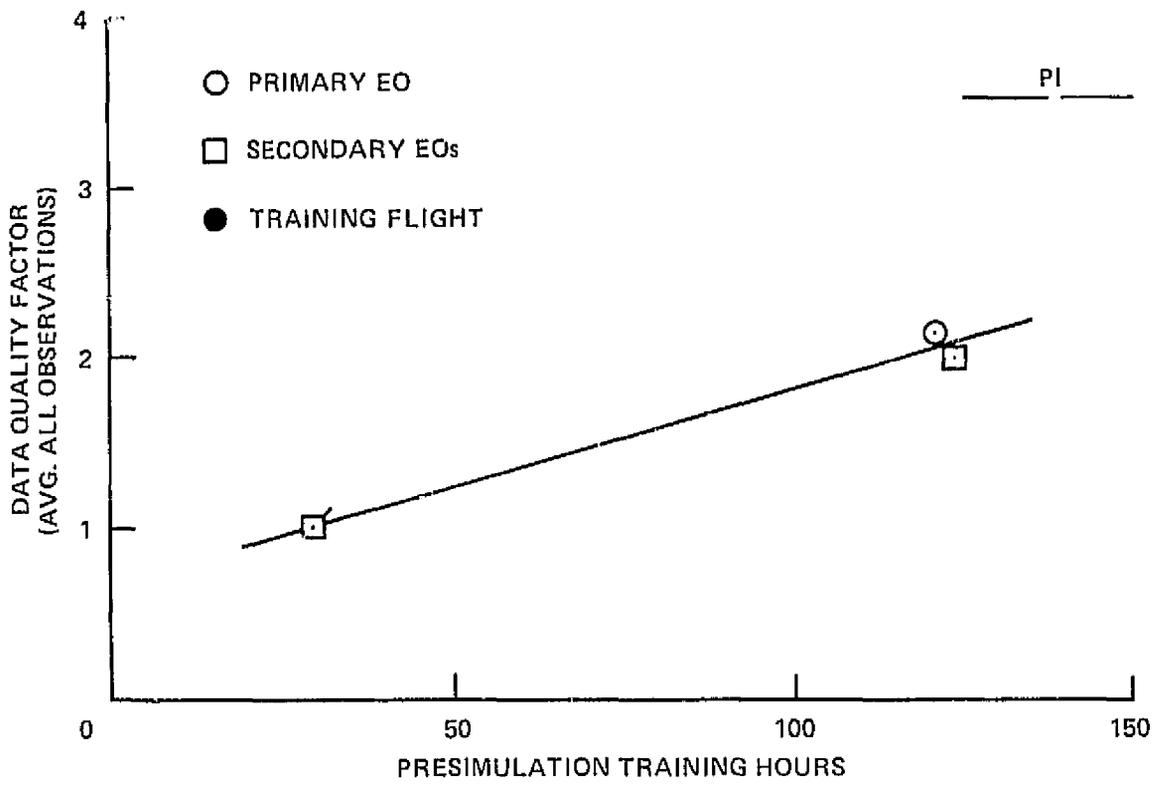
(b) Alaska experiment.

Figure A-21. - Continued.

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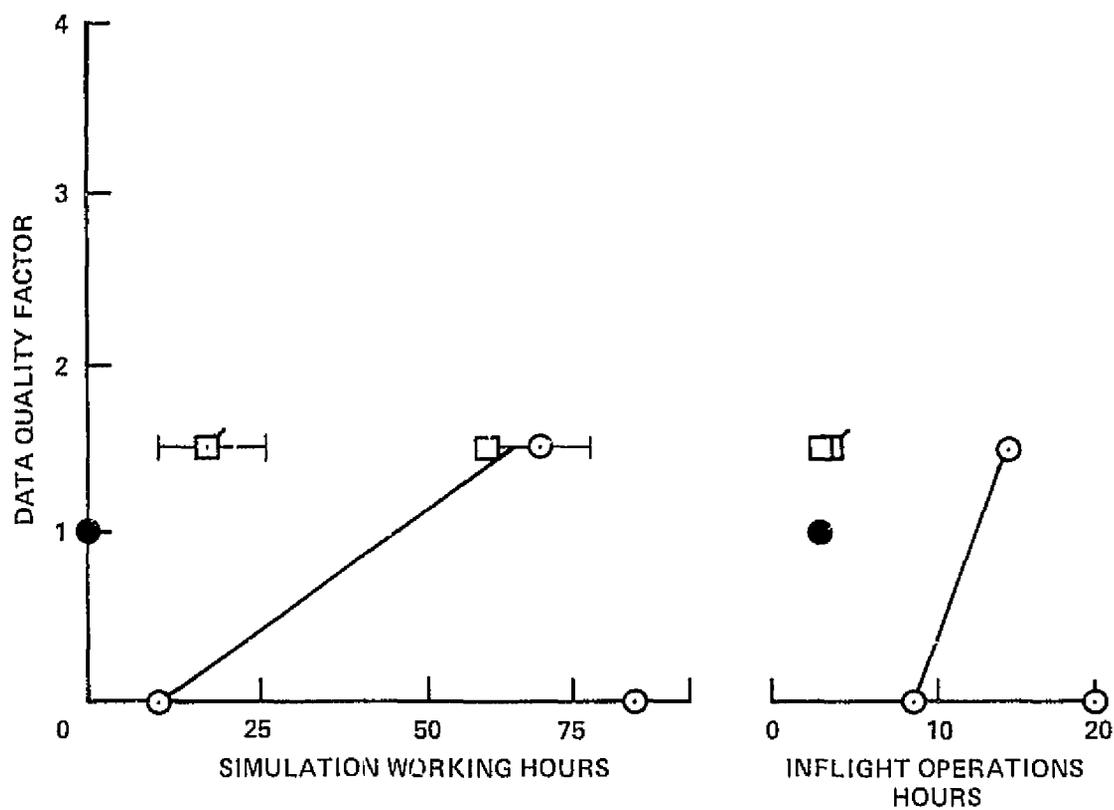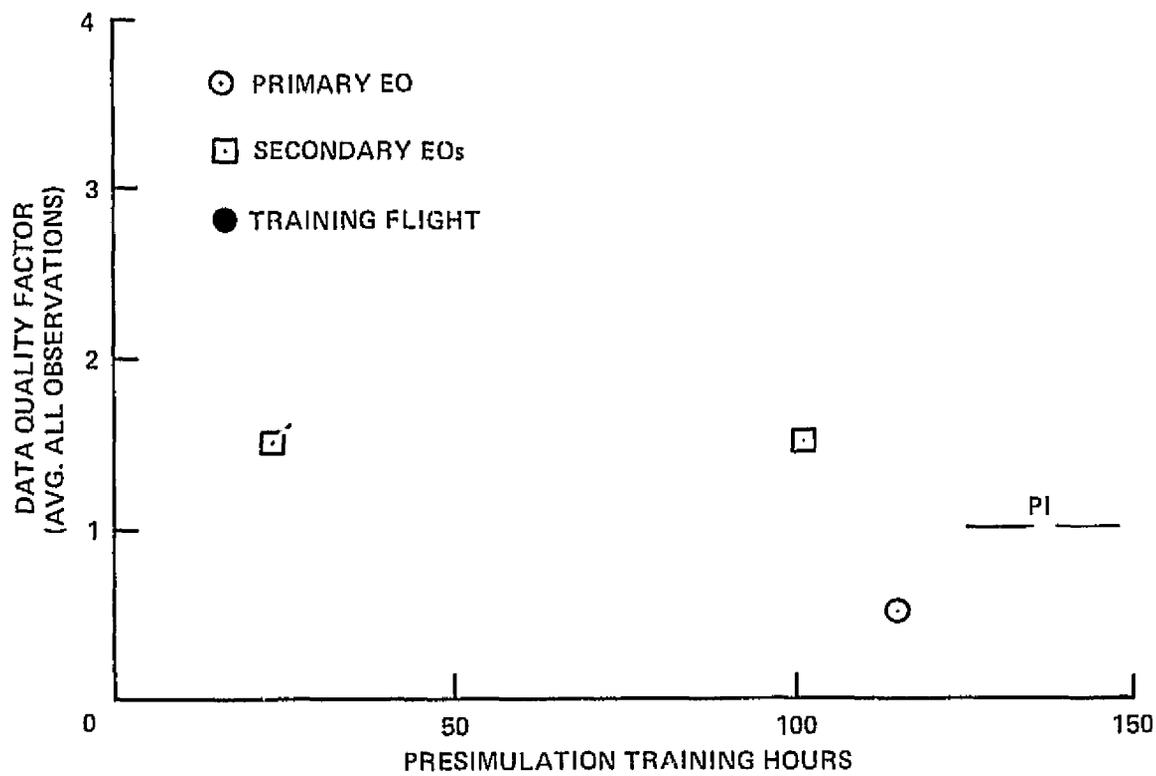
(c) JPL experiment.

Figure A-21.– Continued.
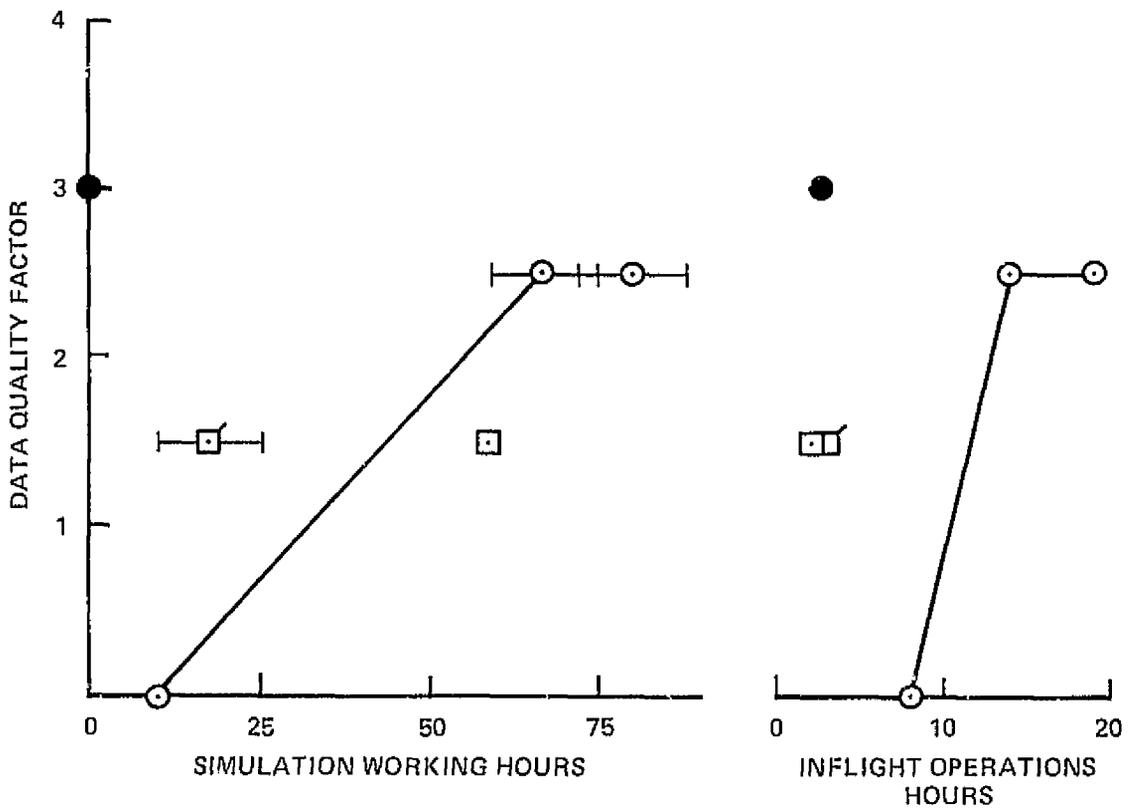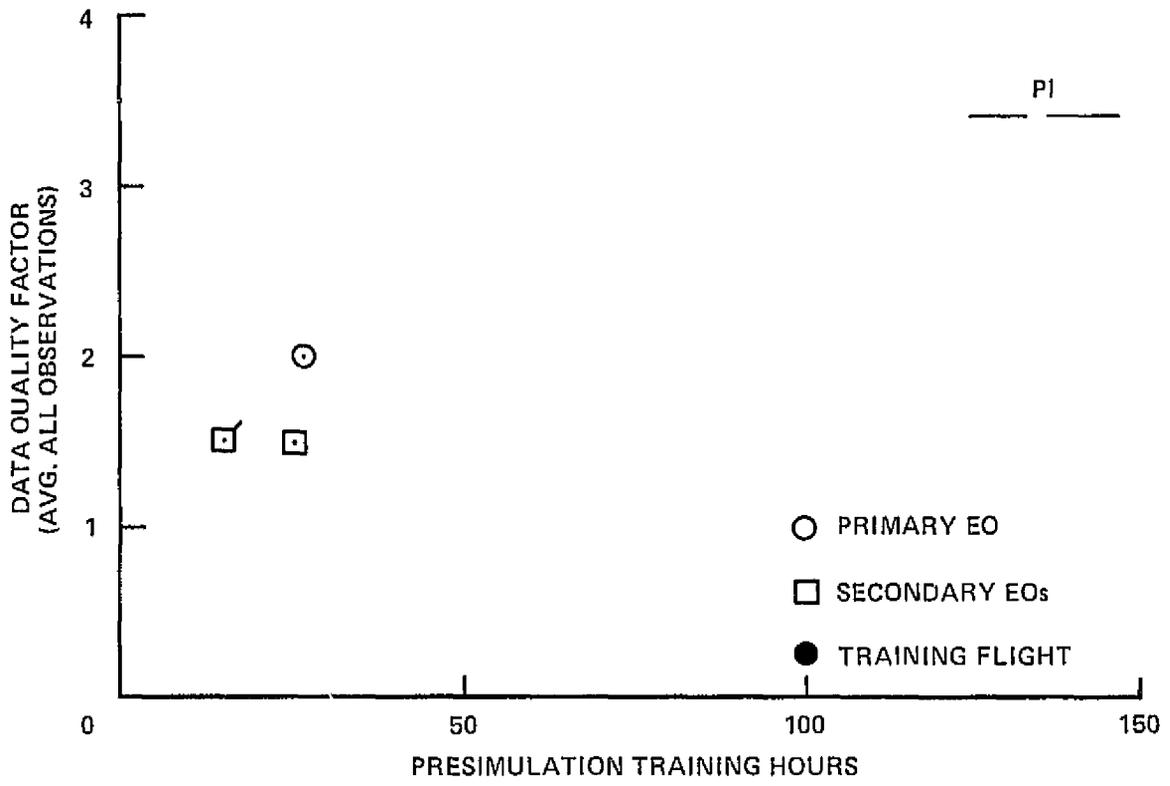
(d) Colorado experiment.

Figure A-21. Continued.

81
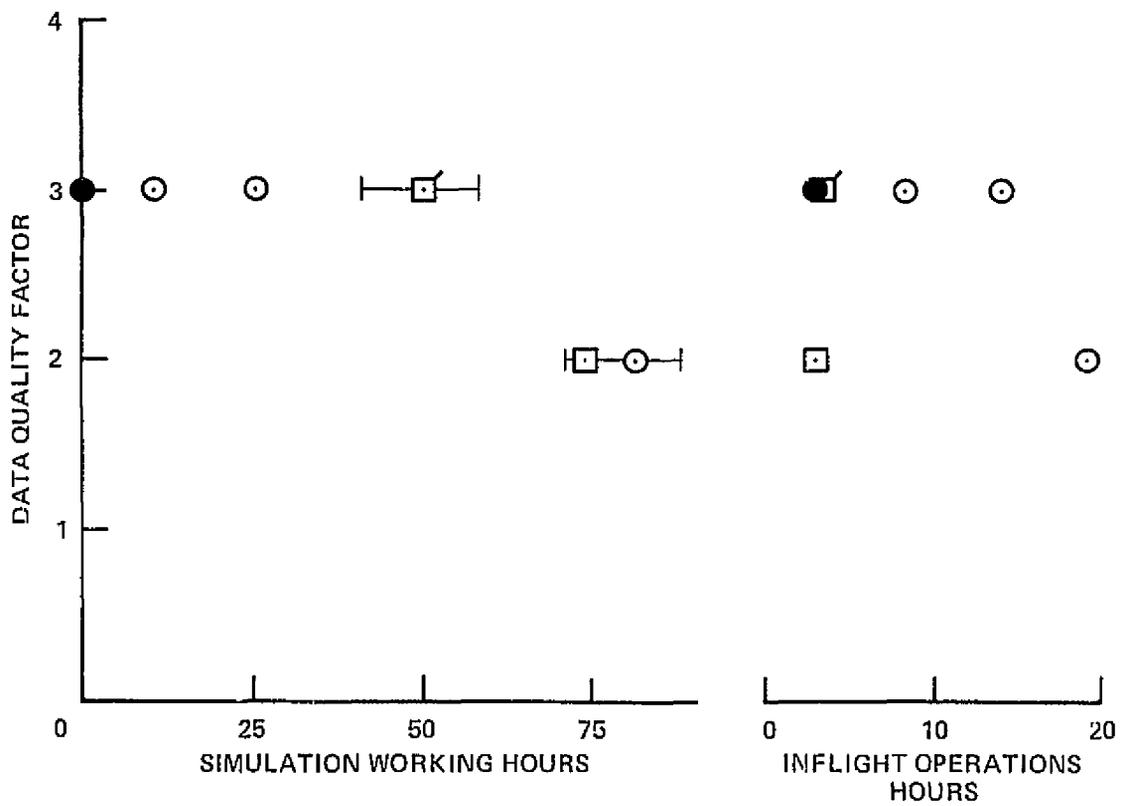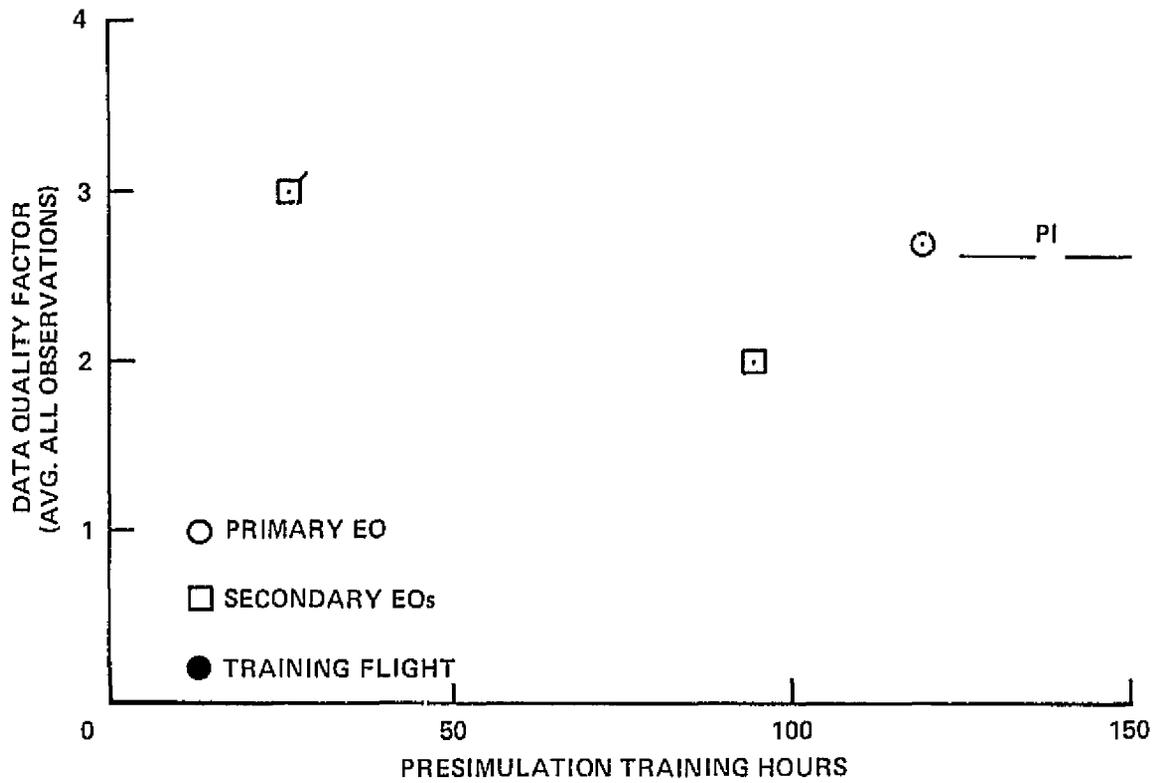
(e) QMC experiment.

Figure A-21.– Continued.
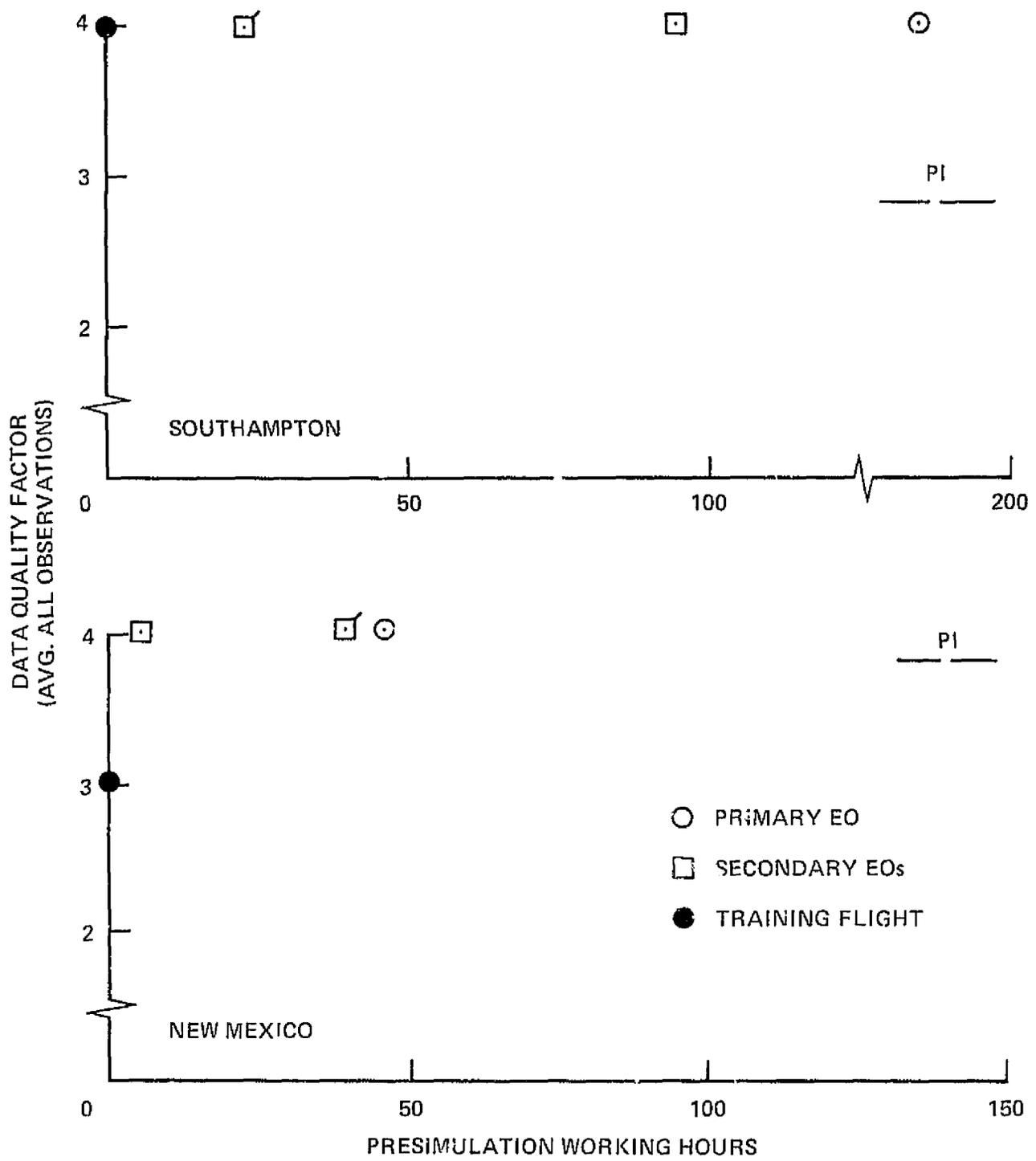
(f) Southampton and New Mexico experiments.

Figure A-21.— Concluded.

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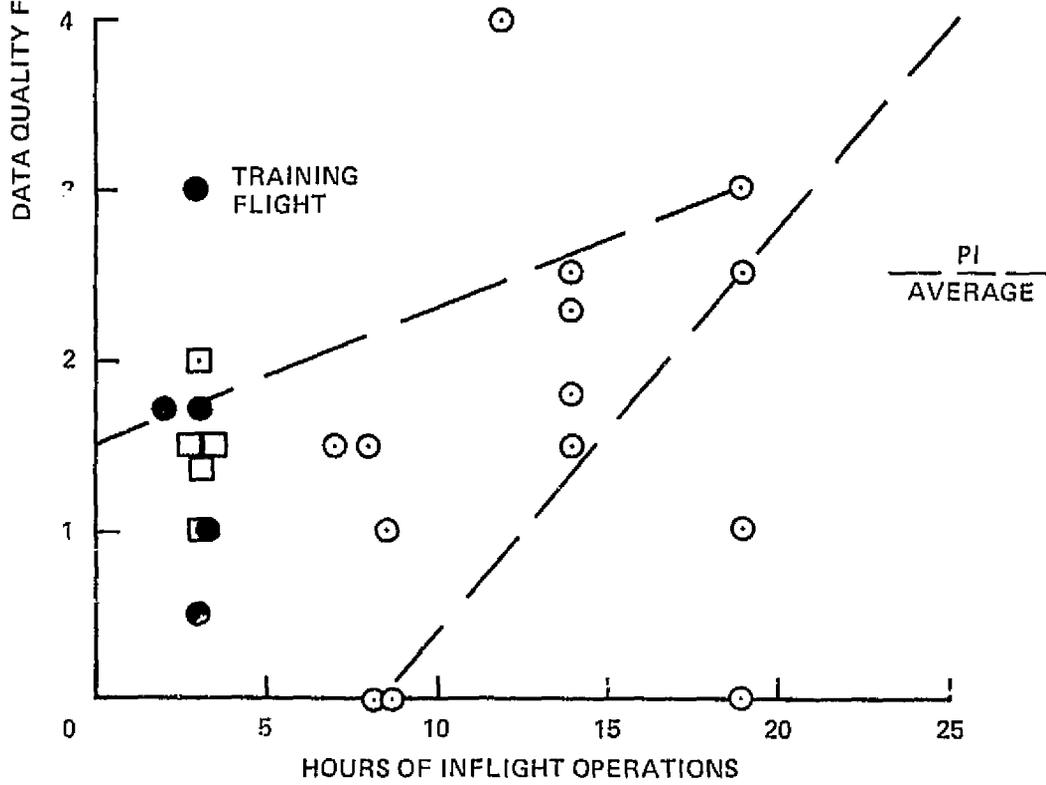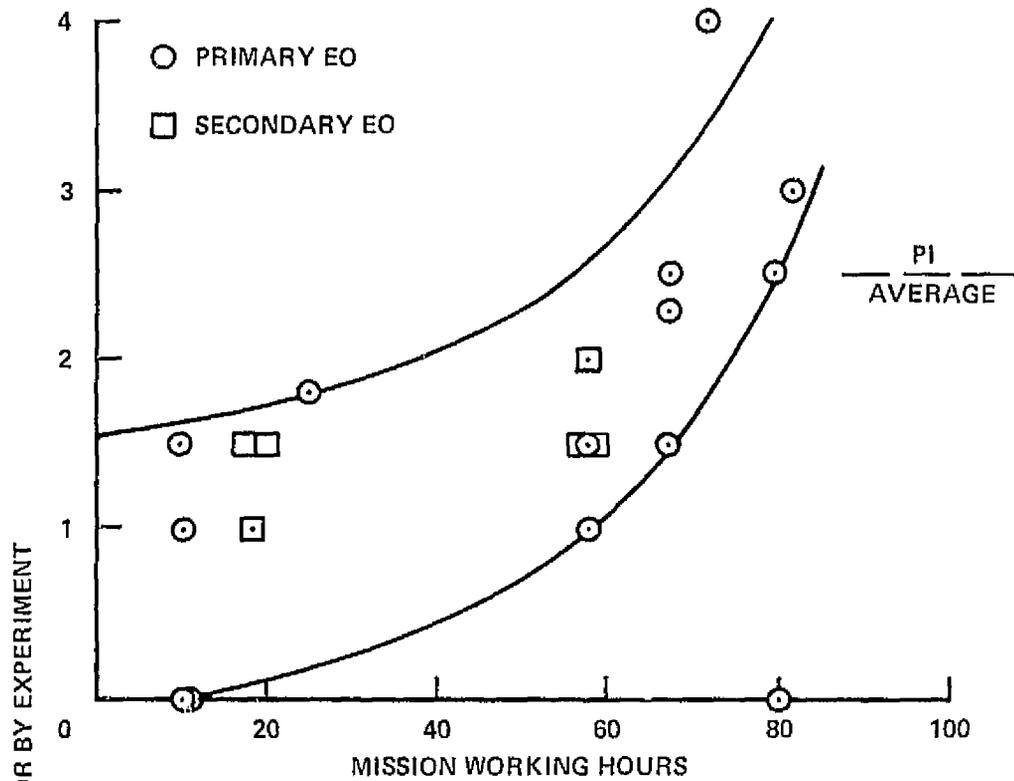
Figure A-22.— Summary of EO performance in flight: Meudon, Ames, Alaska, JPL and Colorado experiments.

Operator Experience Profile

The experiment operators for the Joint Mission had prior experience in related scientific pursuits that ranged from about 3 to 17 years, as summarized briefly in table A-12. Mission planners allowed more training time for the least experienced operator (B), but did not really differentiate among the other three. As it turned out, operator B participated in the development of one experiment (before the official start of training) and carried out the scheduled training program on his full assignment, for a total of 640 hours. C and D, on the other hand, started very late in the training period and for a number of reasons had less than the scheduled time at the home laboratories. Operator D in particular had only brief exposure to one experiment prior to on-site integration, and a total of 240 hours.

Table A-13 summarizes EO performance on an individual basis, and then compares their records on the same experiment. For example, operator C was compared with 12 EO/experiment combinations; on his first flight on a given experiment he achieved better data in one case, and equal or better data in 7 cases than did other EOs on the same assignment. By combining the indicated four columns into a composite performance parameter, and using the experience and training data from table A-12, a parametric relationship, as in figure A-23, can be derived. This relationship is of course unique to the the present situation and at best a first indication of the relative importance of background experience and specific training. Tentatively, it appears that experience covers a 400-hour training increment, and that some 600 to 700 hours are required to develop a fully qualified operator who has had only a few years of research experience.

EO Evaluation of the Operating Environment

MSFC observers during the Joint ASSESS Mission distributed two separate questionnaries to the EOs. One (Environmental Supportiveness Scale) was developed for use with personnel undergoing simulated missions in a MSFC facility. In general, this questionnaire concerns physical aspects of the simulation. Table A-14 summarizes the replies from three of the EOs.

None of the three EOs reporting felt very strongly about living and working conditions in the CV-990. None felt any aspect of the environment was superlative. One felt the lighting was very poor in most areas and another complained excessive aircraft noise in the forward end. These two observations were the only extreme ratings.

As the Joint Mission was the first of its kind, it is not possible to make comparisons between two or more missions to which a respondent may have been exposed. This factor undoubtedly detracts from the objectivity of the responses indicated in table A-14.

A second questionnaire (ASSESS CV-990 Crew Questionnaire) was prepared specifically for the Joint Mission, (table A-15). In general, the three responding EOs confirmed the ratings of the previous questionnaire. They were pleased with quality of support and the supporting personnel. Suggestions were offered for improvements in the arrangement of experiment modules in the rack, provisions for handling cryogenics, and improved PI support of secondary EOs. Experiment preparation was judged hasty and incomplete. The workbench and tool kit were considered adequate, although some missing supplies and tools were noted. Additional automation of some experiments were felt to be in order, particularly of the QMC experiment.

The EOs felt that some major functions were not accomplished as planned but that they were reasonably well equipped to make procedural-change decisions, particularly with respect to their prime experiments. Regarding training, the EOs felt they understood the experiment but had insufficient opportunity to operate the experiment before the simulation period. Operating procedures were considered generally satisfactory.

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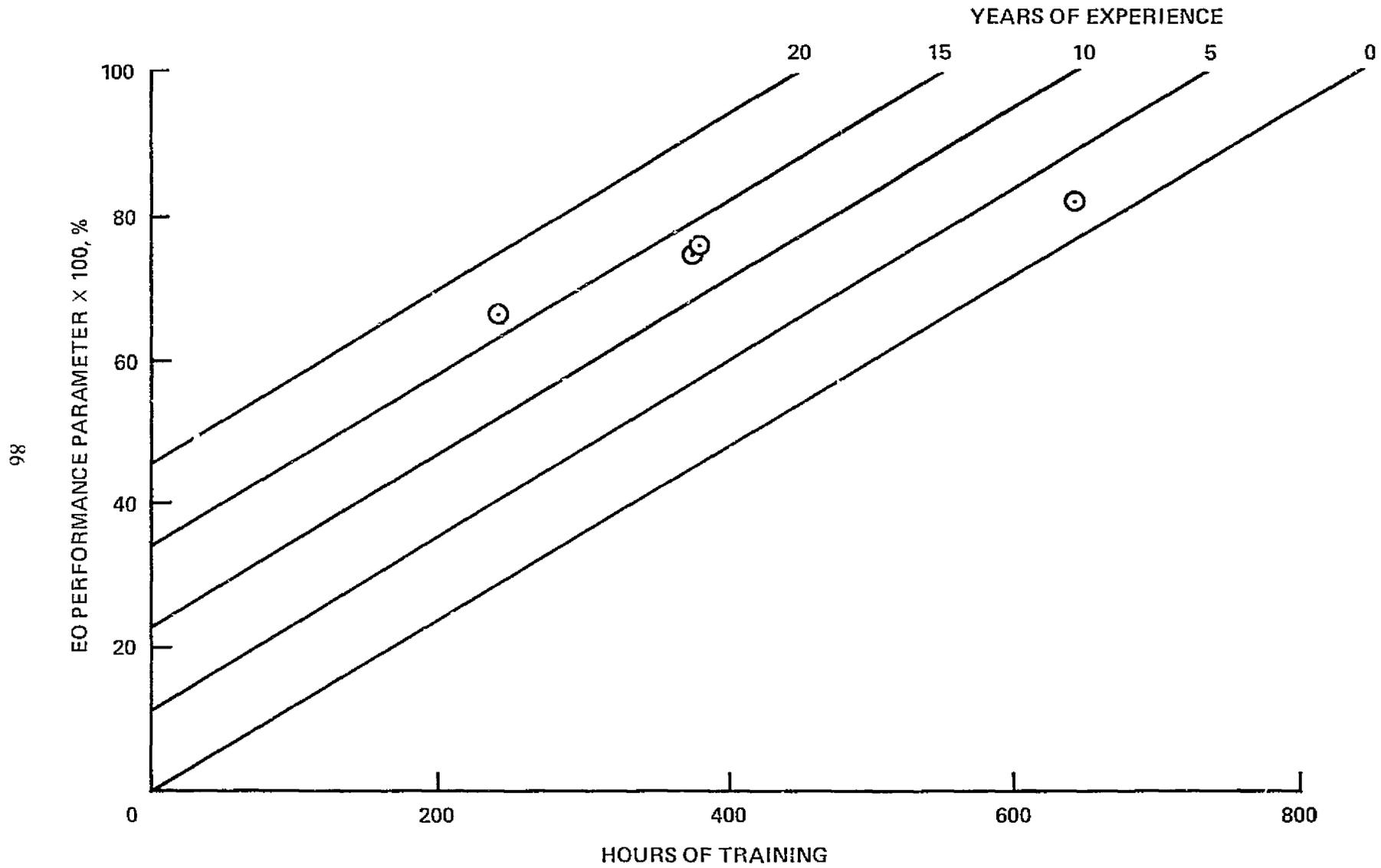
Figure A-23.— Background experience and specific training contribute to EO performance.

TABLE A-12.   SUMMARY OF OPERATOR EXPERIENCE

EO	Premission Experience				Total	
	Post-Grad Education	Research in Field	Flight Research	Other Related	Yrs. of Experience	Hours of Training
A	4 yrs. PhD.	3 yrs.	Flight Mission (1)	6 yrs.	13	375
B	2 yrs. PhD. Candidate	< 1 yr.	Sounding Rocket (1)	------	< 3	640
C	5 yrs. PhD.	8 yrs.	Flight Mission (2) Sounding Rocket (2)	------	13	380
D	4 yrs. PhD.	5 yrs.	Apollo & Skylab Programs Flight Mission (1)	8 yrs.	17	240

TABLE A-13. EO PERFORMANCE COMPARISON

EO	Overall Individual Performance			Comparitive Performance of EOs					
				First-time Operation of Expmt.			All Operations of Expmt.		
	Problem Response, %	Time Utilization, %	Data Quality, %	Number of Comparisons	Data Quality		Number of Comparisons	Data Quality	
					Better	Equal/Better		Better	Equal/Better
A	92	78	48	7	0 (0%)	5 (71%)	7	0 (0%)	4 (57%)
B	73	79	80	12	6 (50%)	12 (100%)	12	3 (25%)	9 (75%)
C	84	79	53	12	1 (8%)	7 (58%)	12	6 (50%)	10 (83%)
D	78	59	40	7	2 (29%)	5 (71%)	7	2 (29%)	4 (57%)

↑   ↑   ↑   ↑

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TABLE A-14.   RATING OF ENVIRONMENT IN PRIMARY WORK AREA

Subject	Item	Avg. Rating*	Comparison
Overall Suitability	Interest in Tasks	3.7	Above Avg.
	Quality of Support	3.3	
	Relative to Other Areas Used	3.3	
Research Operations	Supplies (GFE)	3.3	Above Avg.
	General Equip. (GFE)	3.0	Avg.
	Internal Communications	3.0	Avg.
	Maintenance Equip.	2.7	Below Avg.
	Stowage Facilities	2.5	
	Experiment Equip.	2.3	
	Working Space	2.3	
	Physical Layout	2.3	
	External Communications	2.0	
	Lighting	1.7	
Human Comfort	Trash Management	3.5	Above Avg.
	Odor Control	3.3	Above Avg.
	Noise Level	2.0	Below Avg.

*Rating Scale:
    5 = superlative
    4 = very good
    3 = average
    2 = poor
    1 = very poor

TABLE A-15.-- CREW QUESTIONNAIRE

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
1. Was the CV-990 layout satisfactory? Explain.	Reasonable within limits of experiments. Occasional times when cabin too crowded.	No. The equipment was awkward to use because of its height and the forward or backward facing of the gear often obscured viewing of essential chart recorders or scopes. The separate areas for each experiment made wearing a headset difficult.	Yes, except for minor inconveniences, such as having to switch headset connection when going from station to station and the inadequate curtaining off of the separate experiments.
2. Was the Mission/Manager Operations team support adequate? Explain.	Manager very good. Team adequate, with a few wrinkles. During night de-briefings were not vigorously enough conducted.	With regard to Preparation/Explanation of flight paths, responsibility for aircraft systems and safety, organization of support, e.g. cryogenics, the support was more than adequate.	Yes.
3. Define your major logistics problems during mission preparation and operation. How did you resolve them?	Organization of cryogenics and use of cryogenic detectors. Resolved by transferring helium etc. on ramp outside aircraft, but not a satisfactory solution.	No comment.	Major difficulty was adequately interfacing with PIs of back-. experiment. Overcome by relying on EO-EO interchange of information.
4. Were you permitted sufficient participation during the preparation phase prior to the mission? Explain.	In general NO. The relatively short lead time meant that PIs were too preoccupied with changes to let EOs have a large say.	During the preparation I had enough opportunity for participation in the prime experiments. There was not enough time to get too involved with my secondary experiments.	Prime experiments, mostly yes. Backup, some no.
5. Define any equipment that you didn't include but which would have been useful.	Cryogenic detector with cooling and pumping capability.	No comment.	Wire. List of specific fuses by instrument, and fuse selection by instrument would have speeded replacement.
6. Was communication external to the CV-990 adequate? Explain.	Basically yes, but it might have been useful to have more independent channels, one connected to each experiment location (this may not have been a proper simulation, however).	For all that transpired, yes. The communication wasn't used to its limit as it could have been for a major repair.	Yes.

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
7. Did you utilize the work bench and tool kit? Would you recommend additional capability? Explain.	Yes. A complete kit of electrical fuses for all equipment should form a part of the tool area.	Yes; the work bench was excellent. Additional capability no (except one small Allen key I needed was not included).	Yes, I utilized the work bench and tool kit. No additional capacity recommended based on experience in these flights.
8. Would you recommend more automation of the experiments? Which ones? Explain.	Queen Mary College: Automate starting, reversing, and initiation of scans. Bring all controls to one major console. New Mexico: Simplified loading of films. All controls to visible heights. Southampton: Control panels at more accessible heights and positions. Meudon/Groningen: More centralization of controls. Active on-line use of computer to set parameters as well as to log them. All experiments: Abolish chart recorders using ink pens. Use modular and plug-in cassette type loading of all data recorders.	I don't think more automation is needed, just careful evaluation of the time available to the FO to do the allotted tasks, e.g. he (she) shouldn't have to return to a piece of equipment at a critical time just to turn it off.	QMC would, with small expenditure, have the interferometer mirror scan terminated by a microswitch. This would have allowed much greater FO time flexibility on the airglow experiments.
9. Describe all major functions planned but not accomplished and tell why they were not accomplished.	Mapping of μ Ophiuchi was only done for 20 min. on one night instead for 1 hour on three nights. Nights 1 and 2 were cut off by aircraft problems and night 3 by a cryogenic problem.	Insufficient time was allowed for review of the Southampton data in between flights. New Mexico: During the flight they had planned to move the 35-mm camera from a mount on one side of the aircraft to a similar mount on the other side. This was too ambitious for one person doing three experiments. QMC: Their requirements simplified continually up to the time of the confined mission. This mostly due to the plane not fly-	All accomplished, but time line sometimes slipped due to a problem with one instrument which might delay interaction with the others.

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
9. (Cont.)		ing above the tropopause which meant a limb-scanning technique was not applicable. Also proposed was some selection of stabilized mirror angle to optimize a signal to noise – as indicated by the on-board Fourier transform. This was dropped because of the difficulty in obtaining good noiseless interferograms, and the extra time it would take the EO with the changing external environment.	
10. How easy was it for you to make real-time procedural changes?	Fairly easy to change filters and apertures as well as all standard mapping parameters. Easy to change astronomical objective only if an adequate star chart had been already provided (it was on all occasions).	With the equipment and objectives thoroughly understood and the guidelines for any decisions clearly outlined, any changes were not difficult – once used to working in the aircraft environment.	Prime: yes. Backup: required decisions which may not have been best.
11. Do you consider your support systems training to be adequate? Communications, power distribution, cryogenics, ADDAS. Discuss each one.	Communications on board gave little trouble, though times to each turn were not always announced. Training was short and OK. Power distribution gave no troubles. Training OK. Cryogenics gave problems, but totally unrelated to any training hang-up. ADDAS downtimes were a nuisance, but not training-related.	Communications: yes. Ames responsibility and no training was necessary. Power distribution: yes ADDAS: yes. Experimenter training was adequate. Cryogenics: yes.	Communications: yes. Power: yes. Cryogenics: no. ADDAS: N/A.
12. Do you consider your experiment systems training adequate? Discuss each experiment.	Meudon/Groningen: Too short. Much of practical familiarization on first EO flight. Southampton: Too short, but system gave no trouble in practice.	For my primary and secondary experiments I had visited the PI's institutes and studied in as much detail as possible (given the time and material available) the theory behind the experi-	JPL, Alaska, Colorado, New Mexico: Yes. Southampton: Yes, but limited time available for practice. QMC: No. Meudon/Groningen/Ames: N/A

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
12. (Cont.)	QMC: Too short, but system worked reasonably well. New Mexico: Very short, but adequate.	ment and the design of the equipment and the electronics used. For the primary experiments, by confinement I had received sufficient "hands-on" training, but for the secondary ones, in between visiting the PIs and the mission the equipment changed in several details and I had insufficient "hands-on" to become familiar with all the changes. For the problems that arose, my training was possibly more than adequate. Any more problems might have tested the thoroughness of the training.	
13. Did you feel a need for more indoctrination for the experiments you did not operate?	No.	No, as I was familiar with all the experiments.	No, although more might have been useful.
14. Were experiment operating procedures adequate? Was there too much or too little detail? Discuss each experiment.	Procedures were very good. They were worked out by EOs in close collaboration with PIs. Some more detail is needed for a back-up EO than for a prime EO.	Southampton: Television: I felt familiar enough with the equipment not to need to procedures during operation. The procedures layout made it difficult to use quickly. Photometer: Level OK. Nikon: Too much detail e.g. the instructions for mounting the camera in the zenith window. New Mexico: This procedure was very accurate, which it needed to be so as not to forget any of the many small steps, or damage the equipment. Difficult to use for hurried reference. QMC: I liked the level of this procedure. It assumed that the operator was familiar with the e-	JPL, Alaska, Colorado: Adequate, as I wrote much of it with the PIs. New Mexico: Very good. Southampton: Good. QMC: Inadequacies noted; e.g. some procedures told what to do, but not how to do it.

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
14. (Cont.)		equipment and was a very useful checklist to help organize the operator's time and avoid omissions. Alaska: Accurate, well laid out, quick to use. Colorado: Very clear, and easy to refer to in a hurry, with the right amount of explanation with each instruction to enable manipulation of the sequence if the need arose. JPL: OK. Enough details for airglow operation.	
15. Did the experimenter's reference material provide you with all the information you needed? Where was it weak?	In general this material was very good. Much technical information was available in considerable depth. It was, however, hard to translate the information into practical terms. We had to pressure to get photographs of panels with correct settings, in order to learn at location. Other than that of PI, often these were not available.	Not really tested because of the nature of the problems that arose.	Not extensively consulted.
16. Were there any onboard functions that should have been conducted by non-research personnel?	You should try asking technicians instead of scientists to run the whole system. They may turn out to be better EOs.	The majority of the preflight preparation time was taken up in changing films, loading tapes, cleaning and changing chart recorders etc. – which took time away from repairs or reviewing data.	No comment.
17. If you were going to participate as an EO on a future mission, having been through a CV-990 simulation, what would you do differently?	Demand more automation, and more inputs generally at an earlier stage of PIs planning. This could eliminate poor chart recorders and other trivial but	Carefully arrange the timing of a visit to the PI's institute, when the equipment to be used was all present but not finally assembled so that the EO could parti-	Require exposure to all experiments to be operated before the installation phase.

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
17. (Cont.)	time-consuming chores.	cipate in the last stages of troubleshooting. Arrange the duration of the stay to just include enough time to complete any background study of the theory behind the experiment and the equipment. Discuss with the PI any changes in equipment design which would make operation more efficient. Have more final "hands-on" training.	
18. Listed below are several problem areas you may have encountered. Please review the list and place the problems in rank order (1 for your most severe problems etc.) as they affected you. Feel free to list any others if necessary.			
a. Design of experiment workstation	10	2	
b. Mission/Manager/Mission Operations support	12	12	
c. Presimulation experiment integration	5	10	
d. Support systems training	6	9	
e. On-board personnel interactions	13	13	
f. On-board/external scientific communications	11	11	
g. Real-time systems flexibility	8	4	

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TABLE A-15.— (Concluded).

QUESTION	OPERATOR A	OPERATOR B	OPERATOR C
h. Light levels	9	3	
i. Noise levels	7	1	
j. Habitat vibrations	1	8	
k. Experiment training	2	5	
l. CV-990 layout	3	6	
m. Maintenance capability	4	7	

GENERAL EO OBSERVATIONS FOLLOWING THE MISSION

Following is a summary of EO comments and conclusions regarding their experiences on the confined mission. These remarks cover a variety of subjects, some of which, are specific to each EO's experiment responsibilities.

Operator A

System Operation

On the first flight of the confined mission, operator A found that it was fully possible to operate the Meudon/Groningen experiment in flight and obtain data. The system acquired the planet Venus immediately and recorded good, if weak, signals in all infrared channels. It was much harder to hold the faint stars in the field of S Cephi (the second object chosen), and just as the aircraft was turning out to the M-17 leg, oil pressure failure in one engine caused an abortive end to observations.

During the following day, operator A achieved an improvement in his acquisition procedure as a result of intercom discussions with a member of the Meudon experimenter team. On the second flight, having acquired Venus, he was able to acquire S Cephi much more easily and made scans. The sources M-17 and p Oph were also acquired and mapped successfully in more than one IR wavelength band. However, the p Oph measurements were again curtailed by engine problems.

As a result of a leak of air through a faulty teflon gasket seal on the third flight, the operator was unable to pump sufficiently on the detector cryogen. Signals were low at the beginning of the run, and eventually went to zero as the helium became exhausted from the detector dewar.

On the fourth flight of the confined period, operator A was assigned to his backup experiments the New Mexico/Queen Mary College/Southampton group. He found that the main problems were in the setting up rather than operation. Many laboratory chart recorders were used, and sensitive infrared film had to be loaded into two cameras. However, observations went well, and he was able to identify the main noise source in the QMC system – RF pickup – which occurred whenever the pilot-ground radio link was in use. It was not as difficult to keep these seven individual airglow instruments going as it had been for one man to operate the single telescope system plus cryogenic detectors. The prime airglow experiment operator (B) provided operator A with some useful training during the confined week.

During his one permitted hour on duty on the fifth flight operator A was able to render assistance, chiefly to operator B.

EO Qualifications

Operator A's basic conclusion from his experience on the confined flights is that an EO can operate complex scientific equipment and obtain data under the conditions imposed on this mission, and by implication could do so on Spacelab. In order to operate successfully, however, an EO should not become too tired. When alert, he can spot faults and errors, correct them more quickly, and make better scientific as well as technical judgments. Naturally, he is also less inclined to make his own errors.

Further, a single EO, trained to operate experiments in this way, can do far better than a single PI could do on his own. The EO must operate partly as PI but more as a highly skilled technician

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and engineer, a job most PIs are not used to. He noted that PIs on this mission   and on all others operate as leaders of teams, and are not necessarily the best-equipped team members for hands-on operation of equipment.

Automation

To facilitate a smooth run for the EO, the experiments must be as well automated as possible. Automation does not necessarily mean a great deal of expense. For example, a single reversing microswitch would have taken most of the labor out of operating the QMC experiment. In the present set of experiments, hours of preparation every day could have been saved by the use of cassette type recorder for all kinds of data records, including audio and video tapes, films, and above all paper charts.

Operator A stressed that the standardization of recording equipment, and the use of simplified clip-in/pull-out cassettes for every kind of data-acquisition medium would be a Spacelab investment that would pay for itself in cost effectiveness of Shuttle time many hundreds of times over. Simple push-in/pull-out module designs are available for some of these devices, and for the rest, the Spacelab program should pursue their acquisition vigorously. It should be possible to test out such systems during future simulation experiments in aircraft.

Support Systems

Of the ancillary systems, the interc n link was certainly effective, and should need little if any augmentation on a real flight. Workbench facilities were good. Only one significant item was missing when needed: a set of European-sized 6-amp fuses, which failed on the Groningen experiment following failure of an aircraft converter.

Participant Morale

Operator A felt that a highly significant factor in the relative success of the confined mission was the excellent personal morale of the EO team under the benign guidance of the Mission Manager. Not only did he do his job very well indeed but his constan consideration for the general personal needs of the EOs was remarkable. Further, he noted that pe.,onal relationships among the EOs were excellent, with every expected support coming from one to another. This morale factor, although not easy to quantify, must be strongly encouraged for Spacelab operations. It would be disastrous to allow a spirit of competition or worse, sourness, to arise among a trainee rew. To some extent, the hostile experimental environment can be expected to foster cooperation among the crew, as it probably did on the Joint Mission.

EO vs. PI Performance

Operator A also compared results for his primary and backup experiments during the EO confined flights with those obtained by the PIs during the unconfined flights. He noted that during the two weeks of unconfined experimentation,useful scientific data were obtained by the Meudon/ Groningen experiment. These data were of three kinds: system noise data, obtained by looking at the sky during flight; data on known astronomical objects, chiefly M-17; and data on mainly unexplored objects, chiefly ρ Oph. Although mission data are still in a preliminary state of analysis, he concluded that noise data obtained throughout the mission (both confined and unconfined flights) will be of value in predicting how to use airborne systems in general, and that the measurements are more precise and more general than any equivalent measurements made with the NASA C-141 or Lear Jet telescope systems.

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On the scientific side, he noted that more data were obtained on post-simulation flights than during the EO flights, but the quality is no different. He suggested that the mission as a whole will yield publishable astronomical material.

Operator A drew similar conclusions for his backup experiments (Southampton, QMC and New Mexico) — namely, that the amount of data obtained in the unconfined 2 weeks is greater than that obtained in week 1 by perhaps more than a factor 2, but that the quality is essentially the same.

Operator B

Scheduling

Much of the time between flights was spent preparing the equipment for the next flight. This work included changing batteries, films, tapes, and charts on recorders, filling a dewar with liquid helium three times every 24 hours, and monitoring the ensuing pumpdown. After making minor repairs and participating in briefings with each of the PIs over the voice link, operator B found that little time was left for prolonged troubleshooting of the equipment such as searching for sources of EMI.

Acclimation

For the first flight, it was difficult to think quickly under pressure in the noisy, dark, and uncomfortable conditions. It also took a long time to get all the equipment for each experiment turned on and working properly. By the last flight, operator B found the environment no longer strange, and his proficiency in equipment operation had increased significantly.

Performance and Training

Evaluating his inflight performance in the light of his training, operator B concluded that the PIs tended to assume that their equipment would work as expected during the flights without any problems and therefore tended to instruct the EOs simply on how to operate the equipment. Operation of a perfectly working system according to some checklist requires relatively little training, and operator B felt that the EOs themselves had to continually push for more thorough instruction. Correction of even the minor faults or mistakes that inevitably occur requires a "feel" for the equipment. In the view of operator B, the importance of hands-on training was illustrated during the confined period when an EO was operating his secondary experiments: On numerous occasions, the EO would require assistance from the prime operator for some small task that unresolved might have led to a loss of results.

Operator B felt that his training was more than sufficient to deal with the minor problems or repairs that were needed during confinement. He noted, however, that some major problems, such as RF interference on one experiment, were not handled by the EO or by the PI in conjunction with the EO via the telephone link, but were left to the PIs during the nonconstrained flights. He suggested two possible explanations: (1) the postflight voice link between EO and PI was too slow and inadequate — for example, the PI could suggest a change for one flight and would then receive a report on that change after the flight; or (2) the EO had insufficient responsibility and training for initiating corrective changes in the equipment on his own. For future missions, the EO's responsibility for debugging and maintaining the equipment could perhaps be more clearly defined and the training oriented accordingly. Operator B also noted that none of the reference manuals placed on board by the PI was used.

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Automation

In the opinion of operator B, the experimental equipment for which he was responsible was sufficiently automated, and he noted that it was possible to set up and keep the several experiments running simultaneously. He did feel, however, that consideration should be given to the time available to the EO and the number of tasks he has to perform. For example, there was little time available for the prolonged data analysis during flight as originally proposed by some PIs, and in many cases the operational requirements for an experiment were reduced by the PI just before the confined phase of the mission. Also, certain operations should be avoided — for example, the requirement for one experiment that data collection be stopped at the end of a scan and reinitiated every 7½ minutes, a recurring deadline that limited the EO's other activities.

Aircraft Missions and Spacelab Training

Operator B considered aircraft missions such as the Joint Mission very valuable training for a prospective scientist-EO preparing to work in a hostile and strange environment under PI pressures to obtain good results from their equipment. Such missions also afford good opportunities for Spacelab PIs to learn about the design of equipment that will yield optimum results with a proxy operator having many different responsibilities.

Operator C

Simulation Quality

Operator C noted several limitations on the confinement aspect of the mission, particularly those resulting from the presence of nonconfined personnel needed on the aircraft between flights. At one stage in the confinement, while the EOs were going through preflight procedures, there were approximately ten nonconfined personnel on board, seriously restricting freedom of movement in the cabin. Some control should have been exercised on the number on board at a given time. (He also suggested that all PR work such as photography, be scheduled later in confinement, when problems and procedures have been smoothed out.)

Working Relationships

Operator C also commented on the supportive working relationships among the crew, noting that he could not recall hearing a single sharp word exchanged among the five participants during the confined period.

EO Decision-Making

One of the PIs remarked at a debriefing that his instrument was not turned on for an hour and a half after takeoff on one of the flights. Operator C's opinion was that the experiment in question was not working, and was not obtaining useful scientific information at that time. As a result, the responsible EO decided to spend extra time ensuring that some problems were overcome on other instruments before spending time turning on the instrument in question. Operator C noted that EOs will have to make such decisions and take the responsibility for them: Blindly following time sequences involving faulty instrumentation can jeopardize the total information output of an integrated payload. He noted further that EO training must be sufficiently comprehensive to allow recognition of the difference between data bits being generated by an instrument, and useful data bits being so generated.

Inflight Data Documentation

Another debriefing comment was that certain physical records being downlinked contained insufficient EO documentation of data to be useful. However, operator C could not recall any requests for additional information during the confinement week, suggesting that either the problem was limited to one flight late in the week or the PI had not examined his records in detail earlier in the week. Further, he could recall no postconfinement request for any EO to fill in missing documentation from memory.

PI Flights

In addition to his work on the aircraft during the confinement period, operator C had the opportunity to accompany the PIs on several flights during the postconfinement period. As an example of his observations on those flights, he cited an experimental procedure requiring real-time integrated spectra to be copied from the computer in two ways, one considerably more complicated than the other. On observing the two PIs operating the system during flight 15, operator C noted that only the less involved procedure was being followed, and on inquiring was told that "We do not have time to do both!" At the same time, three other PI group members were operating the remainder of the instruments, which had been the responsibility of one EO. In addition, major modifications in instrument configuration were made after confinement and prior to postconfinement PI flights. Operator C suggested that after the PIs have analyzed their data, they should be asked:

1. How much useful data was obtained by the EOs?

2. How much useful data was obtained by the PIs postconfinement?

3. How much of the PI-obtained data would have been possible without the experience gained by EO flights and the subsequent experimental modifications?

Mission vs. PI Objectives

PI knowledge of postconfinement flight opportunities undoubtedly compromised the ASSESS concept. This was stated specifically by some of the PIs, and certainly led to a more casual approach to EO training. Some also felt that the mission was concerned less with science than with instrument development and an introduction to future Spacelab operations. While PI reluctance to devote full attention and energies to missions relying solely on EO performance to obtain data is understandable, it also precludes a valid ASSESS operation. Operator C suggested that consideration be given to a purely confined mission, possibly encouraging PI participation by providing opportunities unique to the mission — for example, a number of aeronomy flights over the so-called South Atlantic anomaly.

Experiment Preparation and Mission Schedule

While it should not be necessary to freeze an experimenter's system far in advance, the responsible EO should be given a space of at least several days for hands-on operation of a finalized configuration. It would seem reasonable to require the PIs to complete their systems sufficiently ahead of the start of a mission to allow two full working days for EO system operation during periods when the aircraft is accessible.

Further, operator C felt that the concept of testing the EO's ability to obtain useful scientific data, as opposed to just going through operational motions, could be validated only if the PIs considered for repeat flights in a series of ASSESS-type missions are those who demonstrate that previous flights were scientifically productive.

Finally, he expressed the hope that future missions of this type would be better funded, specifically including the appointment of a mission scientist for the entire planning and operating period. Such a mission scientist need not be a NASA employee, but could be chosen to participate in the same manner the EOs were chosen. He would visit the PIs' laboratories soon after their proposals are accepted, interact with them by describing problems in instrumentation unique to an aircraft environment, and help map out solutions to those problems based on past experience of other experimental groups.

During the installation phase, the mission scientist would be available to adjudicate conflicts in flight plans well before the days of flight. Also, he would be available to arrange conditions such as air conditioning necessary for the safe operation of instrumentation on the aircraft, and to act as liaison between PI and EO if either feels the interaction between them is insufficient to ensure a successful operation. For the Joint Mission, some of these functions were filled by the Mission Manager, but his various logistic and administrative duties made it difficult for him to be available to the PIs and EOs as often as desirable.

<p align="center">Operator D</p>

Communication

Operator D considered communications with the PIs to be very good. They were informal, not stilted, and useful for the crew. Two groups were probably guilty of a little too much "hand-holding," but that seemed a small price to pay for the other good points of the system. Although there may have been occasions when an inflight communication line to the ground would have been useful, such a need certainly did not arise very frequently on this mission. During data taking, as opposed to preparations and troubleshooting, the crew operated by themselves for the most part. Operator D was not aware of any instances on the mission when the TV downlink was absolutely necessary.

Workload

There were two groups of three experiments on board that were run by one EO each. By accident or by design, the workloads for these three experiments were such that when they were running, one EO could operate all three of them and be about as busy as the EO who was running the single infrared instrument. Setup was a very different problem, however, since each of the three experiments required about as much attention then as the IR instrument. Since all the PIs wanted to be turned at the same time (the start of the flight!), the EO workload for these two groups was considerably heavier for the first part of the flight than that of the infrared EO. In the future, EO assignments should be based in part on the setup periods, not just periods of operation. For example, perhaps the IR operator on the Joint Mission could have helped out the other EOs during experiment setup. The pressures of getting all experiments on and running are, of course, not unique for this mission and will undoubtedly recur in the future.

Support Instruments

Even through not providing ultimately usable scientific data (which was usually on mag tape) the availability of visual output (Strip chart or CRT) greatly enhanced operator confidence and ability to keep up with experiment performance.

Some of the software was less tractable and forgiving of mistakes than others. One program in particular frequently had to be reloaded for seemingly trivial errors like typos. On some experiments, it was apparent that operations were simplified by the use of good old-fashioned switches that could be easily repositioned if a mistake was made.

Experiment Preparation and Mission Schedule

Operator D did not feel it was realistic to establish a premission cutoff for PI modifications, improvements, and fixes to facilitate EO training from then on. He noted that one of the good things about the Airborne Science program is the flexibility of the system in allowing last-minute PI changes. The experiment preparation period also contributes significantly to EO training if the EO participates as a team member in these continuing modifications.

Secondary Experiments

Operator D did not train on his three secondary experiments as an integrated unit, even though they were all in the aircraft and available to him. Because the control panels were quite separated, however, he did not feel that the lack of integrated training proved a deficiency in flight. If all three control panels were integrated together, more efficient operation might have been possible, but nevertheless probably would not have required more than a day of integrated operation during training.

EO vs. PI Performance

As absolute as possible a comparison should be made between EO and the PI performance under similar circumstances, with the same equipment problems and the same workload. Only in this way is it possible to determine what additional training, if any, was necessary to improve the quality of EO performance. There is no value to comparisons between the performance of one PI working on, for example, the QMC experiment and that of the EO for all three atmospheric experiments, because the PI did not have the workload of the other two experiments. Questions should center on things the EOs did not catch that under a smiliar workload the PI would have caught, and so forth. Operator D also noted the importance of EO familiarity with aircraft science operations to his overall performance.

Hands-on Training

Operator D felt that a particularly important factor in his training for both primary and secondary experiments was the willingness of the PIs to let the EOs operate and "play" with the experiments on the ground. Of significant training value also was the EO checkout flight, which allowed the EOs to operate their primary experiments once before confinement. This experience, he felt, put them well up on the learning curve before their first "real" flight and can be compared perhaps to their first (and only) flight on secondary experiments during the confined period. Operator D noted by the end of his first confined flight on the Ames detector, which took place two weeks after his EO checkout flight, he was certainly well over the shoulder of the learning curve and probably also after his flight on secondary experiments. He suggested that no matter how much ground training is provided, there will be at least a short learning curve when the "real" mission begins, and

that if one does not operate an instrument for a protracted period of time (say a week or more) his proficiency will decrease. He felt that for the experiment load of the Joint Mission, the training period was approximately correct.

Flight Events

On the first confined flight, operator D had no assignment but spent approximately one hour testing the Ames detector assembly for microphonics, which seems a perfectly proper use of the spare man on a flight. On the second flight, he was assigned to his secondary experiments. Two problems had occurred on the first flight with Colorado/Alaska data-handling system and although one part of the Colorado problem was fixed, significant problems remained in both experiments with no fixes suggested by the PIs. An added task was to check the alignment of the sky-viewing mirror of the Alaska experiment, a short two-man job that was readily accomplished with the help of operator C, who was unassigned that night.

Other operations on the second flight proceeded quite normally except for great difficulty locking on to Venus with Alaska star tracker. Operator D notes that the reason for this was his failure to turn on the high voltage of the star tracker, a major mistake that resulted in his obtaining only about 5 minutes worth of data that flight for Colorado on Venus. He felt it was worthwhile to explore the reasons (not excuses) for this error:

1. In training, the EO had always interacted with the system _after_ the system had been turned on and so never had to turn on the HV.

2. There was some carelessness in delineating the division of labor between the EO and the heliostat operator.

3. The EO was also careless in studying and following the guidance and acquisition procedures because of basic assumption that they were trivially straightforward to an astronomer, and so did not need to be studied.

4. There was also a psychological problem in that the EO assumed the error was in the alignment of the telescope, because on the previous night there had been considerable difficulty due to a misalignment problem.

5. The high-voltage switch is small and somewhat obscurely placed on a panel filled with other switches that are not used in normal operations.

On the third day, operator D was again unassigned and in the afternoon performed two fixes to the Ames detector: (1) resoldering a wire, and (2) removing a washer that had been used to wedge the filter wheel in an attempt to reduce the microphonics problem. This latter item had been discussed before the constrained period and he was well prepared for it. The TV downlink was used so that the PI could watch the EO do it, but operator D felt that the use of TV in this case was more to reassure the PI than for actual assistance or instruction.

On the fourth day (which was a repeat of the third), operator D was again off duty but continued to work on repairs to the Colorado and Alaska equipment suggested the previous afternoon. Problems resolved included replacement of a fuse that was previously unknown to any of the EOs, repair of a faulty power supply in the D/A converter by running wires from another power supply in an unused box.

Even though operator D was technically off duty the third flight, he participated in preflight repairs because it seemed reasonable that extra help would be available to do just this sort of thing

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on Spacelab and that the crew would not be rigidly limited to three people at all times. In the same spirit, he also did some further testing of the Ames dewar during the flight and helped operator B on the acquisition of Venus. The two EOs had trouble locking on because the star tracker alignment was shifted by one-half of the radius of the finder field of view. Operator D noted that the finder system on the Alaska telescope is definitely below par.

On the fourth flight, operator D was assigned to his primary experiment, the Ames 3-6 μm filter wheel spectrometer, which he had not operated on the telescope since his EO flight two weeks before. Preparations during the afternoon were quite straightforward. A major concern was the need to rebalance the Meudon telescope. Although operators A and D understood this procedure in principle, neither EO had ever balanced this telescope before or even received any formal training on this task. Despite this concern, and with perhaps a little beginner's luck, the rebalancing was accomplished with surprising ease. The planned use of small weights to compensate for LN_2 boiloff during flight was also easily accomplished, especially with the aid of the two torque motor ammeters installed for this purpose. Observations were scheduled for Venus, α Herc, and IRC-10216, and all the fields were quickly found. Acquisition of Venus in the diaphragm was impeded by three problems:

1. The location of the diaphragm had moved relative to the offset coordinate system.

2. The aircraft had large roll amplitude that repeatedly drove the telescope to the stops causing it to lose lock and interrupt the acquisition procedure.

3. At the beginning of the Venus run, operator D may have been over-controlling during the search pattern. (This last might be called a decrease in proficiency from not having operated the telescope for two weeks.)

Because of these problems, data on Venus were obtained for a period of only 5-10 minutes and then only minimally, because of repeatedly losing lockon, when the telescope was driven into the stops. Since the coordinates of the diaphragm had been obtained, lockon for α Herc was considerably easier. The data obtained, however, were still minimal since the sequence was something like 10 seconds of data, 20 seconds off, 10 seconds of data, etc. After the end of the α Herc leg, adjustments to the autopilot were made that greatly reduced the problem – the roll oscillations were now smaller than the width the gimbal stops. IRC-10216 was found by hand rastering in the approximate location and good data was obtained. Due to EO troubleshooting efforts, the microphonic noise was significantly reduced than on operator D's checkout flight two weeks earlier. An apparently new problem was a large sky offset (perhaps caused by the mylar).

On the fifth flight, operator D was again assigned to his primary experiment, the Ames detector. Preparations were even more relaxed, and in fact all the crewmen were sitting around a good portion of the afternoon. Just before the beginning of the Venus run there was a brief period of relatively high noise on the strip chart, not due to the amplifiers. Before the acquisition of Venus and before operator D had a chance to solve the problem, it disappeared on its own and did not reoccur. After that, acquisition of Venus proceeded quite readily, and although there was some aircraft roll at the start of observations, considerable apparently good data were obtained on Venus.

CONCLUDING REMARKS

The selection and training of operators (payload specialists) for Spacelab missions will be of critical importance to the overall success of the mission. This Joint ASSESS Mission provides insight to these processes, to the close working relationship between EOs and PIs, and to the performance of the operators in a simulated Spacelab environment. The four EOs selected for this mission included one doctoral candidate, two senior scientists, and a scientist/astronaut, with a range of ex-

perience in closely related fields from 3 to 17 years. Training plans for the individual EOs made allowance for their background experience, and for the inherent complexity of their primary and secondary research assignments. Despite the informality with which the training activity was planned and implemented, and the "last minute" nature of their experience with the fully operational experiments, the EOs performed in a very creditable manner during the simulation period.

The following specific comments on EO qualifications, training, and operations reflect primarily the experience of the operators themselves, with supporting views from the PIs and others directly involved in the conduct of the mission. Inasmuch as this Spacelab simulation imposed a very real atmosphere of isolation and responsibility on the EOs, the observations given here have direct bearing on comparable elements in the developing Spacelab program.

Experiment Operator Qualifications

1. The experiment operator should be a research scientist who understands the theory and objectives of the experiment, who can interpret the data obtained, and who has sufficient knowledge of electromechanical hardware to identify and correct operating problems. Neither the purely theoretical scientist nor the competent technician can handle all aspects of this complex assignment.

2. An operator need not necessarily be a specialist in the particular experimental field, but should be experienced in closely allied research to enable effective, in-depth training to be done.

3. At least one member of the operating team should be qualified by experience for general troubleshooting of electronic equipment. As consultant to the other operators, he may make a vital contribution to the success of experiments, as was observed of Operator B on the Joint Mission.

4. The qualifications and responsibilities of backup operators should be clearly defined, and should be based on the assumption that they may be called on to perform the duties of primary operators without benefit of assistance or consultation.

Characteristics of an Effective Training Program

Home Laboratory

1. A well-defined training plan should be developed and implemented on schedule.

2. Responsibility for training segments should be assumed directly by the PI or assigned to cognizant team members far enough in advance to permit adequate content and schedule planning.

3. Training elements should be keyed into the experiment development schedule at appropriate spots, usually as soon as element objectives can be met with existing equipment.

4. Training should start as soon as essential equipment is on hand and some subsystems are working.

5. The periodic nature of training requires coordinated scheduling of EO obligations at several locations. Such scheduling is greatly facilitated by firm experiment development schedules.

6. Science training by the PI team should be supported by a carefully chosen list of pertinent background literature.

7. Technical guides and or manuals should be available for experiment components, including those built by the PI team.

8. Laboratory training should be planned to cover both normal operations and maintenance functions for each experiment subsystem. Late developing subsystems, such as secondary instruments and data-handling equipment, are particularly vulnerable to training oversight.

9. The depth of desired EO response to equipment problems, and the degree of freedom allowed for real-time decisions, should be defined early in the training period, with maintenance training tailored accordingly.

10. Hands-on operation of the fully assembled flight experiment, and of each subsystem, should be part of the basic laboratory training. This initial familiarization with the total experiment package should be accomplished before the integration period at the launch site, when other tasks may assume first priority.

11. When feasible, in-the-field training on real targets should be done, to move one step closer to real-life operational experience.

12. Laboratory training of an EO who will operate several experiments should relate to time-share priorities being developed by the PIs involved, and to timelines for group operation.

13. Training on secondary experiments may not require the same level of proficiency as for primary experiments, but should still be adequate for independent operation.

14. A full-time Mission Scientist on the Mission Manager's staff could perform a valuable liaison function among PIs and EOs during the laboratory training period and beyond.

Integration Site

1. Hands-on participation in experiment installation and checkout should be part of the training experience, and should be carefully planned in advance to coordinate EO activities with the several experiments involved.

2. Experimenter preoccupation with equipment development tasks at the payload integration site can seriously cut into EO training at a critical time in the preparation period, and reduce EO proficiency in flight. Instead of being available to assist EO training on an operating experiment, the PI in this situation is attending to tasks that should have been completed in the laboratory.

3. Experiment integration and operational verification of hardware, software, and procedures should be completed on schedule to permit planned training activities to be fully implemented.

4. Hands-on training for normal experiment operations in a realistic ground-based simulator should reduce adaptation time to real mission conditions.

5. Integrated payload training is necessary to develop realistic timelines for EO operation of several experiments.

6. Normal-operations training has priority over maintenance training; if the first is delayed by equipment problems, the second may be impacted significantly. Contingency planning should allow for this possibility.

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7. Final training segments should be carefully planned to achieve the desired proficiency on both primary and secondary experiments, in the limited time available.

8. Experience in scientific data evaluation is a necessary part of the training program, to enable real-time decisions for maximum quality research results.

9. Adequate training enhances recognition of and response to abnormal situations using onboard references and tools, avoids the delay of PI communication and evaluation of verbal data, and equips the EO for decisions in real-time to optimize the scientific return from several experiments.

10. Priority decisions relating to experiment operating schedules during the mission can guide training emphasis and timeline development.

General Observations on Training

1. Prior experience is not an adequate substitute for current training on present equipment.

2. Once a system is learned, it should be practiced often to prevent loss of proficiency. Intervals between practice sessions should not exceed one week.

3. "Soft" areas of training hamper performance when time schedules are tight, with a resultant loss of research data.

4. Some latitude may be allowed for post-deadline experiment modifications, in individual cases, if the EO can participate fully.

5. Operator experience in closely allied fields, and familiarity with the research environment, appear to reduce the amount of integrated payload training required for proficient operation. Valuable background experience of this type may be acquired in aircraft missions for experiments employing telescopes for IR or UV astronomy.

Recommendations for Spacelab Equipment and Operations

Research Equipment

1. Selection of experiments for spacelab should consider two requirements: demonstrated scientific results on a previous simulation mission and demonstrated experiment performance well in advance of the launch date.

2. Automation of experiments is required to reduce oprator workload and avoid fatigue during observation periods. Individual experiments and especially multiexperiment groups were deficient in this respect.

3. Management should furnish guidelines to assist PI planning for experiment automation.

4. Experiment controls should be arranged for ease of operation and to minimize chances for mistakes. Joint Mission control layouts were far from optimized, even on individual experiments.

5. Standarized cassettes should be developed for all recorders – tape, film and paper chart – to facilitate reloading with minimum loss of time.

6. Management should supply information on standard, Spacelab-rated instruments to guide PI selection; alternately, a pool of such equipment could be available to the PI.

7. Tools and supplies to support experiment operation and repair should be carefully selected to enhance EO performance.

8. Aircraft mission experience should enable PIs to design a better experiment for their own or proxy operation in Spacelab.

9. A real-time visual readout of scientific data is very helpful to the experiment operator, who can evaluate and respond at once to maintain quality of results.

10. Experiment-specific software must be reliable, since the operator may not be trained or have the time to effect changes.

Research Operations

1. Mission duration should be 14 days or longer for EOs to develop full performance potential.

2. Operations schedules should allow for a learning or shakedown period at the start of a mission, during which time EOs adapt to the environment in both the physical and procedural sense.

3. Reasonable automation of normal experiment operations frees the operator for real-time evaluation of data, informed response to unique research opportunities, and the exercise of optional modes of data acquisition.

4. Operator timelines should allow for EO support during peak workload periods, as for example, during equipment turn-on at the start of observations.

5. Provisions for maintenance and repair should involve active support by the off-duty operator to the fullest possible extent.

6. PI communication is not necessary or even desirable during periods of normal operation, but can be vital to the resolution of equipment malfunctions. At such times a TV downlink may facilitate the solution.

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Operator A

Age:
Citizenship: British
Marital Status: Married

Education

Open Scholar (Physics), Jesus College, Oxford University 1959-62.
B.A. (hons. Class I) physics - Oxford, 1962.
Skynner student (Astronomy) Balliol College, Oxford, 1962-65.
D. Phil. Department of Astrophysics, Oxford, 1965.
Post-doctoral fellow, Lick Observatory, Univ. of California 1965-1966.

Appointments

Staff scientist, J.P.L., Caltech., 1966-67.
Lecturer in Physics, Queen Mary College, London, 1967.
Currently on leave of absence as Visiting Scientist, ESTEC, 1974.

Other Appointments Held

Course consultant in Earth Sciences; Open University, U.K., 1970-71.
Consultant in Infrared Physics, National Physical Lab., U.K. 1971-72.
Visiting Astronomer, High Altitude Observatory, Boulder, Colorado, U.S.A.,
    Summer, 1972.
Member ESRO Post-Apollo Infrared group and Infrared Mission Definition Group, 1973.

Membership

Royal Astronomical Society (Fellow).
American Astronomical Society.

Publications

Author or co-author of over twenty papers.

Operator B

> Age: 24
> Citizenship: British
> Marital Status: Single

Education

1962 - 69	Alleyns School, Dulwich, London
1969 - 72	Downing College, Cambridge
1971	Awarded College Scholarship
1972	B.A. in Physics (1st Class Honours)

Present Activity

1972 - 74   Ph.D. student at the University of Sussex, working both experimentally and theoretically on non-linear wave-wave interactions in magnetoplasmas. This program is relevent to both plasma physics and to magnetospheric and iono-spheric studies. An R.F. plasma apparatus has been built and various diagnostic techniques employed. Also wave launching and detecting systems have been built and are in current use. The research project is well advanced and a number of results are being obtained at present (July '74).

Other Scientific Activity

1973   Aided the University Rocket Group in a campaign in the north of Norway by manning a sight for photographing releases of Barium in the ionosphere.

Operator C

Age: 37
Citizenship: Canadian
Marital Status: Married

Education

1955 - 60   B.Sc. (Math & Physics) University of British Columbia

1961 - 63   M.Sc. (Physics) University of British Columbia

1963 - 66   Ph.D. (Physics) University of British Columbia

Employment Experience

1966 - 69   Associate Research Scientist, The Johns Hopkins University

1969 - 74   Associate Physicist, Kitt Peak National Observatory

Present   Visiting Research Scientist, The Johns Hopkins University
             Visiting Associate Professor, University of Maryland

Project Participation

Investigator; NASA Sounding Rocket Flights 4.163, 4.217
Investigator; NASA 1968 Airborne Auroral Expedition
Principal Investigator; NASA 1969 Airborne Auroral Expedition

Consulting Arrangements

1967: NASA Langley Research Center
1973: Geophysical Institute, University of Alaska

Professional Organizations

American Association for the Advancement of Science
American Geophysical Union
Canadian Association of Physicists
Optical Society of America

Miscellaneous

American Geophysical Union delegate to the SV General Assembly of the
    International Union of Geodesy and Geophysics, Moscow, USSR,
    August, 1971

Operator D

Age: 39
Citizenship: U.S.A.
Marital Status: Married

Education

Attended primary and secondary schools in Shrewsbury, Massachusetts;
received a Bachelor of Arts degree in Astronomy and Physics from Amherst
College in 1958 and a Doctorate in Astronomy from the California Institute
of Technology in 1962.

Organizations

Member of the American Astronomical Society; the Royal Astronomical
Society; and the International Astronomical Union.

Special Honors

Awarded the NASA Exceptional Scientific Achievement Medal (1973) and the
Outstanding Leadership Medal (1974).

Experience

Prior to his selection for astronaut training by NASA, was an Associate
Professor of Astronomy at the University of Wisconsin.
He has logged over 1,300 hours flying time in jet aircraft.

Current Assignment

He was selected as a scientist-astronaut by NASA in August, 1967. He has
completed the initial academic training and a 53-week course in flight
training at Williams Air Force Base, Arizona. He was a member of the
astronaut support crews for the Apollo 15 and 17 missions and served as
Program Scientist for the Skylab Program Director's Office during the
three manned Skylab flights.
In August 1974, he was named Chief of Scientist-Astronauts for the Science
and Applications Directorate at the Johnson Space Center.

Appendix A-2

Experiment Operating Procedures and Training Plans

Operating procedures in varying detail for the various experiments were prepared for each experiment. The Meudon and New Mexico PIs prepared their own procedures, while the remainder were prepared at Ames during the payload integration period by the EOs and PIs working together, with the EOs doing the bulk of the detailed writing.

Each set of operating procedures is presented in its original form except for some format and minor style changes. All of the procedures show a fine-grain level of operational detail. The large number of operational details required of the EOs also is readily apparent, and it is easy to understand why the EOs recommended automation of many experiments control functions.

In many ways, the New Mexico material is the best example of a carefully thought out presentation, and it is the only one containing sketches of the equipment showing the location of controls and other items requiring operational attention. Without such sketches a complete stranger to the equipment would have difficulty operating the other experiments. Only the Alaska, Queen Mary, and New Mexico experimenters prepared written EO training plans. These are included in the respective sections on procedures.

University of Alaska

In their original October, 1974 proposal for the Joint Mission, the Alaska experimenters presented a unified schedule of experiment development, research planning, and operator training. The time and cost of hardware preparation to facilitate proxy operation was weighed against estimates of operator training required for competent performance, with the result that eight weeks of classroom, laboratory, and field work was proposed at the PI's facility Preparation of a training syllabus was estimated to take an additional 8 man-weeks, with active training to begin in late October, 1974. Final training on the integrated experiment would be done at Ames.

Inasmuch as the Alaska experimenters had first-hand experience in previous ASO missions, their estimates of training time were considered realistic, if somewhat conservative. This last point became the subject of negotiations between the Mission Manager and the Alaska experimenters, since EO time schedules and budgeting constraints were both limiting factors. The final schedule and content of training was completed in early December, as shown below; only one week of EO experience at the home laboratory would be augmented by intensive training during the 4-week period of integration and inflight checkout at Ames. The detailed listing of subjects and attendent references emphasizes the strong scientific orientation of the training. Note that items 2 and 3 (previously in equal detail of training) have been significantly curtailed, with strong dependence on EO experience as the background to hands-on operational training. This approach was not unreasonable considering the qualifications of the primary EO, but was at best marginal for the secondary EO from Europe. As it turned out, the secondary EO spent about 2½ weeks at Alaska, while the primary EO spent only the allotted one week.

EO Training Chronology

Training Plan Outline	December 13, 1974
List of references for review of scientific disciplines (see section 1 of Training Detail)	December 13
Assembly of schematics and instruction manuals for optical, mechanical and electronic subsystems (see sections 2 and 3 of Training Detail)	January 15, 1975
Operations manual for setup-operation-alignment and calibration of instrument	March 7
Listing of various experiments, details of resolution wavelength, scan rates and operational procedures for each data acquisition phase (see section 4 of Training Detail)	March 7
Allocation of specific experiments to various flights and interaction between 1-meter instrument, JPL's instruments and other EO activities	March 7
On site visit by EOs to observe and take part in ground-based operation of the instrument	March 7-15

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Review of EO visit and modification of initial
    procedures to be used during actual training
    period at Ames

March 15-April 15

Installation, checkout-training of EO

May 5-May 31

EO Training Detail

Dec. 13, 1974

1. Review of Scientific Objectives (corresponding references are listed in bibliography)

    a. Studies of trace constituents in the atmospheres of

        (1) Venus
        (2) Saturn
        (3) Mars
        (4) Jupiter

    b. Studies of the terrestrial night airglow

        (1) Herzberg O_2 bands. Intensities and vibrational distribution
        (2) OH bands. Intensities and rotational distribution
        (3) OI line emissions--5577 and 6300 Å
        (4) Mesospheric temperature

    c. Studies of the terrestrial twilight airglow

        (1) Intensity and vibrational distribution of N_2^+ lng band emissions
        (2) Intensity of N_2 band emission
        (3) Intensity of OI line emissions

    d. Studies of solar optical radiation

        (1) Solar UV flux at various altitudes
        (2) Fraunhofer and telluric features in the solar spectrum at various heights

    e. Gaseous pollutants in the terrestrial atmosphere

        (1) Spectrophotometric detection of NO, NO_x, SO_2, HCl, etc.
        (2) Spatial distribution of the above

    f. Plasma pause related phenomena

        (1) SAR-arcs: studies of optical emissions and their extent. Region of proton precipitation
        (2) Current theories

    g. Coordination with satellite overpasses

        (1) Spectrophometric airglow measurements during overhead passage of AE and OGO
            satellites

2. Basic Operational Principles of Spectrophotometric Instrumentation

   This section will consist of a collection of schematics and instrument manuals. Basic understanding of optical instrumentation, computer operation and data handling will be assumed as part of the expertise of the EO and will be elaborated on during the actual training period.

3. Telescope and Heliostat Tracking System

   This section will consist of a collection of schematics and instrument manuals. Telescope operation and guidance will be part of the EO training program and depend partially on the expertise of the EO.

4. Scientific Experiments

   a. Planetary astrophysics

      (1) Acquisition, tracking, and recording of various parts of planetary discs for spectrophotometric analysis of illuminance
      (2) Choice of wavelength regions
      (3) Subtraction of suitable solar spectrum from planetary spectra
      (4) Real-time analysis

   b. Terrestrial airglow and related phenomena

      (1) Recording airglow spectra in different wavelength regions
      (2) Real-time analysis of vibrational and rotational distribution of optical band emissions
      (3) Correlations of the intensities of various optical emissions

   c. Solar optical radiation

      (1) Solar spectra at different heights and resolutions
      (2) Spectral identification and intensity normalization

   d. Spectrophotometric studies of gaseous pollatants

      (1) Detection
      (2) Quantitative determination of concentration along line of sight in industrial, agricultural, and recreational regions

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Alaska Operating Procedures

I. Standby Condition (with power on rack and beam prior to preparation for flight)

    A.   <u>Beam</u>.   Turn 60-Hz power box ON at station 18.

        Thermoelectric cooling unit control. Turn power OFF. Set temperature control at -30°C. (Rotate knob counterclockwise as far as possible). Meter should read about 6 amps. Make sure N_2 supply is flowing.

        <u>Spectrometer</u>

        1. Fan on detector head is on (activitated by I-A above)
        2. Shutter switch on slit plate ON (toggle toward outboard)
        3. Cam motor switch (on cam motor housing on spectrometer) ON, motor not running, (toggle forward)
        4. Slit width "0"

    B.   Spectrometer Control Box
        1. Power switch OFF
        2. Scan control on STOP
        3. High-voltage control:

            (a) Switch OFF
            (b) Potentiometer to "0"

        4. D/A position switch on "1"
        5. Front panel jacks empty
        6. Accumulation switch on "25 ms"
        7. Scan period on 16 sec
        8. Shutter Control Switch DOWN

        <u>Formatter</u>

        1. This is left in ON position all the time. (Only lights up when computer is ON).

        <u>Tektronix Console Stand</u>

        1. Front switch ON (taped in position) and left in ON position for the entire mission.
        2. Back switch to TTY (taped in position) and left in ON position for the entire mission.

        <u>Console</u> (Tektronix scope and keyboard unit)

        1. Local/line switch on LINE
        2. 1 switch: right side down
        3. 2 switch: right side down
        4. MAKE COPY switch OFF (spring returns to OFF)

Brush Recorder

1. Power OFF
2. Chart speed OFF; switch on "÷ 100"
3. Both channel sensitivity switches on "100 mV/Div," "X 1"
4. Sensitivity verniers on calibrated "1" positions
5. Zero suppression switches OFF and verniers at "0"

Computer

1. Power key OFF
2. Switches 0 through 15 down
3. All toggle switches in neutral (spring returns to center)

D/A Converter

1. Power switch OFF

Tape Recorder

1. No tape on spindle

Multiplexer I-O Box

1. Sonalert switch OFF (down)

ADDAS

1. I-O box power switch ON and left in ON position
   for the entire mission

Telescope Controls

1. Power switch in box nearest to window ON and left ON all the time

2. Heliostat covered and caged; power OFF

II. Preparation for flight (at least 2 hr prior to flight) (power ON),
    request power at stations 6 (60 Hz) and 18 (60 and 400 Hz)

A. Beam
   Turn ON 60-Hz power at station 18

   Spectrometer Slit

   Check to see that all filters are removed from in front
   of slit; put mask ON

Wavelength Drive

1. Select cam to be used initially and put it on camshaft
   (see appendix A-2a)(Cam # is last digit on cam)
2. Select subsequently required cams and place them in
   storage in the telescope mirror compartment
3. Position with tape Hg pen ray lamp in front of hole in mask
   on slit and plug in power supply

B. Rack
   Control Box

1. Flip power switch ON
2. Turn function selector knobs to H.V. monitor
3. Flip red high-voltage switch ON
4. Slowly (15 sec) turn high voltage pot until digital voltmeter
   reads 1.10
5. Turn scan control switch to RUN and then STOP it exactly
   at the end of flyback as indicated by the shutter opening
   (2nd sound). Visually observe that the cam follower has stopped
   immediately after the steep portion of the cam.

C. Beam
   Spectrometer

1. Flip cam motor switch (on cam motor housing) to OFF (aft)
2. Loosen allen head screw on cam follower arm at grating shaft, while
   holding the grating angle position indicator to keep grating from moving
3. Position angle indicator to desired lower angle initial position of grating
   (see appendix A-2a)
4. Tighten securely allen head screw on cam follower arm at grating shaft while
   holding the grating angle position indicator to keep grating from moving. At
   the same time, make sure that the cam follower arm is pushed as far in as
   possible on the grating shaft and the roller bearing is riding fully on the cam
   edge
5. Flip cam motor (on cam motor housing) switch ON (forward)
6. Open slit to 0.2 mm

D. Rack
   Computer

1. Turn power key switch to ON position
2. When Tektronix scope turns bright green push PAGE on the Keyboard
3. RAISE switches 7 and 10 (this corresponds to octal 440)
4. Successively raise toggle switches RESET and START
5. SAAS Program 2.4 should appear on screen
6. Enter lower wavelength bound number and push RETURN (see appendix A)
7. If a new statement HIGH= appears on screen enter upper wavelength bound
   (see appendix A-2a); if a new statement did not appear, see Program Loading
   Procedure (appendix A-2b)
8. Flip all switches (0-15) down

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D. Rack (Continued)

9. Press down control (CTRL) key and while holding it down, type T; scope should
show current UT time (day, hour, minute, second) if aircraft time generator is on.
If not, raise switch 10 on the computer. Type Control T on the keyboard. Scope
should respond with the message DDD/HH:MM:SS. Enter current day and time
(Days/Hours:Minutes:Seconds) through keyboard. Type RETURN.
10. Type M, then enter an appropriate five-digit code (see appendix A-2a); type RETURN
11. Type W, enter slit width, type RETURN (see appendix A-2a and slit width code table.)

Brush Recorder

1. Load new roll of chart paper-letting 1 ft. stick out at bottom—label
2. Flip power switch ON
3. Attach chart to take-up bar
4. Turn chart recorder on to secure take-up

Tape Recorder

1. Load new data tape according to diagram inside tape recorder and label.
Carefully follow tape-threading diagram and check tape path after loading
2. Press LOAD switch, observe forward motion of tape to reflective marker
on tape (5 or 6 ft)
3. Press ON LINE
4. Close door and replace bungee cord
5. If nothing works go to step 3 of appendix A-2e

E. Beam
Mercury Lamp

Flip power switch ON

F. Rack
Control Box

1. Turn scan control to RUN
2. Set scan period to that appropriate for intial observations on flight (see appendix A-2a)

Brush Recorder

Adjust chart speed (see appendix A-2a) and sensitivity to acquire wavelength calibration
from Hg lamp, and label chart accordingly

Computer

1. Flip in order switches 9, 5, and 0 UP
2. Type A, wait for about a minute; scope should display GOT IT message after
two scans have elapsed. If this does not happen, raise and lower switch 9 several
times and then leave it in UP position. After about a minute the message
GOT IT should appear on the scope

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F. Rack (Continued)

    3. Type RUBOUT; scope should display a trace of one scan. It takes about two minutes to complete the display
    4. Record on hard-copy unit

Tape Recorder

Check to see if tape advances a little after each flyback of spectrometer cam

G. Go Through the TURN-OFF PROCEDURE prior to takeoff.

III. Turn-Off Procedure (Prior to takeoff)

A. Rack
Computer

    1. Flip all switches (0-15) down
    2. Wait for one scan period, raise RESET switch, then turn power key switch OFF

Control Box

    1. Turn high-voltage pot to zero (0) slowly
    2. Flip red high-voltage switch OFF
    3. Turn scan control switch to STOP
    4. Flip power switch OFF

Brush Recorder

    1. Push chart speed control OFF
    2. Flip power switch OFF

Tape Recorder

Secure door with bungee cord

B. Beam

Spectrometer

    1. Close slit to 0
    2. Turn off and remove calibration devices and store
    3. Install appropriate filter and mask (see appendix A-2a)
    4. Check dry N_2 flow; if N_2 is flowing, leave 60-Hz power on station 18 and the power switch on T.E. control box ON

IV. Turn-on Procedure during Flight after Final Power Interrupt

A. Rack

Check power is ON on Stations 18 and 6.

Control Box

1. Flip power switch ON
2. Flip red high-voltage switch ON
3. Slowly turn high-voltage pot until digital voltmeter reads 1.10, and lock the potentiometer
4. Set scan period to desired value (see appendix A-2a)
5. Set integration period to 25 ms (see appendix A-2a)
6. Turn scan-control switch to RUN

Computer

1. Turn power key switch ON
2. When Tektronix scope turns bright green, push PAGE on keyboard

Tape Recorder

1. Press LOAD (tape should move forward)
2. Press REWIND, hold down briefly until tape begins to rewind, release button (tape should now rewind to load point)
3. Press ON LINE
4. If the tape recorder does not work, flip switch "0" on the computer DOWN and just continue; however, skip all tape recorder commands.

Computer

1. Raise switches 7 and 10
2. Successively raise toggle switches RESET and START
3. SAAS Program 2.4 should appear on screen.
4. Enter lower wavelength bound number and push RETURN (see appendix A-2a)
5. If a new statement HIGH= appears on screen, enter upper wavelength bound (see appendix A); if a new statement did not appear, see Program Re-Load Sequence in appendix A-2b
6. Flip all switches (0-15) down
7. Press key CONTROL (CTRL) down and while holding it down, type T. The scope should show the current UT time (day, hour, minute, second), if aircraft time generator is on. If not, raise switch 10 on computer and type Control T. Scope should respond: DDD/HH:MM:SS. Enter day and time (Days/Hour:Minutes:Seconds) through keyboard and type RETURN.
8. Turn all switches (0-15) down.
9. Type @E to position tape past previously recorded data. Wait until the last record data time is printed and the tape begins to move forward on to the unrecorded portion of the reel. The tape will move, but no times will be printed on the scope. Raise and lower switch #13. Ignore TAPE NOT READY message. Type @< to backup to last record. Note: IF COMPUTER TYPES "EOF" or "TAPE ERROR" during this process, repeat "@E" command.

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A. Rack (Continued)

    10. Flip in order switches 9, 0, 1, and 5 UP
    11. Type M, then enter appropriate five-digit code (see appendix A); press RETURN key
    12. If the computer cannot be used for summing scans, consult appendix I (Signal Averaging on the Enhancetron)

Brush Recorder

    1. Flip power switch ON
    2. Press desired chart speed (see appendix A-2a for detailed requirements on each flight)
    3. Adjust sensitivity settings as outlined in appendix A-2a

D/A Converter

Flip power switch ON

Lights

Turn all panel lights ON (Operator's Choice)

Tape Recorder

    1. Check to see that tape reels move slightly after each flyback in the spectrometer. IMPORTANT. If not, wiggle up and down computer switch 0 and leave it in up position. Next wiggle switch 13 and leave it down. Check to see that tape is moving.
    2. If the tape recorder does not work, flip switch "0" on the computer DOWN and carry on as already described

Multiplexer I-O

Turn on Sonalert

B. Beam
   Spectrometer

Open slit to desired value (see appendix A-2a)

Windows

    1. Open plastic covers on 14° and 65° windows
    2. Check for fogging IMPORTANT

Star Tracker Set Up

Go through search and capture procedure for planetary or stellar observations as described in appendix A-2c for those missions requiring the use of this system (appendix A-2a)

C. Rack
Keyboard on Tektronix Display Unit

Type W; scope should display SLIT WIDTH = . If it does not, type W again until scope displays SLIT WIDTH = , and enter slit width (see appendix A-2a and Slit Width Code Table).

V. Data Acquisition (Make Verbal Comment on PA system at Points X) After Capture on Venus Mission (X) Venus Captured (if target is lost at any time go to step 9)

1. Observe that signal is on scale on Brush chart recorder:
   (X) Venus Signal OK. If not, adjust pen sensitivity accordingly.
2. Clear sum buffer by pressing CONTROL Key and typing S on Tektronix keyboard (2 buttons) (X) Sum Buffer Clear.
3. Press key A. When scope read GOT IT press RUBOUT. This will display trace on scope. (If doesn't display, twiddle 9 & 13 switches). (X) Single Trace on Scope.
4. Press hard-copy button and go get the copy.
5. Press S then A, which will indicate how many scans have been summed. When this number is at least 5, press P then A and the summed scan will appear on the scope. Adjust Y amplitude according to appearance of trace by pressing YA followed by number: RETURN (X) Sum Buffer Captured 5 Scans.
6. Press hard-copy button and go get the copy.
7. Update sum trace and secure hard copy as time permits, preferably every 5 min
8. At end of Venus mission, secure hard copy of total sum and also dump sum trace onto Brush recorder at appropriate sensitivity and zero offset settings after switching signal lead to D/A box next to recorder. The chart dump is made by typing H then A after setting Brush recorder sensitivity to 200 mv/DIV.
   (X) Call Out End of Venus Mission. Describe Operation.
9. If during this procedure the target is lost:

   a. Immediately verbalize this state (X)
   b. Go back to telescope and reacquire
   c. Verbalize recapture (X)
   d. Go back to step (1) above after capture

VI. Turn-Off Procedure Prior to Landing

A. Rack
Control Box
Computer. Flip all switches (0-15) down, wait 10 sec

Tape Recorder. Press rewind button and watch tape rewinding. If tape is not rewinding, press LOAD followed by REWIND. Wait for one minute, then press REWIND again.

Spectrometer

1. Tur high-voltage pot to zero-0, slowly (15 sec)
2. Flip red high-voltage switch OFF
3. Turn scan-control switch to STOP
4. Flip power switch OFF

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Computer

Turn power key switch OFF

Brush Recorder

1. Push chart speed control OFF
2. Flip power switch OFF

D/A Converter

Flip power switch OFF

Tape Recorder

Secure door with bungee cord

Lights

Turn all panel lights OFF

B. Beam
    Spectrometer

Close slit to 0

Thermoelectric cooler control box:

Turn power switch OFF (leave temperature control at -30°C position, i.e., turned counterclockwise as far as possible)

Star-Tracker Control

1. Power supply always ON
2. See appendix C

Heliostat control is through the "ghost," but EOs should be part of the shutdown procedure and the "ghost" operator should be aware of the conditions under which the system will be shut down.

VII. After Landing

A. Rack
    Tape Recorder

1. Remove tape, and make sure it is labeled; remove Write Ring
2. Secure door with bungee cord

Brush Recorder

Remove chart paper and label

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B. Beam
    Spectrometer

    1. Remove optical filter and mask, if present, and store in tray
    2. If removed, replace filter holder on spectrometer, and secure it in place with
        the screw

Appendix A

Nominal Instrument Settings

Experiment	Mirror in front of slit	Control box		Brush recorder			Spectrometer							Star tracker	Five digit code	Wave-length setting GS (Å)
		Scan Period	Accum. Period	Chart Speed	Sensitivity Ch. 1	Sensitivity Ch. 2	Cam Number	Slit Width	Lower Grating Angle	Filter #1	Filter #2	Mask	Order			
Venus	NO	32 sec.	25 msec	10 mm/sec Both single scans & sum.	5mV/Div Nominal Adjust to contain whole spectrum on one channel.	20 mV/Div	9		32.5°	7.54	3.74	ON	3	YES	If only 7-54 filter used: 01091 If both filters used 01291	LOW =2965 HIGH =3540
Night Glow O₂ Herzberg Bands	YES	16 sec.	25 msec	2 mm/sec Single scans 10 mm/sec Sum	2 mV/Div	10 mV/Div	9	6mm	32.5°	7.54	3.74	OFF	3	NO	If only 7-54 filter used: 01092 If both filters used 01292	LOW =2962 HIGH =3540
Night Glow OH Meinel Bands	YES	16 sec.	25 msec	2 mm/sec Single Scan 10 mm/sec Sum	2 mV/Div	10 mV/Div	7	2mm	61.5°	2.59		OFF	2	NO	03073	LOW =7273 HIGH =7396
Hg Spectrum	NO	32 sec.	25 msec	10 mm/sec	Appropriate value to get spectrum		9 7	0.2 0.2	32.5° 61.5°			ON		NO	00094 00074	LOW =2965 HIGH =3545 LOW =7273

Appendix A-2b   Computer Operation

I. Program-Starting Procedure

1. Flip switches 7 and 10, on the computer up and all others down.
2. Successively flip toggle switches RESET and START up. Screen should clear and program label SAAS PROGRAM VERSION 2.4, etc., should appear at the top of the screen.
3. Punch into keyboard the requested information on wavelength settings. If these are not accepted by the computer, go to Appendix A-2b (Sec. II) and reload the program.
4. Flip all switches (0-15) Down.
5. Press key CONTROL (CTRL), and while holding it down type T. Screen should show current UT, time if airplane clock is operating. If the later is not operating, flip switch 10 up and press keys CTRL and T simultaneously. Screen should respond with request DDD/HH:MM:SS. Type in day of year, hours, minutes, and seconds for UT including the slash and colons. NB: Even if airplane clock is functioning, pressing keys CTRL and T will produce a request for DDD/HH:MM:SS by the computer on the screen if switch 10 is inadvertantly left in the up position. Enter any value for DDD/HH:MM:SS and repeat 5.
6. Press W key. Screen should respond with request for slit width. If not, continue typing W until scope displays SLIT WIDTH= . Enter appropriate slit width followed by RETURN Key.
7. Type M. Then enter an appropriate five-digit code (see appendix A-2a); type RETURN.
8. If computer does not respond with message in 2 above, or to the instructions in 3 and 5, reload the program as described in II.

II. Program-Loading Procedure

1. Mount program tape SAAS 2.4 on the tape recorder (see diagram on tape deck).
2. Manually load enough tape on take up reel to get a grip.
3. Press LOAD button at the top of the tape deck. At this point tape should advance and position itself to the reflective marker which is on all tapes. If tape does not advance a short length and/or continues to move forward for more than one minute it means that it has been inadvertantly positioned past the marker. Press REWIND button even if the tape is moving forward. This should position the tape at the load point.
4. Press ON LINE button.
5. Raise switches 0, 11, and 14 on the computer. All other switches should be down.
6. Successively raise toggle switches RESET and PROGRAM LOAD.
    At this point, the magnetic tape should move and a "#" sign should appear on the scope screen. Type 14 (fourteen) on the keyboard. Then push RETURN button on keyboard. The computer should load the program and halt. 'f the computer gives ERROR message on the screen, press REWIND followed by ON LINE buttons on the tape recorder, and then carry out steps II-5 and II-6 above.
7. Press REWIND button. When tape stops, press REWIND button again to remove program tape.
8. Load data tape the same way as the program tape (steps II-1, II-2, and II-3).
9. Go to section I to start program.

II. Program-Loading Procedure (cont.)

10. If data tape already contains data which is to be saved, it must be positioned past the data:

    a. Lower all switches
    b. Make sure tape recorder is ON LINE
    c. Rewind tape by keying "R
    d. Move to end of tape by keying "E (press PAGE key to clear a full screen)
    e. When time printout ceases, raise switch #13; ignore TAPE NOT READY message; lower switch #13
    f. Back up to last recorded data record by keying "<

III. Data-Manipulation Procedure

(For detailed description of the procedure, consult appendix A-2d.)

A. Direct data from spectrometer

1. If spectrometer H.V. is on and cam is rotating, flip switch 9 then switches 0, 1, and 5, of the computer UP.

2. Press A on keyboard. After a short time (about twice the scan period), the message GOT IT should appear on the screen. If this does not happen, raise and lower switch 9 on the computer several times and then leave it in ON (up) position. If after about 2 min following this procedure the message GOT IT does not appear on the screen, restart the program as described in section I.

3. After GOT IT message shows on screen, press key P and then key A. At this point, the screen should display information about the record in A buffer, i.e., date, time etc., low wavelength, high wavelength, sum of scan, etc. Next the screen will proceed to trace the scan record in buffer A. It takes about 2 min for the graphic display to be completed. When this is completed, two lines, a vertical and a horizontal should appear on the screen.

4. The slow graphic display of data on the screen can be stopped at any time by raising, momentarily, switch 6 on the computer and then flipping it down. The cross lines should appear on the screen together with the unfinished data display.

5. Move the horizontal line down to about one inch above the bottom of the scope, with the aid of the "Horizontal" thumb wheel control on the keyboard. Then press keys CTRL and Y simultaneously. This shifts the baseline of the display to the position of the horizontal line and permits an extended vertical display of the record in A buffer.

6. Press key P then key A. The track on the scope will be redrawn with a shifted base.

7. To change the vertical scale of the trace, type Y then A then the desired vertical scales (50 means 50 counts/inch, etc). This should only be done after the cross lines have appeared at the end of the graphic display or when the later is aborted through the use of switch 6 on the computer (see 4 above).

8. To change the horizontal scale type D then A on the keyboard. Enter the low and upper bound values of wavelength desired on the display. Then press keys P and A successively to obtain the display of part of the A buffer on an expanded wavelength (abscissa) scale.

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9. To calibrate the lower and upper bound values of wavelength, select two known spectral lines from a Hg spectrum displayed on the screen. Position vertical line on the first (left) known spectral feature. Type X then A on the keyboard. Enter the wavelength of this feature, followed by RETURN. Move the vertical line to the second (right) feature of known wavelength and type X. Enter wavelength of this feature. Press RETURN key. The computer has now completed wavelength calibration.

IV. Tape Playback

1. Turn OFF all switches; turn ON switch 5 to suppress dark subtraction.
2. Ensure that tape is mounted and on-line. The write-ring should have been removed from the tape reel; the RING light on the tape unit should be out (not illuminated).
3. Type @A to request tape read to go into the A buffer (if the B buffer is desired, type @B).
4. Rewind tape: type @R.
5. Read the first recorded scan:
    Type @ followed by RETURN.

    NOTE: Whenever a record is read into the computer, the time of the beginning of the scan is displayed, followed by the beginning and ending Angstrom values of the wavelength region used. Following this is MODE= and the data mode code (set by the M command in keyboard mode when the scan was originally recorded.)

6. Reset the display limits to the input wavelength region and plot the trace. TYPE RUBOUT. The resulting display may be manipulated in the same way as a scan obtained directly from the spectrometer.

    NOTE: If both an A buffer and a B buffer were in use prior to beginning tape playback, pressing RUBOUT will cause both traces to be displayed. To Release the A buffer, type CNTRL-A; to release the B buffer, type CNTRL-B.

7. Any of the magnetic tape commands may be issued at this point:

@A	-	Use A buffer for subsequent input
@B	-	Use B buffer for subsequent input
@ ⏎	-	Read next record
@DDD/HH:MM:SS⏎	-	Read down to record with date/time DDD/HH:MM:SS or later
@E	-	Read down to EOF
@R	-	Rewind tape
@?	-	Type time of current record
@<	-	Backspace over one record
@nnn<	-	Backspace over nnn records
@Mxxxxxx⏎	-	Read forward to first record with data mode code xxxxx

    NOTE: "⏎" means depressing the RETURN key

V. To Sum Data from Tape

1. Perform the setup described for tape playback above.
2. Choose the beginning time of the interval to be summed, and position the tape to the desired scan record.

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Example: The tape begins at day 142 at 04:16:32 (hours:minutes: seconds). It is desired to start summing at 0530. Type @142/05:30:00 followed by RETURN. The time on each record will be displayed as it is read. Press PAGE each time the screen becomes full (red light glows on top of keyboard). The tape will stop with the nearest scan with time not earlier than 0530 in memory.

NOTE: There may have been interruptions in the data recording prior to the desired time. This will cause the reading to stop on an EOF or TAPE ERROR. Repeat the search command. If the tape starts running off in the unrecorded part of the reel, raise and lower switch 13. Ignore TAPE NOT READY message; type @R to rewind tape.

3.   The tape may be backed up over any number of records. To back up a single record, type @< . To back up 4 records, type @4< . The computer responds with KEYBOARD COMMAND when the operation is complete. There is no time printout.

4.   Summing will begin with the next record read. Type CNTRL-S to clear the sum buffer. Now raise switch #1. Type a search command for the ending record of the summed interval. Data will be summed as it is read. Type SA to capture the sum, type PA to plot it (use B if the B buffer was in use).

NOTE: Summation may be continued over EOF or TAPE ERROR stops. Repeat the search command. Summation will automatically stop if the wavelength region changes from that at the first record summed.

NOTE: Tape reading may be stopped before the end of a search by raising switch 8. Remember to lower switch 8 after reading has stopped.

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Appendix A-2c   Search and Capture Procedure

Telescope Finder Alignment Check

Star-Tracker/Heliostat Operation

1. Check to see that IPA HV switch (high voltage) is OFF.
2. Check power station 18 for 60- and 400-Hz power.
3. Turn on (check) star-tracker power supply.
4. Install voltmeter set for 5/10 V on "Star Presence" (+) and "Ground." The voltmeter is in the storage bin.
5. Remove light stop between beamsplitter and IPA unit.
6. Set heliostat "cage/uncage" to CAGE.
7. Turn on heliostat system (4 switches), and allow 5 to 10 min for gyros to warm up.
8. Move star-tracker control switch to FIND.
9. With heliostat still in CAGE Position, move heliostat mirror by hand to set azimuth = 305° and elevation to the values for Venus for the beginning of each mission plus 90°. This should place Venus in the field of the view finder.
10. Uncage heliostat.
11. Turn IPA "HV" switch ON, dark sky should read less than 1/2 V on meter. (Twilight sky reads about 3.5 V, Venus also about 3.5 V; Venus during twilight reads about 3.7 V.
12. Using joystick, move star image to center of cross hairs. Meter reading should increase.
13. Using joystick, peak the meter reading.
14. When meter reading is at peak level, turn star-tracker control switch to track. Reading on meter should increase slightly and remain steady (Note the actual reading).
15. System is tracking star. If meter reading is high enough (i.e., greater than about 2 V) star image should remain steady indefinitely.
16. An indication of star-tracker operation is provided by the short- and long-term stability of the meter reading.
17. If star track is lost, go to step 8 above and reacquire star image.

Turn Off

1. Cage heliostat.
2. Turn off IPA high voltage.
3. Turn of heliostat system (all 4 switches).
4. Put a light stop between beam splitter and IPA unit.

NOTES:

1. During turns it is important that the heliostat does not bump into its mechanical stops. Before a turn, cage the heliostat and wait until the course is steady again and go to steps 7 and 8 above to reacquire star image.

2. If the heliostat is bumped while uncaged, it may start oscillating (amplitude about 10°). If this happens, it is important to cage the heliostat as soon as possible to prevent amplifier burnout. Go to step 8 above to reacquire star image.

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Appendix A-2d   SAAS Spectrometer Program Version 2.4

The following computer program for the data-general Nova 1200 computer facilitates recording and displaying spectrometer scans from an auroral spectrometer. The program is controlled by means of the keyboard on the 4010 scope and the 16 switches on the Nova console, the program will perform the following functions:

1. Read input from the spectrometer and store the data as a series of scans. Scans may consist of up to 2000 points, including dark-current readings taken during flyback. The number of points in a scan may be increased, if desired (see later section).

2. Write entire scans on digital magnetic tape in suitable form for later analysis.

3. Display scans on the scope as a connected graph. Facilities are provided for manipulation of the display: the scales, location of baselines, and angstrom range may be changed intera⋅⋅ely.

4. Perform a point-by-point sum of successive scans in order to reduce noise. The sums may be displayed on the scope like any other scan data.

5. Read scans recorded on the mag tape back into the computer for display on the scope. Mag tape data may be run through the point-by-point sum after recording. Periods may be selected.

The program functions as a collection of multiprogrammed "tasks," which run in parallel. Data collection, recording, and summing may proceed while earlier scans are being examined on the display scope.

To Operate

1. Turn the computer on by rotating the power key clockwise to the ON position. This will turn on the magnetic tape unit and the spectrometer interface as well. Turn the Tektronix 4010 scope on with the switch located on the right underneath the keyboard. When the scope has warmed up, it will fill the screen with green light. Press PAGE to clear this. Pressing PAGE at any time will clear the screen without disturbing the program.

2. Load the SAAS program from the program tape: mount the tape on the mag tape unit (see diagram inside the cover). Manually load enough tape on the takeup reel to get a grip. Then press the LOAD key. The tape will position itself to the reflective marker which is on all tape reels. If the tape is inadvertantly positioned past the marker, press REWIND, even if the tape is moving forward at the time. After the tape is at load point press " on line". Now set (raise) switches 0, 11, 14 on the computer console. All other switches should be off. This is octal 100022, the address of the mag tape unit for loading. In sequence now, raise RESET and PROGRAM LOAD switches. The mag tape should move, and a "#" will appear on the screen of the scope. The computer is now waiting for the program number. The SAAS program is always recorded twice on the tape, for safety. Enter 1 or 6 followed by RETURN. The computer will load the program and halt. If it types out ERROR, rewind the tape (press REWIND and ON LINE on the tape unit) and try again with program load.

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3. Now take off the program tape and mount a blank tape for recording data. Press REWIND on the program tape to get it to load point, then press rewind again to get it off the takeup reel. Mount the blank tape in the same way as the program tape. Press ON LINE.

4. Start the program at address 440. This is done by setting switches 7 and 10 only, and the rest OFF. Then successively raise RESET and START. The screen will clear and the program label SAAS PROGRAM VERSION 2.4 will appear at the top of the screen. Later versions will have higher version numbers.

5. The program then types a diagnostic message giving the number   buffers allocated. This version of the program assumes that up to 2000 points (including dark data) will be entered per scan, and will compute the angstrom-step between readings based on the actual number of points it reads and the angstrom scan bounds used. If more than 2000 points come in, the last ones will be rejected (not stored). This value may be changed by user command.

8. At this point, the program is fully initialized. The message KEYBOARD COMMAND: is typed on the screen. The operator may then respond with any of the commands detailed below. Also at this time the console switches are active.

Switch Assignments on the Computer

0. Write spectrometer scans on mag tape
1. Accumulate scans in sum buffer
2.
3.
4. Plot all dark values as zero
5. Inhibit dark value subtraction
6. Supress/abort plotting (see graphics discussion)
7. Suppress logging times after each tape-read
8. Halt forward search on mag tape (see mag tape commands)
9. >> input scans from the spectrometer <<
10. Inhibit parallel time setting
11.
12.
13. Set mag tape DONE —– for diagnotic, do not use
14. Synchronize chart recorder with spectrometer inputs

Keyboard Commands

⏎ : Carriage return

@: Mag tape command

A: Capture the last complete scan as the A buffer; the A buffer may be displayed on the screen (see graphics commands).

Nsss⏎: To set buffer size when sss is the number of words.
WARNING This restarts the program.

B: Capture the last complete scan as the B buffer.

CTL-A: Release the A buffer.

CTL-B: Release the B buffer.

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W: Set slit width. This will be recorded on all subsequent data scans.

S: Copy the contents of the sum buffer to either the A or B buffer. The program
           will ask which one. Note that the A or B buffer must first have been established
           with an A or B command.

CTL-S: Clear sum buffer to zero; reset number of sums to zero.

PA: Enter graphics mode and draw A trace.
           See below for other graphics commands.

PB: Enter graphics and draw the B trace.

T: Type current time DDD/HH:MM:SS

CTL-T: Set universal time (hold CTRL key down and strike T).
           The clock will restart with the new time when the carriage return is struck after
           entering seconds. If switch 10 is down, time will be read automatically from
           parallel time interface.

L: Set the limits in angstroms for all subsequent scans.

Mddddd↲:   Where ddddd is the "Mode" code

Graphics

The program may be placed in graphics mode by the PA or PB commands, entered in
keyboard-command mode. The screen will be cleared, a label typed, and the A or B trace will
be drawn. These traces are scans from the spectrometer (or the mag tape, in playback mode)
that have been "frozen" by an A or B command. These scans are in data buffers that are held
fixed while other data buffers are used to collect more scans and record them on mag tape or
add into the sum buffer.

After the traces are drawn, the program commands the scope to put out its graphic cross
hairs and wait for any key to be struck. When the key is struck, the program can read off the
position of the cross hairs at the time. The action taken then depends on which key was
struck (see below). To understand the graphics capability of the SAAS program, the
following must be kept in mind:

1.   Each trace (A or B) is independently stored and may have its own X or Y scale. The Y
     scale is specified directly in counts/inch. The X scale is determined indirectly from
     the specified range (in angstroms) of the displayed scan. The scans are labeled with the
     time when the first point of the scan was stored (DDD/HH:MM:SS) and the angstrom
     value of the first and last point displayed.

2.   There is an overall scale for the entire display which may be used to expand or shrink
     the displayed trace pair. It is also possible to change the location of the screen
     center so that a desired feature will appear in the middle of the screen. The scales for
     each of the traces convert from engineering units to inches. If the overall scale is set
     to 1 (the normal setting), then these are actual inches on the screen. If the overall
     scale is set to 2, then 2 inches will fill a screen inch, and the display will appear to
     shrink. If the overall scale is set to 0.5, the display will be expanded so that one "inch"
     fills two screen inches.

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3. Due to the large number of points usually plotted, graphics are rather slow. No spectrometer data will be lost during graphics, since the spectrometer data-gathering task runs at a higher priority than graphics.

4. Each trace is plotted in two parts: the first is 0.5″ of dark values and includes all the dark readings from the flyback period immediately preceding the data scan. After 0.25″ gap, the spectrometer data are drawn for 6.25″.

Graphics Commands

These commands may be entered whenever the crosshairs are on the screen. Note that if a command, from the keyboard-command list is entered at this time, the program automatically exits from graphics mode and executies the command correctly in keyboard mode.

DA: Set limits of the display for the A trace. The program will request a low and a high bound in angstroms for the display. These bounds must be within the range of data originally set when the program was started. If the range exceeds the available data, it will be automatically truncated to fit. The resulting display will spread all the points within the given limits across 6.25″ of the screen.

DB: Set limits of ∙ display for the B trace.

MA: Read the current cross-hair position and type out the correct angstrom value and intensity value for the A trace at that point. All scales are automatically taken into account in calculating these figures.

MB: Measure as for MA but for the B trace.

###:   Set the Y scale for the A trace. "###" represents a floating-point number which must be entered after the A and terminated with RETURN. The scale is counts/"inch".

YB###: Set the Y scale for the B trace.

CTL-YA (CTL-YB):   Hold the CTL key down while striking Y the current position of the horizontal crosshair will be taken as the baseline of the A (PA trace). The cross-hair position is noted and the X value stored. The program then calls for the VALUE, which should be entered by the operator as a floating-point number in angstroms. It is the angstrom value at the crosshairs on the A trace. This angstrom value has presumably been determined from theoretical considerations. Now, a second calibration point must be marked with the crosshairs. The operator should strike the X when the crosshairs have been positioned. The value for this point should then be entered. The result is a cleared screen and the printout of the new limits of the scan based on the calibration just performed.
Subsequently stored scans from the spectrometer will be recorded as between these calibrated limits.

XB: Perform wavelength calibration using the B trace.

QA: Type out the current scan limits for A trace. This is the same message that appears after a wavelength calibration.

QB: Type current scan limits for B trace.

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R: Erase screen, draw both A and B traces (if defined) with labels.

WA (WB):   Follow this command with a number in angstroms. If the angstrom value is on the displayed A (B) trace, a vertical line will be drawn to mark it.

HA (HB):   Copy the A (B) trace to the chart recorder. The scale on the chart recorder may be the same as the screen in Y; the scale in X depends on the chart speed. The proper settings for the chart recorder are: 200 mv/mm and a chart speed about 20 mm/sec. The position of the horizontal crosshair at the time of striking the H key determines the lowest value that will be plotted. Values below the crosshair will be zero. Values greater than the range of the chart recorder will be pegged at the maximum.

CR (carriage return):   Exit from graphics mode to keyboard-command mode.

G###:   Enter the overall scale ("inches"/inch), make the current crosshair location become the center of the screen.

RUBOUT: Reset overall scale and screen center to NORMAL. Reset display angstrom-range to data maximums, and redraw trace(s).

Other Notes on Graphics

1.   Raising switch 6 during a plot will terminate the plot. Leave switch 6 up while performing the initial adjustment of the scales, if desired. Raising switch 6 will also terminate chart-recorder output.

2.   With improper scale settings, or requested data ranges that are entirely outside the available data there may be no display. Use the Q command to find out what the limits are, and switch 6 to terminate a plot that is entirely off screen. Note that the computer "windows" displayed data, cutting off portions which will not fit on the screen.

3.   Strike RUBOUT to reset all display parameters to normal, and automatically re-draw all traces.

Typical Operation

1.   Turn computer on and load up a blank tape for taking data, as described above.

2.   Start program at 440. Type "W"; enter slit width of 0, followed by carriage return. Turn off all switches.

3.   Turn on switch 9 to start gathering spectrometer data.

4.   Set time: hold down CTRL; strike T. Time will be read automatically.

5.   Type L and set the limits in angstroms of the spectrometer scan being used. If this is not set, the program initially assumes low = 4000, high = 5000.

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6. Wait for one scan to accumulate. Type A to save the scan in the A buffer. Computer displays GOT IT! when the scan is ready.

7. Type PA to plot the A trace.

8. Type CTL-S to clear sum buffer. (hold CTRL key down and type S). No special response is made by program.

9. Turn on switch 1 to start summing scans.

10. Either wait until the plot is complete or raise and lower switch 6 if impatient. Type YA30 followed by carriage return. This will set the Y scale to 30 counts/"inch" and replot the graph. When the program is loaded, the Y scale is set at 200 counts/"inch".

11. Type SA. This will copy the current contents of the sum buffer to the A buffer, where it will be saved. Summing will go on in the sum buffer. Type PA to plot the summed trace.

12. Identify two known features in the plotted spectrum. Perform the wavelength calibration described under the X command. Reset the sum with CTRL-S.

13. Mount a fresh tape on the mag tape unit. Get the unit on line, with a ring in the tape. Raise switch 0 to start recording scans on tape.

Magnetic Tape Commands

The magnetic tape unit on the system may be used to record and playback spectrometer scans. Playback must be done with the spectrometer disabled (switch 9 down) and mag tape recording off switch 0 down). All mag tape commands are issued from keyboard mode and are preceded with @.

@A: Use A buffer for input. Either A or B must be selected.

@B: Use B buffer for input.

@ (followed by carriage return):   Read one record. Display time, wavelength region.

@E: Go to end of tape. The tape will read forward until either a tape mark or a bad record (parity error) is detected. This command is often used to position to the end of the tape when more than one data session is to be recorded on a single tape. Note that a tape mark is normally written at the end of a recording session when switch 0 is turned off.

@R: Rewind tape to beginning.

@?:   Type out the time on the current record.

@DDD/HH:MM:SS: Read tape until the desired day (DDD) hour (HH) etc. have been passed. Striking carriage return instead of the "/" or ":" will cause the rest of the time to be assumed at zero, and search made accordingly.

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@<:   Backspace tape one record. If a number is typed between the "@" and the "<", the tape will be backspaced that number of times.

Mag Tape Playback Techniques

1. Switch 8 may be used to stop tape from searching forward. Raise the switch, then lower it to issue another command.

2. When the tape is searching forward, the time on each record passed is normally logged. To suppress this, raise switch 7 during searching.

3. To position tape to the end of the recorded portion, use @E until the logged times indicate the end of the last data block. If the tape runs off into the blank space, raise switch 13 to stop tape motion (TAPE NOT READY will be signaled) and issue @< to backspace to last record. Note that it is common to have a garbage record at the end of the tape if the session was not concluded properly (dropping switch 0 and waiting for the last scan).

4. To sum data from tape, do the following:
    CNTRL-S   To clear the sum buffer.
    @DDD/HH:MM:SS   To position to desired time.
    Raise switch 1 to activate the summer.
    @DDD/HH:MM:SS   To read (and sum) to the end of the desired period.
    The sum may be displayed by giving SA and PA.

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Appendix A-2e -- Tape Unit Operation

Procedure

1. Press the POWER key at top of the transport. This should turn on some lights.

2. Mount the tape. (See diagram on unit).
   Wind enough tape to establish a grip on the takeup reel.

3. Press LOAD button. Tape should wind forward and stop at the initial reflective marker.

4. Press ON LINE. The tape is ready for use.

Problems

If the tape just keeps moving forward, press REWIND, go to step 4.

If nothing works, turn POWER off and then on, repeat from step 3.

Appendix A-2f · Wavelength Region Changes

<u>Procedure</u>

1. Lower switches 4 and 9.

2. Type CTRL-T to resync time.

3. Type L. Enter new (approximate) bounds of scan.

4. Make mechanical adjustments to spectometer.

5. Restart spectrometer scans. Raise switch 9.

6. Type A. wait for GOT IT.

7. Type PA to display the trace.

8. Perform wavelength calibration (X Command).

9. Raise switch 4.

Appendix A-2g – Codes for Cams, Filters, Slit Width, and Experiment Type

<u>Five-Digit Code</u>

First Digit	Second Digit	Third Digit	Fourth Digit	Fifth Digit
Not used Enter 0	First Filter #	Second Filter #	Cam #	Experiment

Filter #	Type	Code #	Experiment Type
0	No filter	1	Venus
1	7-54	2	O_2 Herzberg nightglow
2	3-74	3	OH Meinel nightflow
3	2-59	4	Hg spectrum
4	4-96		
5	3-70		

Cam number is last number marked on each cam.

<u>Slit-Width Code</u>

Code	Slit Width (mm)
1	0.1
2	0.2
3	0.4
4	0.6
5	1.0
6	2.0
7	4.0
8	6.0
9	8.0
10	10.0

Enter the code number appropriate for the slit width used.

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Appendix A-2h   Problems and Their Solutions

1. Computer does not reply GOT IT when an A or B buffer is requested.

   a.   Ensure that the spectrometer is scanning - the cam is rotating.

   b.   Switch 9 should be up. Raise and lower it a few times - Leave it up.

   c.   If switch 0 was up (Tape Recording) ensure that the tape unit is on line. Raise and
         lower switch 13, if it was necessary to put the tape on line.

2. Tape unit does not write scans.

   a.   Switch 0 should be up.

   b.   Switch 9 should be up.

   c.   Lower and raise switches to be sure.

   d.   Raise and lower switch 13 after you make sure tape is on line.

   e.   Tape will write only at the end of a scan.

3. No response from computer to keyboard command other than request for A or B buffer.

   a.   You may have erased the screen (PAGE Key) while the crosshairs were on the screen.
         Correct for this error by pushing the space bar until the computer begins responding with
         "Keyboard Command."

   b.   Computer may have been kicked off-line by a transient. Restart at 440 in the usual way.

   c.   The computer and 4010 scope must have been turned on.

4. Computer will not dra⋅ a plot in response to PA or PB. The screen clears but no graph is
   drawn.

   a.   No scan was obtained. Get an A or B buffer.

   b.   Display limits are not in actual wavelength region. Press RUBOUT to set display limits to
         scan limits and replot.

   c.   Y scale is unreasonable. Try a larger valu · (YAxxx or YBxxx command).

   d.   Scan limits are unreasonable. Raise switch 6 to stop plot. Use L command to set scan
         limits.
         Type A (or B).
         Type RUBOUT.

   e.   Record read from tape is bad.
         Get next record "@", carriage return.

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Appendix A-2: - Signal Averaging of the Enhancetron

1. Fetch Tektronix oscilloscope 475 from the back end of the airplane.

2. Plug power cord in the power outlet (unplug power cable to beam for Hg Lamp and use that outlet) and pull the power knob on the scope out to turn it on. (See attached picture of the oscilloscope controls.

3. Turn TIME/DIV switch to X-Y position.

4. Set VERT MODE to CH2.

5. Connect, in parallel, VERTICAL DEFLECTION outlets on Enhancetron to CH2 on the oscilloscope and on channel two of the Brush recorder. Disconnect Channel 2 channel on the brush recorder.

6. Connect HORIZONTAL DEFLECTION outlets to CH 1 on the oscilloscope.

7. Set AC/GND/DC leveler on both channels to DC.

8. Disconnect synch pulse cable from the Brush-Pen-Marker-Box on the right-hand side of the rack and connect it to TRIGGER INPUT terminals on the Enhancetron.

9. Connect SIGNAL INPUT 1 on the Enhancetron to spectrometer output at the T connector on channel one of the Brush recorder.

10. Set DISPLAY SCALE on Enhancetron to 4.

11. Set FAST/SLOW switch above TOTAL SWEEP TIME knob to SLOW.

12. Select TOTAL SWEEP TIME for 1024 POINTS to correspond to spectrometer's scan period (16 to 32 seconds).

13. Set OVERLAP ADJUST knob so that the black line is vertically UP.

14. Set MEMORY GROUP knob to 1024.

15. Set TRIGGER switch on the left bottom of the Enhancetron to EXT.

16. Set TRIGGER switch on the right bottom to the Enhancetron to PLUS.

17. Turn ON power switch on the top right part of the Enhancetron.

18. Set MODE knob to DISPLAY.

19. Press ERASE MEMORY button. The oscilloscope should show two horizontal lines.

20. Turn MODE knob counterclockwise to MEASURE position. The two horizontal traces on the scope should merge into a point at the left side of the scope. At the beginning of the next spectrometer scan the Enhancetron should trigger and the point on the scope should expand to a vertical line and move slowly towards the right. Adjust the BASELINE ADJUST potentiometer on the Enhancetron until the top part of the vertical lines on the scope shows maximum modulation.

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Appendix A-2i (continued)

21. Turn MODE knob to DISPLAY position.

22. Press ERASE MEMORY button.

23. Reset MODE knob to MEASURE position.

24. Adjust sensitivity of channel two on Brush recorder to get a trace for running sum.

25. To stop signal averaging after n scans:

> Turn MODE knob to STOP 1 position and wait until the end
> of the spectrometer scan. Turn MODE knob to DISPLAY.
> Adjust DISPLAY SCALE to obtain maximum vertical
> deflection without any part of the trace saturating.

26. Turn the MODE knob to READOUT to obtain the sum trace on the chart recorder. If the trace does not fill or is saturated on the chart scale, adjust the sensitivity and switch the MODE switch to STOP 2 and then back to READOUT for the chart display. Repeat until a useful record is obtained.

27. Go back to step 19 and repeat the sequence through step 26.

University of Colorado

Colorado 1/8-m Spectrometer

I. Preflight Checks

    A. TTY

        1. Check paper supply and replace as required (if green strip showing on right margin).

        2. Power switch OFF (back of unit).

    B. Display Unit

        1. Line OFF

    C. CPU

        1. Power OFF (key horizontal)

        2. SW down

        3. All switch registers down.

        4. Dep. switch down

        5. All other switches up.

    D. Tape Deck

        1. Program tape loaded in unit zero

        2. Blank data tape in unit 1.

        3. Power switch OFF (back of unit).

    E. GSE

        1. Power switch OFF

        2. Exp. switch OFF

        3. Computer enable switch ON

        4. +28-V reg push button OFF

        5. Frequency switch on 100 Hz

        6. FWD/REV switch on FWD

Colorado 1/8-m Spectrometer (Continued)

       7. 3 sec/MAN switch on 3 sec

II. Turn-on Procedure

    A. Station Power

        1. Power ON, station 17, 60 Hz

        2. Power ON TTY

        3. Line ON on display

        4. Power ON on tape deck

    B. GSE

        1. Power ON, station 18, 60 Hz

        2. Power switch ON

        3. Exp. switch ON

    C. CPU

        1. Power ON (key vertical)

        2. Switch register to 7000

        3. Lift SW switch

        4. Depress ADDR Load

        5. Depress EXTD ADDR Load

        6. Depress CLEAR

        7. Depress CONT

    NOTE: Tape unit 0 should now load program; wait until finished.

        8. Depress SW switch

        9. Depress switch register switches

    D. TTY

        1. Check dot on paper

        2. Command: ZE 1RETURN

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Colorado 1/8-m Spectrometer (Continued)

NOTE: Tape unit 1 will advance slightly; check another dot on paper.

3. Command: R RTPLC.BINRETURN

NOTE: Tape unit zero will load another program. TTY will print: RTPLC, then asks for PROGRAM FILE?

4. Command: EGTWAT.RTP

NOTE: Tape unit zero will advance; wait until completed, then asks for OUTPUT FILE?

5. Command: Insert here predetermined flight code:

XXXXX.DAT (1st must be letter)

Flight Code:

X (Month init.) XX (U.T. Date) XX (Cassette No. for Date)

NOTE: Tape unit one loads; wait until completed.

6. Command; CL 2,10RETURN (from now on, TTY will not print until return punched; commands will appear on display).

NOTE: Unit types copy of command.

7. Command: GO RETURN

NOTE: Unit asks for observing program parameters:

SET F to SCALE

SET S to NSCANS

SET N to NPNTS

SET R to RATE IN .1 MS

W=WAIT(MS)

LIFT SW 0 to GO

8. Command: F= ___ RETURN (Typical:2)

9. Command: S= ___ RETURN (Typical:5) NB: Must be greater than 4.

10. Command N-1000 RETURN

11. Command: R=34RETURN

Colorado 1/8-m Spectrometer (Continued)

12. Command: W=1 RETURN

NOTE: If a bad command causes sequence to stop, simultaneously press CTRL and C; go back to step D1 after tape unit zero rewinds.

E. CPU

1. Lift switch register switch zero.

NOTE: At this stage, spectrometer begins scan; display will begin activating.

III. Operating Procedure

A. To change a parameter

1. CPU: Depress switch register zero switch

2. TTY: Type in new parameter as in step II, D, 8 thru 12.

3. CPU: Raise switch register zero switch

B. To change TTY to red channel: command UD 1 RETURN

C. To change TTY back to blue channel: command UD 0 RETURN

D. To put either TTY channel on tape

1. To enable the blue buffer: command WB 0 1 RETURN

2. To enable the red buffer: command WB 1 1 RETURN

NOTE: Can do either/or steps 1 and 2.

3. To write on tape TTY: command EW 1 RETURN

NOTE: Display will show number of records written. With N-1000, can go to 42 records on one tape.

E. To change tapes

1. Stop recorder

TTY: command EW 0 RETURN

2. Stop scan

CPU: Depress switch register zero switch.

Colorado 1/8-m Spectrometer (Continued)

    3. Put EOF on tape.

        a.   TTY: command EFRETURN

        NOTE: Tape rewinds here.

        b.   Simultaneously push CTRL and C.

    4. Replace tape in tape deck.

    5. Go back to II, D, 1.

  F.   To go to standby

    1. TTY: EW0RETURN

    2. CPU: Depress switch 0

  G.   To come back on

    1. CPU: Raise switch 0

    2. TTY: EW1RETURN

IV. Printing Procedure

Follow turn-on procedure for the 1/8-m spectrometer to step D1, omitting section B.

  A.   TTY Commands

    1. Command: R RUFUSC.BIN RETURN

        NOTE: Tape unit "0" will load the RUFUSC
                     program; wait until tape has stopped and
                     R U F U S C is typed out on TTY.

    2. Command: CR 1000RETURN

        NOTE: TTY will then type out:
                     + 2.00000E+00 REGS ALLOCATED

    3. Command: OP 1:XXXXX (Output file of the records to be read.).DAT RETURN

        NOTE: TTY will type out OK. when finished.

At this time, the record to be examined, printed, etc., can be called up by

    Command: RD 0 XX (record number) RETURN

Colorado 1/8-m Spectrometer (Continued)

> NOTE: Tape unit "1" will read the record into the computer.

B. TTY Display Record

> Command: SL 0RETURN
> SH 999RETURN
> SC XXX (any point between 0 and 999) RETURN

> NOTE: At this point, the record should appear on the display.

C. Record Spectra

To prepare the recorder for recording spectra:

1. Plug in banana plug into rear of recorder, making sure of the polarity.

2. Set the rate at 8 divisions per minute.

3. Set the sensitivity to 5mV scale.

To record spectra:

1. Turn on recorder.

2. Turn pen position switch DOWN.

TTY:

> Command: PL 0 XX (delay time that determines length of record plotted usually 5 or 10 is used)RETURN

> NOTE: As soon as record is ended, raise the pen and turn off the recorder. To remove the record, set the HR MIN switch to N and the paper can be pulled out and torn off.

V. Shutdown Procedure

A. TTY: Simultaneously push CTRL and C

B. Power (wait until tape's rewound)

Turn off power:

> to TTY
> to CPU
> to display
> to tape deck

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Colorado 1/8-m Spectrometer (Continued)

    C.   GSE

        1. Turn Exp. switch OFF

        2. Turn power OFF

JPL Tunable Acousto-Optical Filters

I. Preflight Condition Checks

   A.   TAOF controls (Isomet) (2)

   Power: OFF

   Lower: CCW

   Upper: CW

   Switch: MANUAL

   Tune: N/A

   Drive: Zero*

   B.   Ramp Generators (HP 3310A) (2)

   Function: ramp ($\diagup\diagdown$)

   Range: .0001

   Offset: Negative; arrow up

   Output: CCW

   Dial: $\sim$ 20

   Line: OFF

   C.   Square-Wave Generators (HP 3310A) (2)

   Function: square wave

   Range: 10

   Dial: $\sim$ 20

   Offset: Positive; arrow at 10 o'clock

   Output: CCW

   Line: OFF

   D.   Counter (HP 5248M) (1)

   Power: OFF

Sensitivity: 0.1, preset

Time base: 10 msec

Function: frequency

Plug-in: N/A

E. Counter (HP 5345A) (1)

Power: standby

Time gate: 1 msec

Selector: Frequency A

F. Oscilloscope (Tektronix RM 561A) (1)

Power: OFF

4 traces:

> Switch: ground
> Sensitivity: 2 V/div
> Mode: NORMAL

G. HV Power Supply (Fluke 413C) (1)

Power: OFF

Output: OFF

Voltage dials: OFF

H. X-Y Recorder (HP 7004B) (1)

X module: X_1

X preamp: 0.2 V/in

Y module: Y_1

Y preamp: 0.2 V/in

Power: OFF

Chart: OFF

Servo: OFF

Pen: OFF

Switch: set-up

I. OZ Box (JPL) (2)

Power: OFF

Switch: standby

J. GSE (Colorado) (1)

VM Range: X 100

Power: OFF

Exp. Power: OFF

HV: OFF

Switch: Panel

K. SSR NIM bin

Power: OFF

Rate: slow

L. Supplies:

X-Y recorder pens

Felt pens

X-Y recorder paper ⎫
⎬ or prestamped paper
Stamp and ink pads ⎭

Cassette recorder tapes (4 per flight)

II. UV TAOF Turn-on Procedures

A. TAOF Control

Power: ON (needs 1/2 hour to completely stabilize)

B. Counter (5345A)

Power: ON

C. GSE

Power: ON

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Voltages: check on DVM against nominal range (+10, +4.6, -10, -14.5)

Switch: HV monitor

Exp. power: ON; current reads 10-12 ma

D. Oscilloscope

Power: on (takes some time to stabilize)

Coax switches: UV TAOF

Set zeros: 1 + 2 on top of each other

              3 + 4 on top of each other

    Set 1 and 3 switches to dc

E. Ramp Generator

Power: ON

Range: increase to 10

Scan voltage: set to level for flight via offset and output as monitored on oscilloscope;
              return ramp to .0001

F. Square-Wave Generator

Power: ON

Voltage: adjust to (0; +1.2 V) as monitored on oscilloscope using offset and
              output

G. OZ Box

Power: ON when ADDAS ready for data flow

Numbers: thumb in first ID for night

H. GSE

HV power: ON; check HV mon on DVM (2.2); check counts; check current on
              meter

I. X-Y Recorder

Power: ON

Manually insert paper

Chart: ON, smooth paper, and stamp, fill in data block as needed

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Servo: ON, and adjust X scan by setting ramp generator to a reasonable speed; then return ramp generator to 0.0001. Adjust Y scan by using TAOF Controller power, square wave generator frequency, and ramp generator frequency to predetermine levels.

NOTE: X and Y ranges and offsets are also used as dictated by experience.

J. Ramp Generator

Frequency: set as predetermined (as a check on H above); (must not exceed 4095 counts per 1/2 cycle or will saturate

Verify target is acquired in telescope.

K. OZ Box

Set to test ID for 15 to 30 seconds

L. Ramp Generator

Set to near start of scan by temporarily changing frequency switch

M. OZ Box

Set to RUN

N. XY Recorder

Pen: ON

O. Verbal comments and (time + ID) to cassette recorder

III. Visual TAOF Turn-on Procedure

A. TAOF control

Power: ON (needs 1/2 hr to completely stabilize)

B. Counter (5248M)

Power: ON

C. HVPS

Power: ON

D. Oscilloscope

Coaxial switches to vis TAOF

Set zeros: 1 + 2 on top of each other
3 + 4 on top of each other

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Set 1 and 3 switches to dc

E. Ramp generator

Power: ON

Range: increase to 10

Scan voltage: set to level for flight via offset and output as monitored on oscilloscope;
            return ramp to 0.0001

F. Square-Wave Generator

Power: ON

Voltage: adjust to (0; + 1.2V) as monitored on oscilloscope using offset and output

G. OZ Box

Power: ON when ADDAS ready to accept data

Numbers: thumb in first ID for night

H. SSR NIM bin

Power: ON

I. HVPS

Switch to + (Plus)

Bring HV up to predetermined level

Coax switch on counter to vis TAOF output; check counts-return coax switch to
frequency monitor

J. X-Y Recorder

Determine use later

K. Ramp generator

Frequency: set as predetermined (as a check on H above)

L. OZ Box

Set to test ID for 15 to 30 sec

M. Ramp Generator

Set to near start of scan by temporarily changing frequency switch

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N. OZ Box

   Set to RUN

O. X-Y Recorder

   Determine use later

P. Occasionally verify that no bright star is in field of view when doing OH background
   measurements

Q. Comments (ID & Time) to cassette recorder

IV. UV TAOF Shutdown Procedure

   A. TAOF Control

      Power: to zero*

   B. X-Y Recorder

      Pen: OFF

      Servo: OFF

      Chart: OFF

      Power: OFF

   C. Square-Wave Generator

      Power: OFF

   D. Ramp Generator

      Power: OFF

   E. TAOF Control

      Power   OFF

   F. OZ Box

      Power: OFF

   G. GSE

      HV: OFF

      Exp. power: OFF

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Power: OFF

H.   Counter (5345A)

Power: OFF

I.   Oscilloscope

Off when both TAOFs shut down

V.   Visible TAOF Shutdown Procedure

A.   TAOF Control

Power: to zero*

B.   X-Y Recorder

Pen: OFF

Servo: OFF

Chart: OFF

Power: OFF

C.   Square-Wave Generator

Power: OFF

D.   Ramp Generator

Power: OFF

E.   TAOF Control

Power: OFF

G.   HVPS

HV to zero

Switch: OFF

Power: OFF

H.   Counter

Power: OFF

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I. Oscilloscope (if in use)

OFF when both TAOFs shut down.

J. SSR NIM bin

Power: OFF

Instructions for Lowering the 14° TAOF Window Mount

1. Note that all following instructions apply to both fore and aft sides of mounting structure.

2. Remove top outboard bolts.

3. Remove top inboard bolts.

4. Pull bottom inboard pins.

5. Lower inboard side until bottom hole is in line with upper main frame hole.

6. Insert bottom inboard pins.

7. Pull bottom outboard pins.

8. Lower outboard side until bottom hole is in line with upper main frame hole.

9. Insert bottom outboard pins.

10. Insert and start top inboard bolts.

11. Insert and start top outboard bolts.

12. Tighten all bolts.

Instructions for Raising the 14° TAOF Window Mount

1. Note that all following instructions apply to both fore and aft sides of mounting structure.

2. Remove top outboard bolts.

3. Remove top inboard bolts.

4. Pull bottom outboard pins.

5. Raise outboard side until bottom hole is in line with lower main frame hole.

6. Insert bottom outboard pins.

7. Pull bottom inboard pins.

8. Raise inboard side until bottom hole is in line with lower main frame hole.

9. Insert bottom inboard pins.

10. Insert and start top outboard bolts.

11. Insert and start top inboard bolts.

12. Tighten all bolts.

B = boarding time = T (takeoff) – 1/2 hr   T = takeoff

B – 2-1/2 hr (or more)	1. 2.	Clean pens on S/C and refill with paper Pump out vacuum jacket of dewar for 1 hour or longer (should be down to $\leq$ 10 μ quickly).

B – 1-1/2 hr (or more)	1. 2.	Fill with LN_2 (don't spill on preamp) Put dewar on telescope.

B – 1 hr

1. Check inventory of spares and tools
2. Review flight plan
3. Insert micro dot signal cable into dewar and preamp
4. Hook up other connections (#68 to relay, #67 to bias and pot, signal BNC on rubber band suspension)
5. Check adjustment of attitude meter
6. Close telescope dark slide
7. Turn on power and test electricity:

    a. Is the chopper reference on their scope clean?
    b. Test motor: Hole is at 3.1 on s/c and on DVM
    c. Test s/c event marker on switch box and test our microphone
    d. Test ear plug by turning volume up and down
    e. Check proper position of all grounding switches and standard position of other switches.
    f. Check calibration of s/c: $\pm$ 2″ from middle line = full scale of Ithaco with s/c on 50 V F.S. and Var at the calibrated position
    g. Measure ground power noise level (P/P) at detector
    h. Measure noise level and frequency on scope of the output from B-1 Amp
    i. Check dewar micro phonics by tapping on the top-front side
    j. Look for other noises (signal cable, motor, preamp)

B – 0 hr   Turn everything OFF, clean up area, and sit down.

Ames 3-6 μ Filter-Wheel Spectrometer

I. Procedures

A. Preflight preparations

1. Pump on dewar for 1 hr before filling

2. Dewar cool down LN_2 (2 hr before flight).

3. Bolt dewar on telescope table (O-ring); dark slide closed

4. Balance telescope

5. Check spares, tools, strip chart pens and ink, equipment

B. Inflight operations

1. Equipment preparations

a. Turn on amplifier and other electronics (after takeoff)
b. Open dark slide
c. Set filter wheel at "pin hole" - DVM = -1.86
                                    - S/C = 3.1
To keep polarity — (banana ground side down) or toward aisle.

2. Target acquisition

a. Set "Cuve" to elevation of first object.
b. At acquisition of object: Center it in the field and verify limits of "pin hole" and location for RB/LB.

(French procedures for manual control and then guiding on star.)

c. Maximize signal by adjusting phase vernier. (Maximize on signal and null ±90° out of phase.)

3. Filter-Wedge Operating Procedures

a. At a constant λ, record signal for determination of guiding noise (RB/LB); compare signals with "expected" values
b. Offset to sky location and record for comparison with "a"
c. Repeat (1) and (2) toward end of acquisition period

4. Data acquisition

a. Start scans and set Amplifier Sensitivity to a reasonable value — $\geqslant 300 \mu V$. OK if it pegs on "pin hole".
b. Data scans: "Data Switch" to "LB" or "RB" depending on Polarity of scan. (Zero position is used for "no data" or "bad data" i.e.: if star moves out of diaphragm.)

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  c. Skip scans (2) nearby to look at flux problem

  d. Every 6-12 scans move object to other beam, change data switch (note "zero" during move and adjustment) and resume scans.

   (French procedure to manual control and then guiding on offset star).

  e. Go to "Cuve" and lock telescope before turn,:. End - 30 sec

 5. Postflight activities

  a. After observing, empty dewar of LN_2 and insert copper rod.

  b. Daily pump down dewar jacket to 1-10 μ region (hopefully $\leq$ 1/2 hr).

II. Switch Setup for Normal Operations

 A. Power stations numbers 2, 14, and 15 50 cycle power and outlet behind Meudon computer rack

 B. Hewlett Packard Strip Chart Recorder

  1. Chart Speed (rotary selector switch, recor .,/C)

  2. Chart Drive (Start/Stop)

  3. Power (on/off)

  4. Channel 2 "DVM" (Red)

   Sensitivity (rotary) - 10V.

   Var. (pot) - Full c.w.

   Zero (pot) - pen centered at "5"

  5. Channel 1 "Amp Output" (blue or green)

   Sensitivity (rotary) - 50 (Standardize and/or Record on S/C)

   Var. (pot) - full c.w.

   Zero (pot) - pen centered at "5"

 C. "Kluge" Panel

   Power (on/off)

   Motor (on/off) (drives filter wheel)

   GND on/off)

D.   Ithaco Amplifier

1.   Amplifier D1 or E1

(on/off)

(+/o/–)

Zero suppress (pot) (set at zero unless using)

Meter channel (1/2) (1 is amplifier components on the left of the rack and
2 is the components on the right of the rack.)

Time Constant (rotary) - 100 ms

(Sig/Ref/Reset) ("Ref" checks chopper signal - approx 1/2 scale right de-
flection.)

db/Oct (Integ 6/12)

(Filter/Reset)

2.   Demodulator C1

Phase (pot, 0-180° vernier) Adjust to peak signal; should remain constant for
this configuration of equipment. (89°)

Phase (rotary) - 90°; After adjustment, 0° and 180° will nearly produce zero
(Adjust them to zero using higher gain; more sensitive)

Select f/2f

Freq range (rotary) - 10-100 (Meudon secondary oscillates at 37 cps.)

3.   Amplifier B1

Sensitivity (rotary) - Adjust as appropriate and record setting on S/C, and/or
on microphone! (300 μV should produce noise on recorder of approx.
0.4 in. peak to peak, or 6μV at detector; preamp has a gain of 10X)

Select ON ⏚

Select low f limit (10/100/1)

Select A/A-B/-B

4.   "Data Switch" (rotary) (RB/0/LB) - use as appropriate.

a.   "RB" is for positive scan   sets +5V signal on ADDAS and deflects event
marker on s/c

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b. "0" is for no data or bad data - sets 0V signal on ADDAS and does not deflect event marker on s/c

c. "LB" is for negative scan - sets -5V signal on ADDAS and deflects event marker on s/c

> NOTE: A Positive Scan is one where the scan produces a positive signal i.e.: in the positive channel of the phase. A Negative Scan is one where the object is in the "other beam" and so produces a negative signal.

5. "Asservisement Mirror Vibrant"

Switch (rotary) - position 5 (throw "900" = 9')

Synchrone (on)

III. Cable Connections

Dewar-Preamp (Microdot low noise)

#67/Gimbaled portion - Preamp power (small banana plugs)
                     - Filter pot (Viking plug)
    (15 pin cannon)
#68/Gimbaled portion - Motor for filter (amphenol)
    (15 pin cannon)
#67/fixed portion - "Kluge" Panel/Pot & Bias (15 pin cannon)
    (15 pin cannon)
Amp. output (bnc)   - Amplifier "B1"/"A" signal (direct connection our gimbal)
#68/fixed portion - Relay box
    (15 pin cannon)

Relay Box - 60 Hz outlet   Station #14

Relay Box - 28V Meudon DC power supply (Banana plugs)

Relay Box - 'Kluge" Panel/Motor drive (Viking)

"Asservisement Mirror Vibrant, Test" (bnc) - Demodulator C1/"Ref" (bnc)

Amplifier D1/output (bnc) - "Kluge" Board-Amplifier Output/"Input" (bnc)

"Kluge" board/Amplifier Output/s/c (bnc) - Strip Chart/Channel 1/upper two plugs
                                          (banana plugs - ground lug down)

'Kluge" board/Amplifier Output/T/R (bnc-T) - ↓

     - ↓ADDAS #RC103 (bnc) (Through 1/2 attenuator)
     - Ampex T/R #DATA 1 (bnc)

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Cable Connections (Continued)

"Kluge" board/Position/DVM (bnc) - DVM/"Volts" and "Common" (banana plugs-ground
lug inbd) (or to strip chart/channel #2/upper two plugs-ground lug down)

"Kluge" board/Position/+5V (bnc) - hand held switch box +5 (bnc)
-5V (bnc) - hand held switch box -5 (bnc)

Hand held switch box "event marker" (bnc) - s/c (L.H. event marker on center wire, and
shield to chassis ground)

Hand held switch box - Ampex T/R (Special connector with transformer to bnc for CP100)

Hand held switch box ADDAS (bnc) - ADDAS #RC101 (bnc)

University of New Mexico

New Mexico Training Plan

The New Mexico experimenters submitted the following EO training plans to the manager of the Joint Mission in mid-November, 1974. In subsequent negotiations it was agreed that training would occur in either the February 3 to 13 or the March 5 to 15 period, depending on EO schedules. Also, if convenient to both parties, a longer training period would be arranged at the home laboratory.

This plan was implemented for the primary EO (five days) from Europe and the secondary EO (four days) from the U.S. during the week of March 9. The secondary EO from Europe did not train on this experiment prior to his arrival at Ames. Final training for all three EOs was completed during the integration and checkout period.

It is notable that this training program puts primary emphasis on experiment operations, with science content implicit to the hands-on instruction. This well-automated experiment was relatively straightforward in a single operating mode, and well suited for grouping with two others under the cognizance of a single EO.

Outline of EO Training

I. Training Period

    A. Place: Albuquerque, New Mexico

    B. Date: Preferably after February 15, 1975

    C. Duration: 2 nights (3 days)

II. Objectives of Training Period

    A. EO will accompany P.I. and Co-I. during two night's ground-based observations

    B. EO will learn to operate equipment without oral instructions from investigators

III. Specific Operations EO will Master

    A. Load cassettes for 35-mm camera

    B. Activate timing sequence on 35-mm camera

    C. Unload exposed films from 35-mm camera

    D. Load cassettes for 16-mm camera

    E. Activate timing sequence for 16-mm camera

    F. Unload exposed film from 16-mm camera

    G. Warm up high voltage power supply for photomultiplier tube

Outline of EO Training (continued)

    H.   Check inking of strip chart recorder

    I.   Adjust sensitivity on strip chart recorder

    J.   Record dark current and recorder range

    K.   Turn image tubes on and off

    L.   Operate filter changer

    M.   Complete checklist and data form for each night's operation

Evaluation Criteria for EO Training Effectiveness

1.   EO should be able to operate ground-based equipment after training period in New Mexico.

2.   Primary and back-up EOs should be able to operate aircraft installation after May 5-30 training period.

3.   EO should return usable data to investigators from checkout flight.

4.   EO must return usable data to investigators during June 2-7 flights.

New Mexico Operating Checklists

The responsible EO is expected to fill out a checksheet each flight (checkmarks and all!) to be turned in at end of simulation. The monitor checklist on page 176 is ok together with the special comments page, if used. The primary EO is authorized to use the Abbreviated Checklist, found in back section of notebook, after first flight. As each checklist in the notebook is used, place it in back of notebook and bring forward a fresh checklist. There are several extras for use during practice runs to enable the EO to get the feeling and habit of checking off items when performed.

The following items are to be handed down after each flight in data downlink:

1.   One or two cassettes exposed 35-mm film

2.   One or two rolls exposed movie film

3.   One length of strip chart

Date: _____

Observer: _____

Please check boxes to the left as you complete each item.

Preflight Procedures

	If red line indicator on chart paper is over 75, replace chart paper.
	With rate wheel on standby (recorder need NOT be on), advance chart by rotating wheel above rate wheel to verify that pens are inking.
	Load movie film (it should be warmed to room temp).
	Load 35-mm film (it should be warmed to room temp).
	Check: Dark slides closed on image tubes.
	Check: Lens cover over photometer; #1 filter in place.
	Check settings on instruments and panels (see information sheets if necessary).

Warm-up Procedures (as soon as possible in flight)

	Open plastic windows.
	Turn on 60-Hz and 400-Hz power at overhead panel.
	Turn power ON to high-voltage power supply (far right of panel).
	Turn on current amplifier (push ON button).
	Turn on strip chart recorder (bottom left).
	Write date on strip chart recorder.
	Check: Dark slides down on image tubes.
	Turn on far right toggle switches on image tube power supplies.
	Extract and mount movie camera; plug in ac cord to 24-V transformer outlet.
	Attach cooling hose to lens turret handle.
	Turn on OUTPUT of high-voltage power supply (kV meter should register 750 V).

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Start-up Procedures (In dark skies after twilight, preferably during turn after Venus run)

		Turn recorder rate wheel downward to 1 min/in.
		Remove input BNC connector to chart recorder.
		Lift blue pen from chart; turn lower left red knob to CAL to get blue pen out of the way.
		Set zero on red pen by adjusting right top red knob.
		Turn left top red knob to CAL to record range, then back to VOLTS; mark "red range" on chart.
		Lower blue pen and lift red pen; turn upper left red knob to CAL to get red pen out of the way.
		Set zero for blue pen by adjusting bottom right red knob.
		Turn bottom left red knob to CAL to record range, then back to VOLTS; mark "blue range" on chart.
		Lower red pen.
		Replace signal cable.
		Check: Both pens down. Both left red knobs to VOLTS.
		Remove lens cap from photometer.
		Turn filter-wheel switch to FORWARD position.
		Mark one filter position on chart (filters should change every 20 sec)
		Turn middle toggle switch on 35-mm image tube power supply to UP position (light-emitting diode should come on).
		Open dark slide on 35-mm image tube.
		Check camera viewfinder for image. (If none present, go to next step and check again after first exposure.)
		Plug motor-cam ac cord into main power panel.
		Record "Frame 1" when event marker first registers.
		Secure curtain around window (using green tape if necessary, which should be fairly light-tight).

	Turn on 16-mm image tube (middle toggle switch UP).
	Open dark slide of 16-mm camera image tube.
	Verify image on image tube face by looking in at it.
	Secure curtain around camera lens (use green tape if necessary).
	Look through camera view finder (very dim) to ensure that no part of curtain occults field of view.
	Secure curtain around window (using green tape if necessary).
	Record "movie camera on" on chart recorder as 16-mm timer is activated (power toggle to ON).
	Check solenoid to ensure proper contact with camera.
	Feel motor shaft to ensure film transport.
	If any outside plane lights (other than wing-tip strobe lights) are on, request that they be turned off.
	Note: Landing lights, anticollision flashing lights, and running lights have all been left on at one time or another — all can be turned off (and should be!).
	Next page is monitor sheet for evening. Record initial sky conditions there.
	Set hand timer for ½ hr.

Monitor Checklist: (Performed every half hour)

Date: _____

_____ Look at chart; pens inking, filters changing.

_____ Look in viewfinders for images.

_____ Check solenoid and motor shaft motion.

_____ Record WWV signal on chart on red pen.

_____ Fill in record below.

_____ Set timer for ½ hr.

Note: Be prepared to change 35-mm film when 0 frames is reached; change movie film when 125 ft is reached (or anytime after 100 ft).

Approx. Time	16-mm Ft Counter	35-mm Frame Counter	Sky Conditions
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

ADDITIONAL COMMENTS — may be written below <u>or on chart</u> (in which case time does not need to be recorded.

Approx.
<u>Time</u>   <u>Event</u>

<u>Note</u>: Possible sky conditions: clear and dark (hope, hope!)
                                  flying through ckouds (noted by seeing them in wing strobe light)
                                  distant cirrus up to 6° above horizon
                                  moon 45° from field of view
                                  etc.

Shutdown Procedures

	Current amplifier off — push On button.
	Output of high-voltage power supply off.
	Power of high-voltage power supply off.
	Close dark slides on image tubes and record "image tubes off" on chart recorder.
	Turn power off for both image tubes (all three toggle switches DOWN on both power supplies).
	Put lens cap on photometer.
	Unplug ac cord of cam motor from main power panel.
	Turn movie timer off (POWER toggle switch — OFF).
	Remove input BNC connector to chart recorder.
	Final range check on both pens; do not adjust zero vernier. Mark "red range" and "blue range" on chart.
	Replace BNC connector.
	Record final WWV signal on chart, on red pen.
	Turn off chart recorder; stow chart holder.
	Rotate rate wheel downward to standby position.
	Wait till filter #1 is in position, then turn off filter wheel motor.
	Unplug movie camera motor cord from transformer.
	Remove movie camera from mounting plate and stow.
	Turn off station power (60 Hz and 400 Hz) at overhead panel.

Postflight Procedures (during refueling)

	Remove gray cord plug from motor-cam timer and plug into hand-held microswitch cord.
	Using microswitch, advance film to end of roll (til frame counter reads 0).
	Remove exposed film from camera and stow cassette in leather case.
	Mark date and flight on outside of case on masking tape.
	Plug gray cord back into motor-cam timer.
	Get out movie camera and plug motor into 24-V transformer.
	Turn 16-mm timer power to ON and motor to MAN.
	Run through film to end of roll (125 ft in all).
	Turn timer power OFF.
	Turn timer motor to AUTO. Spare the motor by running it continuously as little as possible.
	Remove exposed film to film can.
	Tape shut (masking tape), and mark date and flight and film length if different from 125 ft on outside of can.
	Stow movie camera, after unplugging motor from transformer.
	Remove used chart from chart recorder; replace take-up reel.
	Re-secure new chart end to takeup reel.
	Turn in chart and films for data downlink.
	Return unused films to refrigerator.

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Loading 35-mm Film (during or between flights)
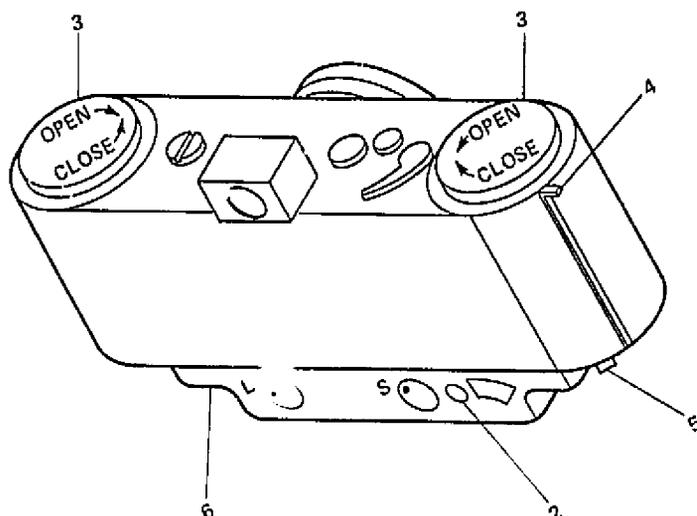
DO NOT LOAD FILM WHEN COLD; ALLOW TO COME TO ROOM TEMPER-ATURE BEFORE REMOVING PLASTIC BAG.

Remove gray cord from motor-cam timer; plug into cord of hand-held micro-switch.

Rotate two large knobs ③ to Open position (if they are not already there).

Support camera back as you lift small pin ④ on side of camera back to open and remove back.

Prepare take-up cassette by opening and extracting reel.

Remove tape from tail of fresh film to be loaded.

Mount fresh film cassette on left side by matching the dot under film tail with white line in camera. You should hear it click into place.

Push up knob ⑥ under reel to secure cassette.

Note: NEVER OPEN FILM CASSETTES HOLDING UNEXPOSED OR EXPOSED FILM.

Pull out film tail and attach in empty reel by entering tail in slot and taping it down.

Place top of cassette (with nameplate) over reel, aligning film in opening.

Put reel and top into cassette bottom, again aligning opening with film.

	Important: Rotate flat-headed pin counterclockwise until you hear (feel) cassette lock.
	Mount cassette in right side of camera back, matching dot with white line — it should click into place.
	Push up knob ⑤ under reel to secure cassette.
	Remount and close camera back by entering tiny hinge on left side (at 90° angle) and snapping shut on right side.
	Rotate both knobs over reels ③ to close position.
	Using microswitch, advance three frames with thumb on knob 5 under right reel. If it moves, transport is ensured.
	Note: Left reel knob may not rotate til slack in loaded cassette is taken up.
	Note: For last film advance, hold microswitch down 3 sec to ensure that camera mirror returns down.
	Rotate frame counter to 250. (It must be pushed in hard to catch frame counter.)
	Plug gray cord into motor-cam timer.

Loading 16-mm Camera (during or between flights)
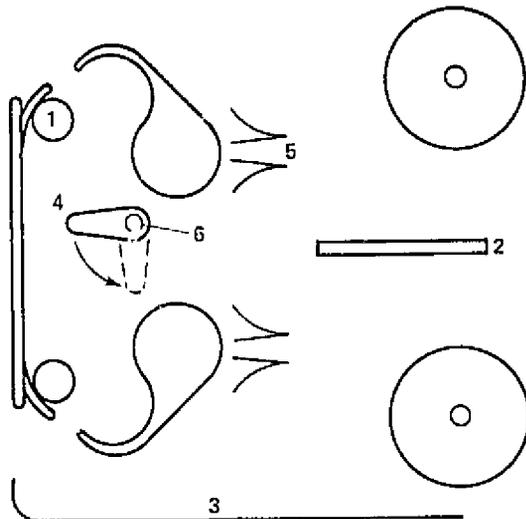
	DO NOT LOAD FILM WHEN COLD; ALLOW TO COME TO ROOM TEMPERATURE BEFORE OPENING BOX.
	Plug motor cord into 24-V transformer.
	Face side of camera such that lens is to your left.
	Turn knob in center of camera body to lift off lid.
	Check that pressure pad pin ① is locked and does not move.
	Push lever ② between reel holders to eject any reels from camera.
	Place reel of fresh film on upper spindle with tail coming from bottom to the left (as indicated by dotted arrows inside camera).
	Cut off end of film diagonally between two perforations with film knife ③ or scissors. Remove cut off piece.
	Rotate lever ④ counterclockwise (downward) 90° to close film loop formers.
	Turn OFF motor switch of 16-mm timer.
	Turn ON power switch of timer.
	Push film tail into metal slot ⑤ and toward upper sprocket.
	Turn motor switch of timer to MAN and push shutter release back to feed film through camera and produce end for take-up reel.
	PLEASE PROTECT MOTOR BY TURNING OFF WHEN NOT IN USE!
	Turn OFF motor switch on timer.

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Loading 16-mm Camera (continued)

	Press knob ⓕ to open loop formers.
	Insert film end into slot in take-up reel. Bend over and rotate to take up slack.
	Insert reel on lower shaft and rotate to take up slack.
	Note: Slack in upper reel is normal.
	Final check: Turn motor to MAN and run through a few frames to ensure proper film transport and loops.
	Replace lid and lock by turning knob clockwise.
	Advance 5 more feet through camera; frame counter will move (very slowly!) from ft to 0.
	Turn OFF power switch of timer.
	Important: Turn motor switch of timer to AUTO.
	Stow movie camera.

New Mexico Components

Current amplifier
High-voltage power supply
16-mm Camera — image tube system
16-mm movie camera timer and transformer
IR Photometer
35-mm Camera — image tube and timer system
Back-up 16-mm timer (formerly 35-mm timer)
Strip chart recorder
Image tube power supplies and image tubes

The notations A, B, and C refer to the locations of spare parts as follows:

A. Storage area in back of low-boy rack on which equipment is mounted.
B. Upper storage cabinet across the aisle.
C. Lower storage cabinet across the aisle.

Current Amplifier
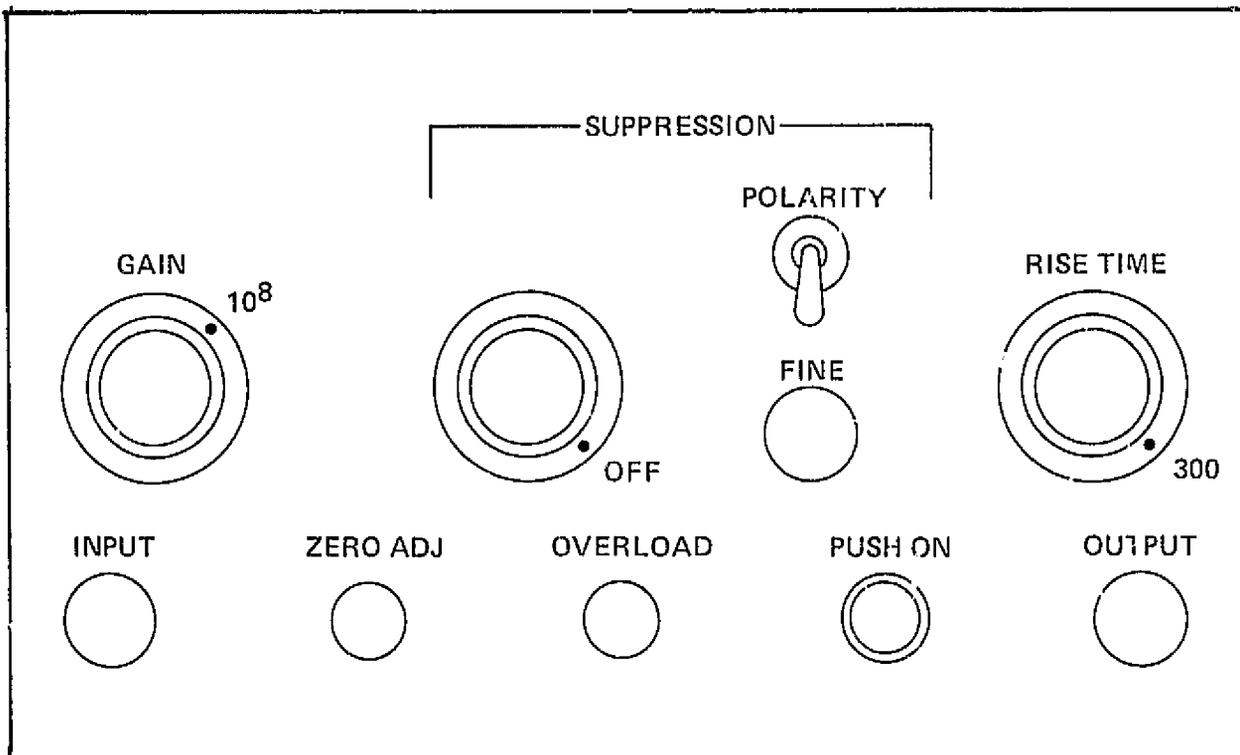
Cable Connections

1. AC cord to main power panel

2. Signal cable (BNC connector) from input to end of photometer (SIG)

3. Signal cable (BNC connector) from output to strip chart recorder input

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Controls

1. <u>Gain</u> – 10^8

2. <u>Suppression</u> – OFF

3. <u>Polarity</u>

   $\left.\begin{array}{c} \\ \\ \\ \end{array}\right\}$ not in operation, since <u>Suppression</u> is OFF; ignore

4. <u>Fine</u>

5. <u>Risetime</u> – 300

6. <u>Zero adjust</u> – preset; do not change

7. <u>Overload</u> – should <u>not</u> be lit

8. <u>Push On</u> – OFF (not lit)

In Operation

1. <u>Push On</u> – ON (lit)

If Overload Light Comes on and Stays on:

1. Reduce Gain to 10^7 (or lower if necessary till light goes off).

2. You are probably looking at something very bright. COVER THE IMAGE TUBES till you can assess the situation.

3. If you reduce gain, decrease sensitivity of chart recorder pens accordingly (by increasing setting on left black knobs by a factor of 5 to 10, such that signals are on-scale and readable).

4. If any of the above occurs, mark it on the chart.

In Case of Failure

1. Check ¼ amp fuse, top of back panel. Spare fuses, green toolbox (B).

2. Check that unit is plugged in to main power panel.

3. No backup unit is available.

High-Voltage Power Supply

244 HIGH-VOLTAGE SUPPLY

VOLTS

600   140

KILOVOLTS   OUTPUT ON   OVERLOAD   POWER
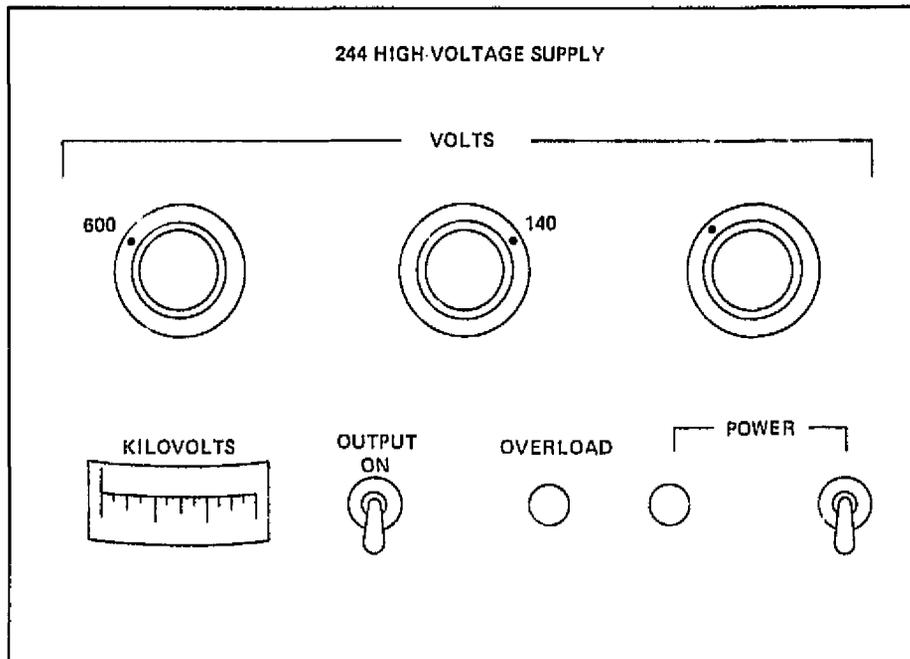
Cable Connections

1. AC cord to main power panel

2. Cable (high-voltage BNC connector) from <u>Output</u> on back panel to end of photometer (HV)

Controls

1. <u>Voltage setting</u> — left knob: 600 V
                              middle knob: 140 V
                              right knob: at marked position

2. <u>KV meter</u> — 0

3. <u>Output</u> — OFF

4. <u>Overload</u> - not lit

5. <u>Power</u> — OFF

In Operation

1. <u>Power</u> — ON (power light lit)

2. Wait one minute after power is turned on, then <u>Output</u> — ON

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3. __KV meter__   ~ 750 V

__If Overload Light Comes on and Stays on:__

1. Turn Output and Power OFF and remove HV cable from photometer.

2. Try turning on HV power supply again. If it does not overload this time, reconnect cable to photometer, after shutting down again.

3. With photometer connected again, turn on HV power supply. If it does not overload now, continue with normal operations.

4. If it again overloads, replace high-voltage cable with spare (A).

5. If it still overloads, see below.

__In Case of Failure__

KV meter does not register when Output is ON, and no signals show on chart recorder pens when photometer is uncovered.

1. Check that unit is plu   into main power panel.

2. Change to backup high-voltage power supply (mounted directly above primary in low-boy rack) by changing cable at rear of supplies from back of rack.

3. Turn on backup unit by rotating switch at left from OFF to Standby; wait one minute, then rotate to ON. Voltage is preset to 750 V.

4. If both units fail, shut down photometer system.

__When on the Ground__

1. Check 3/4 amp fuse on back panel by reaching in behind rack. Fuses: green toolbox (B) -- use 1 amp fuse as replacement.

2. If this fails, try changing regulator tub 8908 (spare in A). This will entail removing unit from rack. While unit is out, check that voltage selector switch on back panel is at 117 V.

3. If this fails, try changing fuse and regulator tube 6AV5GA (A) in backup unit to try and get it operating.

16-mm Camera — Image Tube System
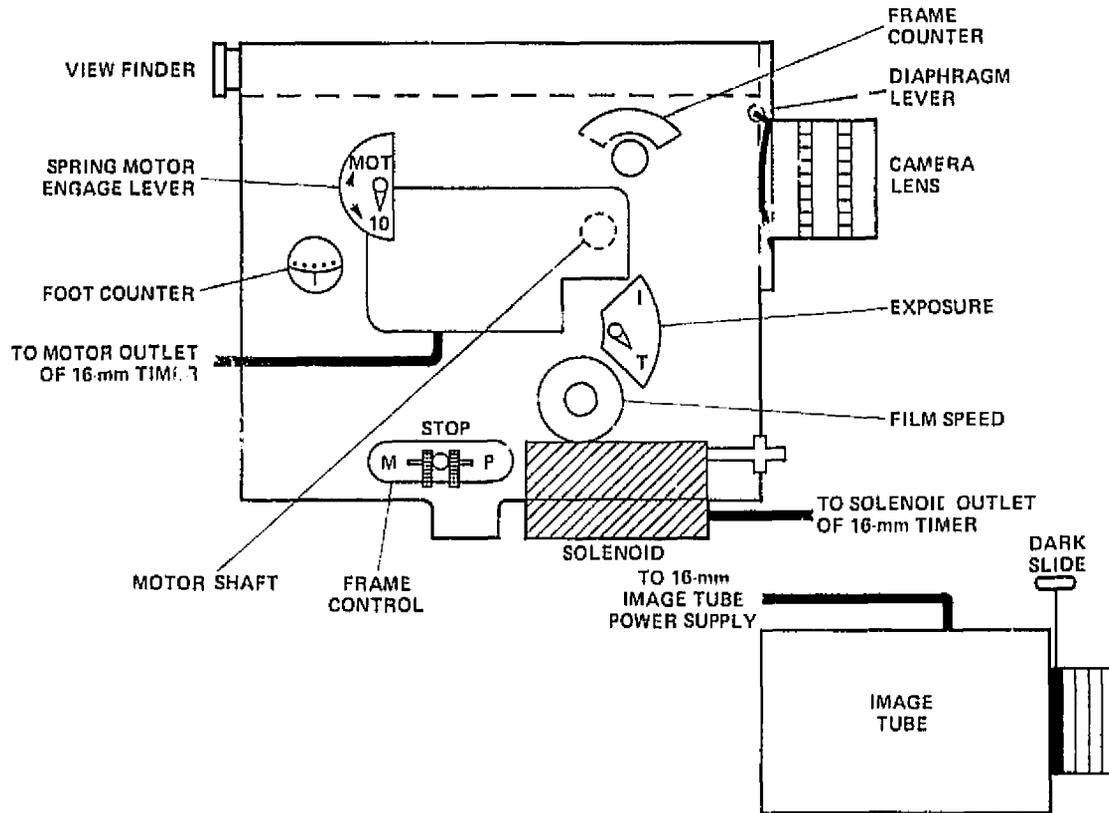
Cable Connections

1. AC cord from camera motor to Motor outlet on left side of 16-mm timer (motor requires 12V dc, not 120V)

2. Solenoid cord to solenoid outlet on right side of 16-mm timer

3. Image tube wires to middle channel of 16-mm image tube power supply

Controls

1. Spring motor engage lever – O (partially concealed under top left corner of motor) O means off; MOT engages spring motor.

2. Foot counter — O when loaded with fresh film
    FT when not loaded

3. Frame counter — inoperable; ignore

4. Diaphragm lever — O (in full UP position; wide open)

5. Exposure - T (T for time exposures, I for instantaneous)

6. Film speed - 24 (although set at 24, this is not used)

7. Frame control - STOP (P is for single frames; M for continuous filming)

8. Camera lens:

    Outer knurled knob - 0.95 (sets F-stop; normal position is full counterclockwise at F/.95, wide open)

    Inner knurled knob - 1.65 ft (the focus; it is taped down and hopefully will not need to be moved)

9. Image tube input lens:

    Outer knurled knob - 1.2 (sets F-stop; normal position is full counterclockwise at F/1.2, wide open)

    Inner knurled knob - 4.45 ft (the focus; it is taped down and hopefully will not need to be changed)

10. Dark slide - always DOWN, except when in operation with no moon and no twilight in field of view (dark skies)

In Operation

1. Solenoid clicks audibly about once every 2 sec.

2. Foot counter advances very slowly (about 25 ft in ½ hr). It only registers to 100 ft, but film roll is 125 ft long, so last 25 ft will be run through with no indication.

3. Dark slide - up position.

4. Solenoid contact rests behind frame control knob in STOP position. It pulls knob to P position on each exposure.

5. Motor shaft can be seen between motor and camera body; one can observe that shaft with wire wrapped around it is turning.

6. Image tube has green image on output face.

In Case of Failure

Solenoid not clicking:

1. Check that solenoid cord is plugged into left side of 16-mm timer.

2. Check that burst, interval, and range controls of timer have not been altered.

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3. Check that timer red light flashes twice for each exposure (each two seconds). If not, see "In case of failure" section of 16-mm timer sheet.

Foot counter not advancing (motor not running):

1. Look at motor shaft between motor and camera body to see if motor is turning. If so, continue normal operations.

2. If motor is not turning, check that motor is plugged into left side of 16-mm timer.

3. Check that lights toggle switch is on 12V dc.

4. Check that motor switch is on AUTO.

5. Check 10-amp fuse, top left corner, back panel of 16-mm timer; spare fuses, green toolbox (B).

If none of this works, shut down. When on ground you may install backup system as follows:

Backup for motor:

1. Remove failing motor; universal joint pin and wire clip must be bent to detach motor from camera.

2. Install spare motor; bend wire clip to lock universal joint.

3. If this fails to operate properly, remove motor, and install hand crank (B).

4. Wind.

5. Rotate spring motor-engage lever to MOT.

6. Film loading is essentially unchanged.

7. In this mode, camera must be wound every 20 min. (Do not shut off system to wind — winding does not interrupt exposure sequence.)

If system is badly out of focus:

1. Lift up tape on image tube input lens and check that inner knurled ring is at 4.45 ft. If not, set it and retape.

2. Lift tape on camera input lens and check that inner knurled ring is set at 1.85 ft. If not, set it and retape.

3. If this does not solve problem, consult with PI.

16-mm Movie Camera Timer and Transformer
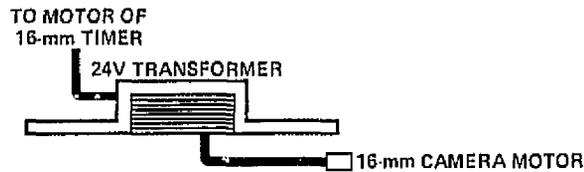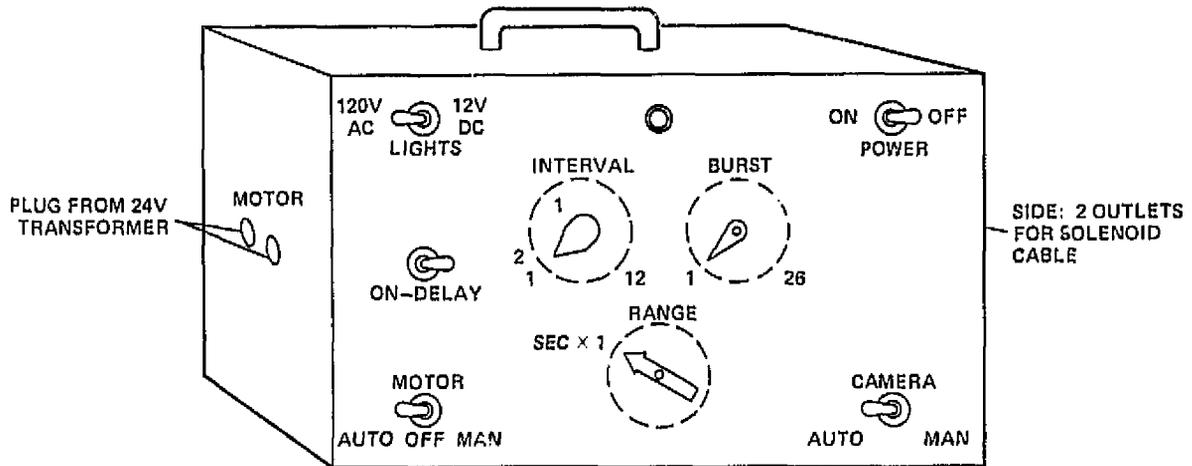
Cable Connections

1. AC power line to power panel, via stablizing transformer.

2. Solenoid cable from 16-mm platform to either outlet on right side marked Solenoid.

3. AC cord from 24-V transformer to motor outlet of 16-mm timer.

Controls

1. __Lights__ – 120-V ac (this toggle switch never moves).

2. __On-Delay__ – preset; do not change it.

3. __Motor__ -- AUTO. This three-way toggle controls the power to motor outlets on left side. MAN gives continuous power, AUTO gives power controlled by timer.

4. __Interval__ – ~ 2. This preset dial controls frame rate; do not chang it.

5. __Burst__ -- ~ 1. This preset dial controls exposure; do not change it.

6. __Range__ – SEC X 1. This dial chooses range for interval control.

7. __Camera__ -- AUTO. Two-way toggle switch; do not change it.

8. __Power__ – OFF.

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16-mm Movie Camera Timer and Transformer (continued)

Operation

1. <u>Power</u> - ON.

2. AC Cord from 16-mm motor into outlet of 24-V transformer.

3. Motor may be in MAN or OFF for some parts of film-loading sequence; when finished, it should be left in AUTO.

4. Red light at top center flashes twice between exposures.

In Case of Failure

If solenoid is not firing:

1. Check that solenoid cable is plugged into right side of timer.

2. Check that <u>range</u>, <u>interval</u>, and <u>burst</u> controls have not been altered.

3. If red light is not flashing every two seconds, check 5-amp fuse, top right corner of back panel (fuses – green toolbox, B).

4. Check that entire unit is plugged into ac power panel, via stabilizing transformer.

If none of this works, go to backup 16-mm timer system.

Backup 16-mm timer system:

1. Extract and load spare movie camera with hand crank.

2. Transfer camera lens to spare camera.

3. Mount and wind spare camera.

4. Remove plug from solenoid outlet of 16-mm timer and plug into solenoid outlet of backup 16-mm timer (formerly 35-mm timer).

5. Activate timer by turning power switch ON.

6. In this mode, movie camera must be wound every 20 min. You need not shut off anything to wind; winding does not interrupt exposure sequence.

In case the above backup timer fails, see "In case of failure" section of backup 16-mm timer (formerly 35-mm timer) information sheet.

IR Photometer

FILTER WHEEL

RV // FO

MOTOR

8 1 2
7
6 5

PHOTOMETER

SIG   HV

TO INPUT OF
CURRENT
AMPLIFIER
TO HIGH VOLTAGE
POWER SUPPLY
OUTPUT
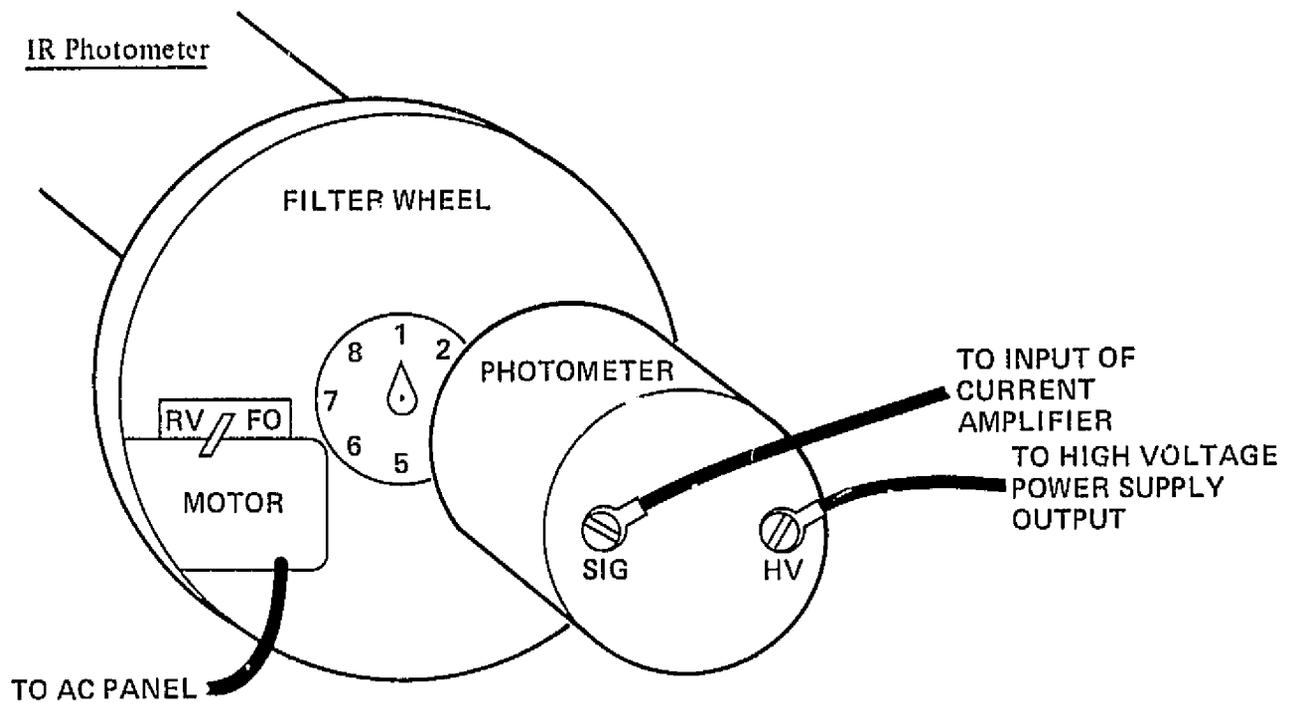
TO AC PANEL

Cable Connections

1. Filter-wheel motor cord to main ac panel

2. Signal (SIG) cable (BNC connector) from end of photometer to input of current amplifier, left side of front panel

3. High-voltage (HV) cable (high-voltage BNC connector) from end of photometer to output of high-voltage power supply, back panel.

Controls

1. Filter-wheel motor -- OFF (center)

2. Filter indicator -- #1 filter

3. Lens cap covering front of photometer

In Operation

1. Filter-wheel motor — FD (forward). Filters will change every 20 sec.

2. Lens cap removed from photometer.

In Case of Failure

1. Check all cable connections.

2. No backup unit available.

35-mm Camera - Image Tube and Timer System

MOTOR-CAM TIMER

TO EVENT MARKER
OF CHART RECORDER

TO POWER PANEL

M JUNCTION BOX

B

BATTERY PACK

IMAGE TUBE

TRANSFER LENS POSITION

OPEN
CLOSE

MANUAL REWIND

OPEN
CLOSE

TO IMAGE TUBE POWER SUPPLY

L

VIEWFINDER

S

EXPOSURE CONTROLS

MANUAL WIND
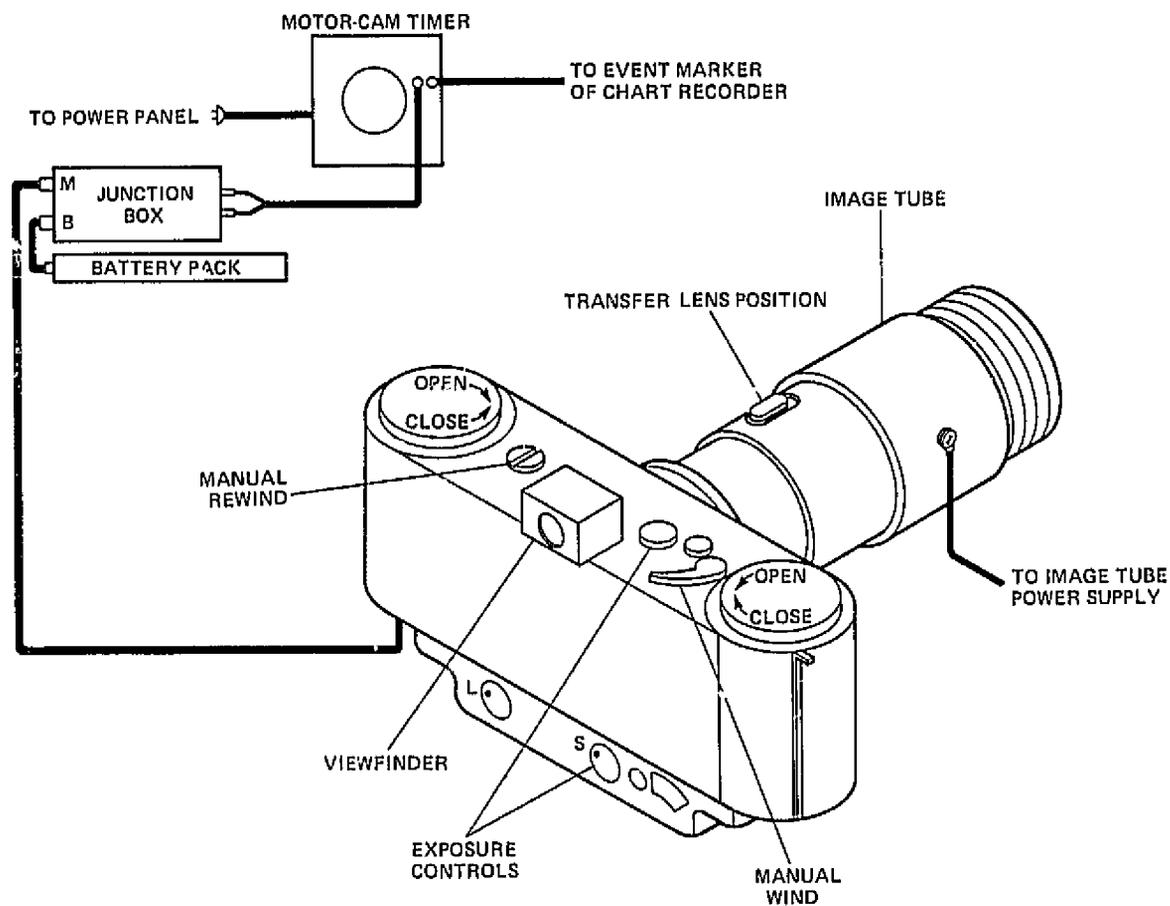
Cable Connections

1. Image tube double wire to middle channel of image tube power supply

2. Cable from front of camera to M (motor) of junction box

3. Cable from B (battery) of junction box to battery pack

35-mm Camera - Image Tube and Timer System (continued)

4. Cable from other end of junction box to motor-cam 35-mm timer

5. Cable from motor-cam timer to event marker of chart recorder

6. Power cord of motor-cam timer <u>not</u> plugged in, since the unit has no on-off switch

Controls

1. <u>Camera lower panel</u> – Left knob to L (this is not in operation), exposure control to S (single framing), frame counter to 250 if loaded with film

2. <u>Camera top panel</u> – Both large knobs to CLOSE if loaded.
    Manual rewind (left) – not in use; ignore.
    Exposure dial – 1 sec.
    Next knob to right - A.
    Manual wind – not in use; ignore.

3. Image tube dark slide – DOWN.

4. Image tube input lens – Outer knurled ring – 1.2 (f-stop, wide open)
    inner knurled ring   5.25 ft (taped down)

In Operation

1. Motor-cam timer plugged into main power panel

2. Image tube dark slide up

3. Camera exposing for 1 sec every minute

4. Event marker on chart recorder registering for each exposure

5. Frame counter decreasing from 250 with each exposure

In Case of Failure

No image visible through viewfinder:

1. Check that dark slide is up on image tube.

2. Check that image tube is plugged into power supply and that power supply is on.

3. Mirror sometimes sticks up, blocking viewfinder. Listen to exposure sequence to try and determine whether mirror comes down.

4. Go to "In case of failure" section of image tube power supply sheet to determine whether power supply is delivering voltage.

35-mm Camera - image Tube and Timer System (continued)

5. If power supply is OK, you may remove camera to look in at image tube face. However, this will entail refocusing.

Camera not firing each minute:

1. Check that motor-cam timer is plugged in and cam is rotating.

2. Check connections between timer, junction box, battery pack, and camera.

3. Check settings of controls on camera.

4. Change batteries in camera battery pack (fresh batteries, A).

If badly out of focus: Consult with PI.

Backup 16-mm Timer (formerly 35-mm timer)
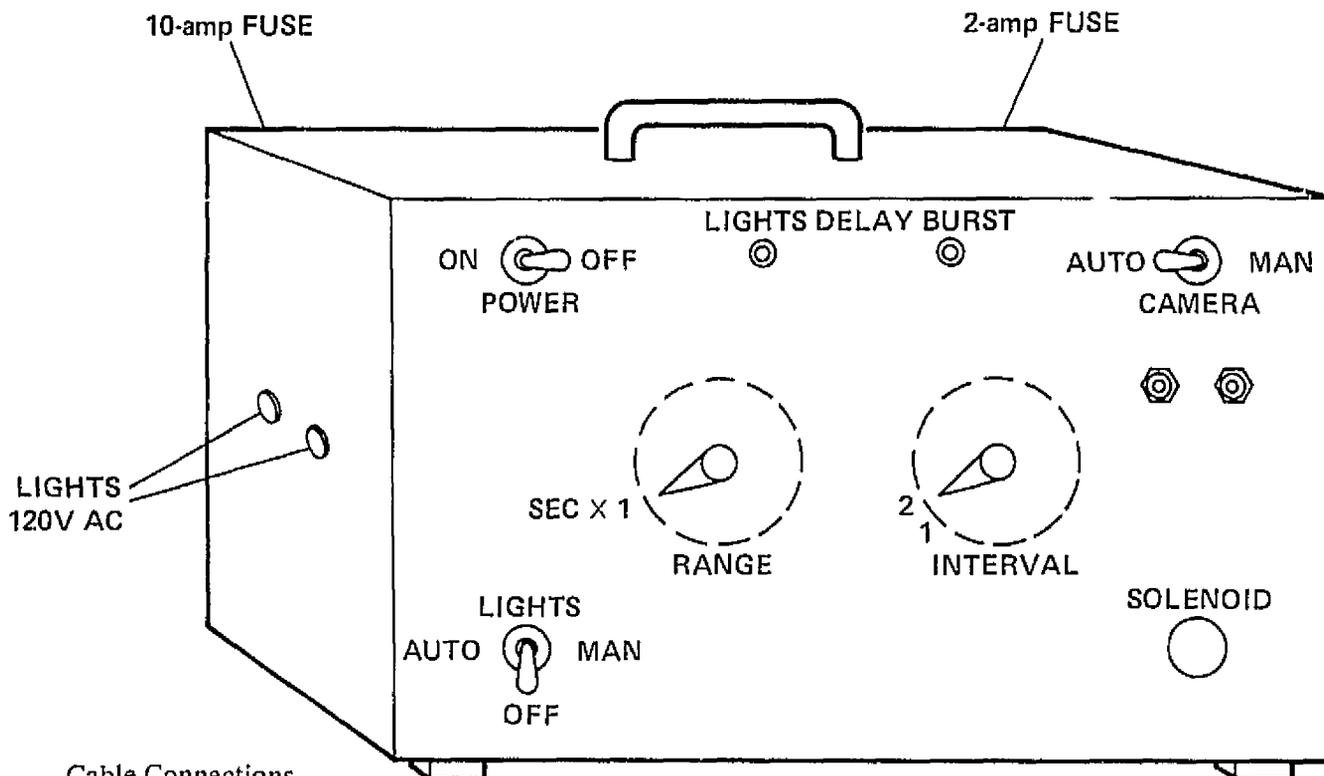
Cable Connections

1. AC power line to main power panel

Backup 16-mm Timer (continued)

Controls

1. Power – OFF

2. Lights – OFF

3. Range – SEC X 1

4. Interval – 2 (preset; do not move)

5. Burst – adjusted to keep solenoid energized 1 sec per exposure; do not change

6. Camera – Auto

7. Lights delay – full counterclockwise (OFF)

In Operation in Backup Mode

1. Power – ON

2. Solenoid plug from 16-mm solenoid plugged into solenoid outlet

In Case of Failure

1. Check that solenoid cable is plugged into solenoid outlet.

2. Check that range and interval controls have not been altered.

3. Check 2-amp fuse, top right corner of back panel.

4. Check that unit is plugged into power panel.

5. Check that burst has not been altered.

<u>Strip Chart Recorder</u>

TO OUTPUT OF CURRENT AMPLIFIER

DAMPING

1

RED ◯ DOT   CAL VOLTS mV   -1 / 0   VERNIER   GAIN

DAMPING

2

BLUE ◯ DOT   CAL VOLTS mV   -1 / 0   VERNIER   GAIN

LAMP FUSE
BEHIND CHART
TAKE UP REEL

EVENT MARKER INPUT
(ON BACK OF RECORDER)

MIN/INCH

RELEASE LEVER
FOR CHART
RECORDER

STAND
BY

OFF   ON
(BOTTOM LEFT)
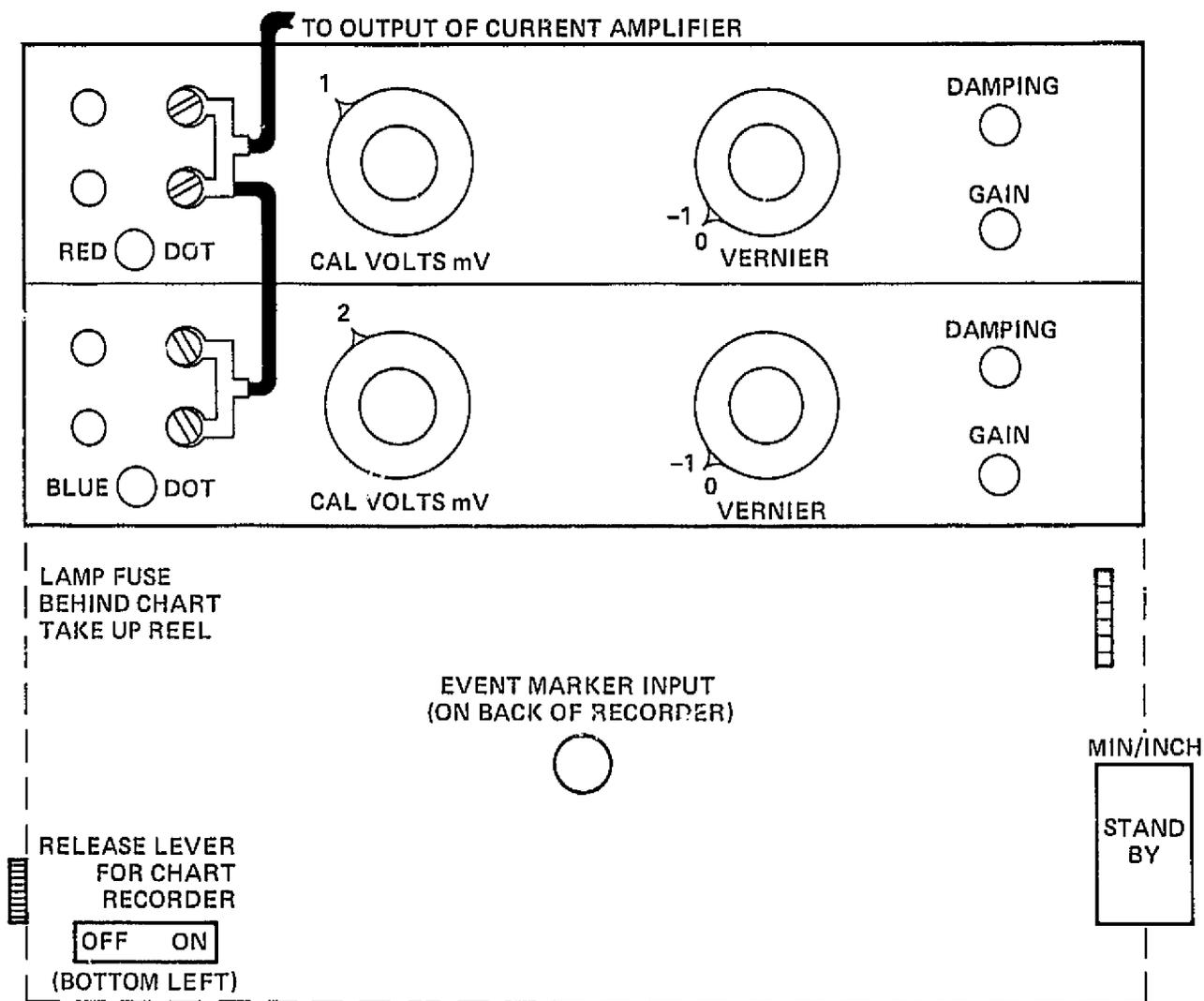
<u>Cable Connections</u>

1.   AC power line to power panel

2.   BNC connector from inputs (connected in parallel) to output of current amplifier

3.   Event marker cable from back of recorder to camera outlet of 35-mm timer

<u>Controls</u>

1.   <u>Top Panel (Red Pen)</u>
     Left black knob   1 (sensitivity; sets full-scale voltage)
     Left red knob -- VOLTS
     Right black knob   0 - 1

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Strip Chart Recorder (continued)

  Right red knob — to be set in flight (zero adjust)
  Damping and gain - do not alter

2. Bottom Panel (Blue Pen)
  Left black knob — 2 (sensitivity; sets full scale voltage)
  Left red knob — VOLTS
  Right black knob — 0 - 1
  Right red knob - to be set in flight (zero adjust)
  Damping and gain - preset, do not alter

3. Min/inch — standby (rate wheel)

4. Power — OFF (bottom left corner of recorder)

5. Chart stowed in vertical position

In Operation

1. Power — ON

2. Rate wheel — 1 MIN/INCH

3. If all blue signals are below 40 percent of full scale:
  Top left black knob may be set to 0.5   (If done, mark it on chart)
  Bottom left black knob may be set to 1

4. Chart may be pulled out to tilted position by pressing release lever above on-off switch.

In Case of Failure

If pen stops inking:

1. Apply suction to pen tip with small plastic bottle (taped to side of recorder) to start ink flowing.

2. If this fails, change ink cartridge as follows:

  a. Remove chart by depressing release lever, lifting 90° and pulling straight out.

  b. To get other pen out of the way, turn its left red knob to CAL.

  c. If in flight, remove input BNC connector to stop pen motion.

  d. Remove cartridge from ink stem, directly behind pen (pull down).

  e. If not empty, replace it and clean pen tip with tiny wire (red case, A) and again apply suction to pen tip with bottle.

Strip Chart Recroder (continued)

f.   If empty, insert new cartridge (red case, A), being sure to push it up over wide top of ink stem.

g.   Holding Kleenex under pen tip, prime by squeezing bulb adjacent to cartridge and/or apply suction to pen tip to pull ink through to pen.

h.   If the cartridge was empty, second pen will be nearly dry also, so change its cartridge too. (Event marker has finer tip; its ink will probably last longer.)

i.   Replace chart by entering it horizontally into slots and swinging down to vertical position.

j.   Check: both pens down; both left red knobs on VOLTS.

k.   On chart, mark "Chart stopped to re-ink".

l.   Align red pen with inch-mark and record a WWV time on the minues — mark "Start chart" on chart.

m.   Replace BNC signal cable.

If event marker pen stops inking:

1.   Do not bother to change cart ' . . night; monitor frame counter or viewfinder of 35-mm camera each half-hour to ver , . camera is operating.

2.   When on the ground, re-ink event pen following same general procedure outlined above.

3.   Event marker pen takes special ink — one new cartridge is in small plastic bag (cardboard box, A).

If all blue signals drop below 40 percent of full scale:

1.   Increase each pen's sensitivity (left black knob) bv decreasing setting one position in counter-clockwise direction.

2.   Mark new setting on chart (Example: "Red — .5V; Blue — 1V").

3.   This procedure may be repeated if blue signals again drop below 40 percent of full scale.

4.   If this is done, check that blue signal stays on scale for #8 filter (if it doesn't, return to previous setting).

Strip Chart Recorder (continued)

No signal showing on one or both pens (but recorder is operating):

1. Check that filter wheel is not on #1 position.

2. Check that lens cover is off of photometer.

3. Check dial settings on panel.

4. Check that BNC cable is properly connected.

5. Try reversing polarity of bottom alligator plug.

6. Try reversing polarity of top alligator plug.

7. Check that high voltage power supply shows output. (If not, see high voltage power supply sheet.)

8. Check cable connections. High voltage power supply → photometer → amplifier → recorder.

Chart paper binding and tearing:

1. At bottom of chart holder, chart must pass through slot, not through bottom roller.

2. You may want to simply tear off chart and start again.

Failure of whole recorder:

1. Check 1-amp fuse behind chart take-up reel (spare fuse, green toolbox, B).

2. Check power cord plugged into power panel.

If none of this works, turn off recorder and move signal cables over to backup recorder:

1. It is already plugged in to power panel.

2. On-off switch is in upper right-hand corner.

3. Go through same start-up procedure as with primary chart recorder.

4. During 15-min warmup period, put ink cartridge (red case, B) on red pen (see re-inking procedure above). Blue pen already has ink cartridge; it may need to be primed.

5. Do not ink up event marker pen until on ground and repairs on primary recorder are not successful.

6. In all other respects, this recorder is identical to the primary recorder.

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Image Tube Power Supplies and Image Tubes
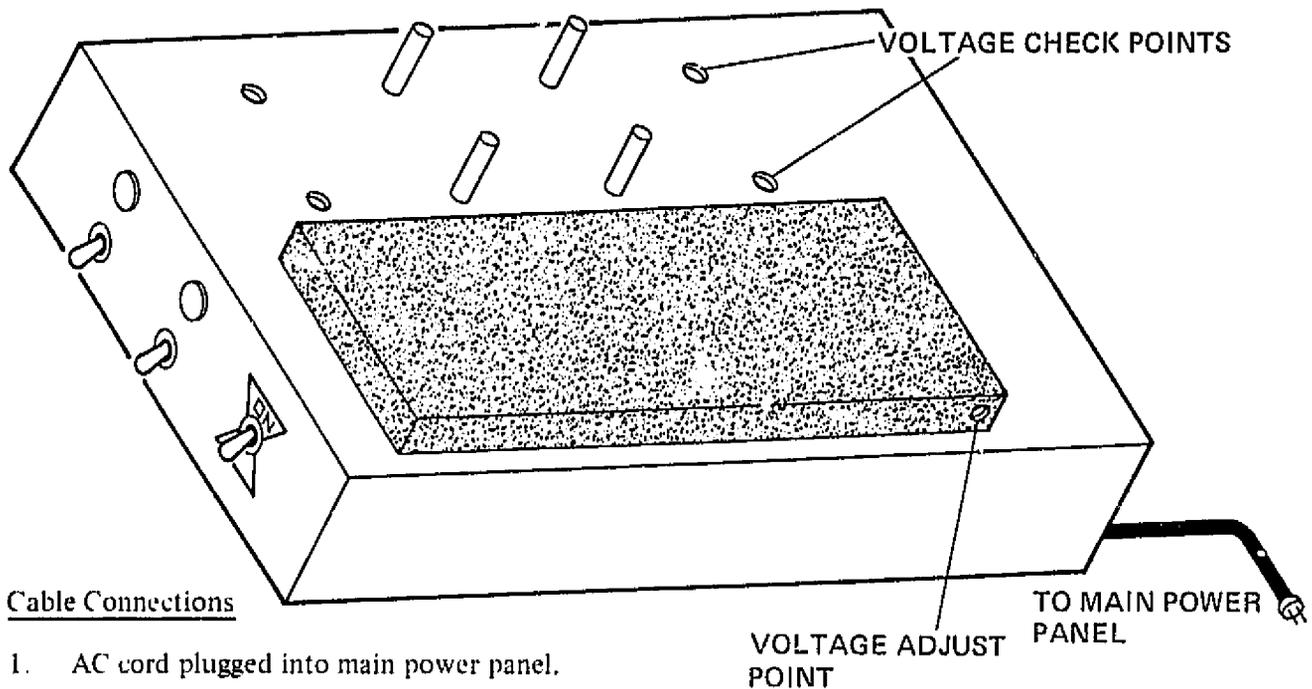
Cable Connections

1. AC cord plugged into main power panel.

2. Double wire from front pin of middle channel to image tube.

Controls

1. Power – OFF (right on-off toggle switch down)

2. Middle toggle switch – OFF (down)

3. Left toggle switch – OFF (down; this channel is never used)

4. Image tube dark slides down

In Operation

1. Power – ON (right toggle switch up)

2. Middle toggle switch – ON (up; light emitting diode should be on)

3. Image tube dark slides up

4. Green image on face of images tubes

In Case of Failure (Check Power Supply First)

1. With digital voltmeter (B), check voltage between the indicated checkpoint. It should be the value listed on power supply to ± 0.03 V.

Image Tube Power Supplies and Image Tubes (continued)

2. If not, replace image tube power supply with spare image tube battery pack (A).

3. When on ground, with voltmeter at voltage check points, adjust at voltage adjust point with tiny screwdriver (green toolbox, B) to see if desired voltage can be obtained.

4. If not, defective module can be replaced by spare (A) at instruction of PI.

5. Do not use left channel of power supply as it does not supply correct voltage.

No image on image tube face:

1. Check that dark slide is up.*

2. Check that input lens is not stopped down. The outer knurled ring which sets the f-stop should be at 1.2

3. Check the power supply as indicated above.

4. If none of this works, shut down. Replacement image tube can be installed on the ground at instruction of PI.

*For 35-mm camera, check that mirror is not obscuring image tube face. Connect microswitch to camera and cycle once, holding it down for several seconds, rather than immediately releasing it.

Abbreviated Checklist (for primary EO)

Date: _____

Observer: _____

See detailed checklist for preflight and postflight procedures.

Warm-up (as soon as possible in flight)

_____ Open plastic windows

_____ Power on -- high-voltage power supply

_____ Amplifier on

_____ Recorder on -- put date on chart

_____ Image tube power On (first switch)

_____ Mount movie camera; plug into 24 V transformer, secure air hose

_____ Output on -- high-voltage power supply

Start-up (in dark skies, preferably during turn after Venus run)

_____ Recorder: 1 min/inch

_____ Remove signal cable, set zeroes, and record ranges

_____ Lower pens

_____ Replace signal cable

_____ Activate photometer and filter wheel

_____ Activate 35-mm image tube and camera (plug in motor cam)

_____ Activate 16-mm image tube and camera (check solenoid and motor shaft)

_____ Set timer

_____ Record sky condition (next sheet)

Shutdown

_____ Amplifier

_____ HV power supply off (output first, then power)

_____ Dark slides down; lens cap on (record on chart)

_____ Image tube power supplies all off

_____ Shut down movie camera, unplug from transformer and stow

_____ Shut down 35-mm camera (Unplug motor-cam timer)

_____ Final WWV signal; chart to standby and OFF

_____ All power off at overhead panel

University of Southampton

Nikon Camera and Timer

The Nikon consists of a fisheye lens, a 35-mm camera body and a motor drive back, all mounted onto a circular plate, which locks to a mounting plate suspended from the Zenith window.

<u>Fisheye Lens</u>

This is a 180° field of view lens with a maximum aperture of f2.8. It is attached to the camera by first removing small end cap by rotating clockwise and checking lens is clean, then pushing button and aligning dots as in figure 1 and then rotating in direction of arrow. The lens will positively lock when button is not depressed. Set focus to infinity pt 1 in figure 2. Set filter wheel to L1A on 2 in figure 2. Set pt 3 in figure 2 to f2.8.
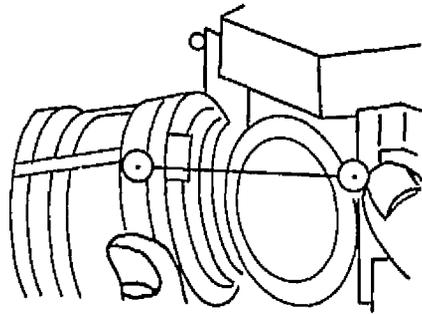
Figure 1
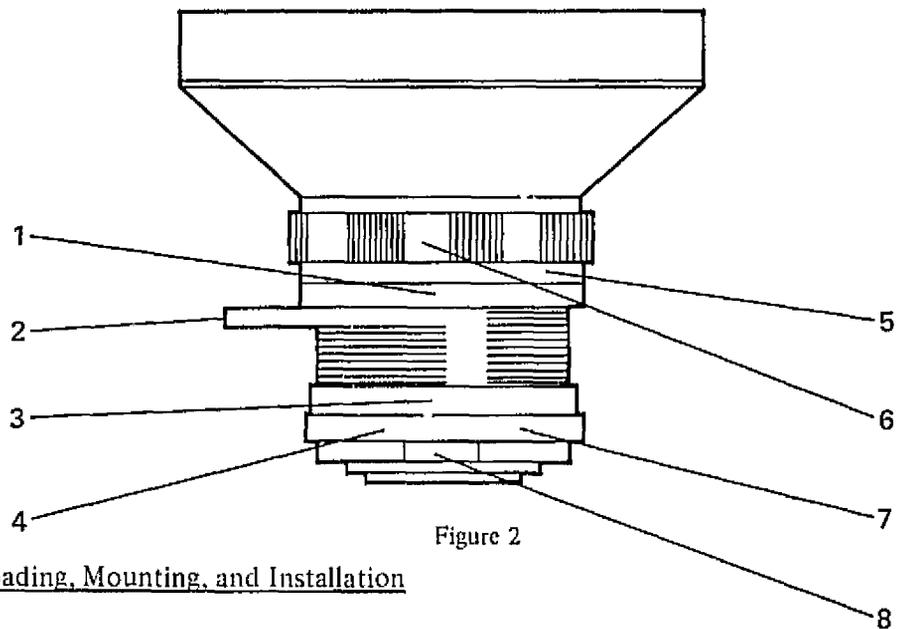
Figure 2

<u>Camera Body (fig. 3): Loading, Mounting, and Installation</u>

Rewind previous film if necessary.

1. Set advance/rewind ring to rewind.

2. Unfold rewind handle and wind in direction of arrow until tension is lost and red dot in shutter release stops turning. Film is now

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rewound. Return handle and turn R/A ring to A. Remove motor back by undoing open/close D-ring on underneath. Remove film and place in light-tight container.

3. Camera mirror in up position. (Check by no image visible in viewfinder. After firing one shot and with lens removed.)

4. Motor back controls set as in fig. 4.

5. Load new film in subdued light as shown in figure 5. Ensure sprockets at A engage in holes and lug at B also engages. Wind on and fire manually until C reaches upper sprocket D. Now replace camera back and move D-ring underneath to "close" position. Now wind on and fire manually till frame counter reaches 0.

6. Mount camera on circular plate on opposite side to handles.
   a. Slide camera under plate.
   b. Do up screw.
   c. Slide on clip firmly.
   d. Do up butterfly nuts on other side.
   e. Insert short cord through slot and plug into motor-back power socket.

7. To insert camera into window:
   a. Remove lens cover, put it away and replace when removing camera again.
   b. Check lens is clean.
   c. Check number of unexposed pictures is sufficient.
   d. Check Zenith window mount has locking clips.
   e. Grasp by both handles and insert into Zenith window mount, and rotate bayonet lock so arrows align.
   f. Hold in place with one hand and insert locking clip with other hand, by placing into hole and rotating till it locks firmly.
   g. Do up other clip.
   h. Check Nikon timer "camera" switch is OFF.
   i. Connect short cord to extension lead. (Camera will wind on if required and timer power is on.)

Reverse procedure for camera removal.

Note: Do not leave Nikon in roof mount during the day for extended periods as it will become excessively hot.
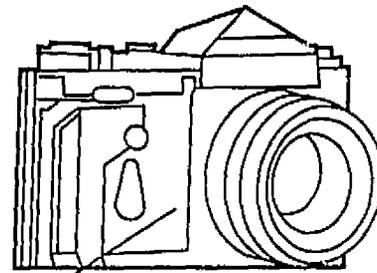
MIRROR LOCK

Figure 3
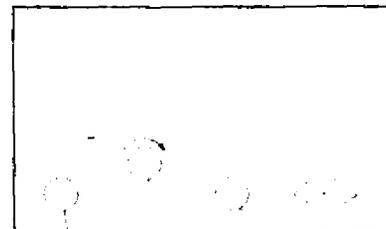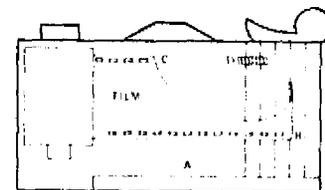
Figure 4

Figure 5

Fig. 6 Sample Nikon Log Sheet

Flight No. 5-First Sheet _____ Date 3 June _____ __ _

Flim Type Kodak Infra-Red Ektachrome 36 exposures.
N.B. Change film if less than 20 exp. left.

Time of Exposure/ Exposure No.	Exposure Time	Delay Time	Comments
19.00/10	16 min	2 min	Sky clear, still twilight. Start.
20.04/14			STOP
20.10/15	20 min	5 min	Sky clear, dark, photometer indicates low light level. Start.
01.10/27			STOP. Landing imminent.

<u>Nikon Timer (fig. 1)</u>

1. Check camera switch is OFF.

2. Plug in XLR plug into camera o/p socket. NOTE: This is a modified LNE plug and must not have mains used on it!!!! (Camera will rewind if necessary.)

3. Check power on rack power panel is ON (keyswitch and neon indicator).

4. Turn ON power switch (neon indicator).

5. Connect 100-Hz TTL compatible if available from integrator electronics to "ext" BNC "skt", with "int" ("ext" switch at "ext"; if not available, turn to int/ext" switch to "int").

6. Set desired time units (e.g., secs/mins switch to mins, all numbers now refer to this unit; multiplier to X 2, a setting of 2 min now becoming 4 min). NOTE: "Expose time" and "intershot delay" LEDs show which operation is in process.

7. Set "Expose time."

8. Set "Intershot delay," such that "expose time" and "Intershot delay" is repetition rate.

9. Press reset button, which starts an intershot delay period when released, so arrange to give first exposure at desired time. (This may be inaccurate if used on short times with "int" clocl, so wait one cycle before executing # 10.

10. Turn ON camera switch.

11. Note time of first exposure on log sheet (fig. 6).

<center>Photometer Operating Procedure</center>

<u>Photometer Head</u>

1. Assemble photometer with desired filters, detector and amplifier. NOTE: If lead sulfide cell (PbS) is in use, a cover is required over the photometer at all times in daylight.

2. Check batteries if PbS cell is in use (90 V).

3. Replace amplifier batteries.

4. Check photometer wheel free and clear.

5. Check cabling.

6. Cover photometer.

<u>Chart Recorders</u>

1. Check inks and paper.

<center>208</center>

Photometer Operating Procedure
(Continued)

Control Racks

1. Select lock in.

2. Check wiring according to appropriate diagrams.

3. Turn on Ithaco if in use. NOTE: If Nikon not required, turn camera switch which is on the Nikon timer OFF.

4. Check main power switch on power panel is on at 110 V (keyswitch with neon indicator).

5. Turn ON Nikon timer/lock-in amp power (neon indicator).

6. Turn ON chart recorder and use zero control (and offset on lock-in if necessary to set zero).

At Photometer Head

1. Check red LED glows in reference unit.

2. Switch on amplifier (and PbS cell if in use).

At Control Rack

1. Reset zero.

2. Set scale (time constants if Ithaco in use) on lock-in and chart recorder to give suitable noise signal. (If rack lock-in's in use, check with oscilloscope that the signal is not overloading at output. If Ithaco is in use, check overload light stays off — it comes on temporarily if range is changed).

At Photometer Head

1. Remove cover (not in daylight if PbS cell) and with diffuse incidence of torchlight check photometer is working at control rack.

Check Phasing

1. Maximize signal on meter if Ithaco is in use, or view an oscilloscope if rack lock-in is in use. Adjust by undoing locking allen screws on back of reference box and turning small slot screw drive to obtain a maximum in phase signal on the scope or maximizing chart recorder displacement.

2. Remove torch.

Lock-In

1. Set scales, time constant, and zero again if necessary.

2. Photometer should now be running.

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Photometer Operating Procedure
(Continued)

3. Note time and date on log sheet (fig. 7), and mark position on chart recorder.

4. During flight, inspect every 30 min and alter lock-on gain, chart recorder gain and time constant as required. Note any changes in log.

At End of Flight

1. Note date and time, and mark position on chart recorder.

2. Switch off chart recorder.

3. Switch off photometer motor.

4. Switch off Ithaco lock-in.

5. Switch off Nikon timer/lock-in if Nikon no longer in use.

6. Switch off rack power panel (keyswitch) unless any other rack functions are still required.

Fig. 7   SAMPLE PHOTOMETER LOG SHEET

Flight No.   5   Dat.   3 June

FILTER	DETECTOR	PRE-AMP	LOCK-IN	GAIN SETTINGS		TIME CONSTANT	TIME	COMMENTS
				LOCK-IN	CHART			
I.R. 1	Silicon Diode 1	1	Ithaco	10 mV	120 mV	3 secs.	19.00	Start of flight-new batteries
"	"	"	"	30 mV	120 mV	"	20.30	Overloading-reduce gain
"	"	"	"	"	"	1 sec.	01.10	Fine fast fluctuations on TV. Reduced Time Constant.

Meudon/Groninger

Operational Procedures

Summaries of operational procedures attached to each rack are reproduced below, followed by the more detailed procedures prepared by the experimenter team.

<div style="border:1px solid black; padding:10px;">

GROUND PROCEDURE

400 Hz 115 V : ON
28 V DC   : ON
4 fans, 2 wave tek, 1 scope : ON   } Rack no. 1
2 regulation de temperature ON

Chauffage gyro : Switch ON (Command panel)

Pump water in cavity if any
Take outside cover off
Make aircraft tidy, tighten tools, parts . . . etc.

Start computer procedure

Analog tape recorder on load tape
Identify carefully new tape : Time, date . . . .
Video tape recorder ON   "   "
   "   "   "   "   "   "

Paper recorder (Allco) ON check roll of paper
Write comments
Check speed, pens, sensitivities

Check helium pressure

Preamp ON
Diff. Amp. + P.A.R. ON
Amplisolator units ON

Check noise level on scope and paper

</div>

TAKE OFF PROCEDURE

Chauffage gyro OFF on command panel
Push "asservi cuve"

Check helium pressure

Keep aircraft tidy

Check again outside cover and water

Take a seat, fasten seat belt . . . .

TELEVISION PROCEDURE

Check sky brightness
Suiveur de spot   ON
Coffret de voies   ON
2 monitors   ON

Adjust high voltage on Nocticon
Adjust focus only if it is really necessary
Adjust reticle illumination and position

Push "Depart" on suiveur de spot
Check window on TV monitor
Adjust window size (Example: 55)

POWER FAILURE PROCEDURE

PDP 11 program restart automatically

TRACKING FAILURE PROCEDURE

Push "Asservi cuve"

Grasp telescope if servo is inefficient

If turbulence is very strong:
     Alim Toupie   OFF
     Lock telescope
     Asserviss. X   OFF   } Within 10s
     Asserviss. Y   OFF

....continued

TRACKING FAILURE PROCEDURE
(Cont.)

If flight is smooth again:
    Asserviss. X   ON
    Asserviss. Y   ON   } Within 10s
    Unlock telescope

Check elevation for a new object

Restart inertial pointing procedure
Restart object acquisition procedure

END OF FLIGHT PROCEDURE

Scanning	OFF
Push "Asservi cuve"	
Toupie power	OFF
Wait for 3 mn	

Lock telescope (manually)
Asserviss. X   OFF   } Within 10s
Asserviss. Y   OFF

Spot follower	OFF
Television	OFF
5 det. synchrone	OFF
2 alim mot. couple	OFF
Miroir secondaire	OFF
28 volts	OFF
400 Hz	OFF
Computer	OFF
60 Hz	OFF
50 Hz	OFF

END

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Flow Diagram of Meudon/Groningen Experiment Operations

```
                                                           ———— T - 3 hr.
┌────────────────────────────┐────────────────
│ CRYOGEN                     │
│ TRANSFER PROCEDURE          │
└────────────────────────────┘
                                                           ———— T - 1½ hr.
┌────────────────────────────┐────
│ DETECTOR PROCEDURE          │
└────────────────────────────┘
                                                           ———— T - 1 hr.
┌─────────────────────────────────────────────────┐
│    GROUND PROCEDURE                              │
│                                                  │
│                                                  ———— T - 40 min.
│  ┌────────────────────────────────────┐          │
│  │ OUTSIDE COVER/WATER CAVITY          │          │
│  └────────────────────────────────────┘          │
│                                            ———— T - 30 min.  (But note power shuts
│  ┌──────────────────────┐                  │         down around here)
│  │ START COMPUTER        │                 │
│  └──────────────────────┘                  │
│                                                  ———— T - 20 min.
│  ┌────────────────────────────────────┐          │
│  │ ANALOG TAPE REC. ON ETC.            │          │
│  │ VIDEO TAPE    REC. ON ETC.          │          │
│  │ PAPER         REC. ON ETC.          │          │
│  │ PREAMP/DIFF/LOCK-N PAR ON           │          │
│  └────────────────────────────────────┘          │
└──────────────────────────────────────────────────┘
                                                           ———— T - 5 min.
┌────────────────────────────┐
│ TAKE-OFF PROCEDURE          │
└────────────────────────────┘                             ———— T - 1 min.

                                                           ———— T + 5 min.
┌────────────────────────────┐
│ TELEVISION PROCEDURE        │
└────────────────────────────┘
                                                           ———— T + 15 min.
┌────────────────────────────┐
│ DATA ACQUISITION PROCEDURE  │
└────────────────────────────┘
                                                           ———— T + 25 min.
┌────────────────────────────┐
│ INERTIAL POINTING PROCEDURE │
└────────────────────────────┘
                                                           ———— T + 30 min. ≡ A - 10 min.
┌────────────────────────────────────────┐
│ SET (AND TYPE):                         │
│                                         │
│ 1) FILTER NO.                           │
│ 2) DIAPHRAGM. DIAM (ARCMIN).            │
│ 3) BEAMTHROW        (   "    ).          Secondary
│ 4) PREAMP GAIN.                         │
│ 5) AMPLIFIER GAIN.                      │
│ 6) LOCK IN GAIN.                        │
│ 7) X AMPLITUDE (ARCMIN).                │
│ 8) Y AMPLITUDE (   "    ).               │
└────────────────────────────────────────┘
                                                           ———— A - 1 min.
┌────────────────────────────┐
│ OBJECT ACQUISITION PROCEDURE│
└────────────────────────────┘
┌────────────────────────────┐
│ OBSERVING PROCEDURE         │
└────────────────────────────┘
┌────────────────────────────┐
│ STOP ADJUST STAR            │
│ TRACKING FAILURE PROCEDURE  │
└────────────────────────────┘
┌────────────────────────────┐
│ OBSERVING PROCEDURE         │
└────────────────────────────┘
┌────────────────────────────┐
│ END OF OBSERVATION          │
│ END OF FLIGHT PROCEDURE     │
└────────────────────────────┘
```

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Pumpdown Procedures

Situation	Preparation	Pumping	Shutdown
- V1 open	- open V5	Close V5.	- close V2
- V2 closed	- connect dewar	Switch servo on and press V4 close-valve button for small leaks till P1 remains steady at value 30 torr with pressure control dial. When V4 is opened fully (after ~30 min), slowly open V3. In case of a sudden rise in P1, close V3, wait 2 min, and try again.	- switch pump off
- V 3 closed	- close V1		- close V3
- Buffer	- switch pump on		- admit He at inlet
- He filled	- open V2		
- V5 open			- open V5
		Close V4.	- open V1
		Switch servo off.	
		Start measurements when P1 < 10 torr.	

EO Notes:
1. V4 close button makes pressure on Speedivac gauge fall.
2. Set point <u>anti</u> clockwise makes Speedivac gauge fall.

Pump Cutoff Emergency Procedure

1. Close valve V2 (Open V1*).

2. If V3 open, close V3.

3. Close V4 by pushing close-valve button with finger. Pressure on Speedivac gauge will drop until wheel stops turning, then turn servo off.

4. Circuit-breaker switch. In middle position when tripped.

   a. Push away to OFF position and

   b. After <u>1 min</u> pull right roward you.

---

*Admits air

Detector Procedure (after pumpdown)

1. Switch on low noise amplifier (gain 920).

2. Switch on PAR (diff) amplifier (gain 10 X; 3-100-Hz input switches to ac).

3. Switch on PAR lock-in amplifier.

   a. Adjust reference frequency and amplitude ($\sim$37 Hz and 50 percent on scale, i.e. +1).

   b. With strong source, adjust frequency trim and phase.

   c. Select desired sensitivity setting. Noise level of detector should be 5 percent of scale with attenuation 20 dB, sensitivity 1 mV and time constant 300 ms.

   d. Select desired time constant.

4. Switch on amplisolators.

Start Computer Procedure

1. Power at computer (key) – ON

2. Load dectapes on units 0, 1, 2. Before setting units as below, first put each tapereader on LOCAL. Push fast wind → for at least 10 turns for each dectape.

	UNIT	WRITE	REMOTE/LOCAL
PROG. 1	0	ENABLE	REMOTE
1st DATA	1	ENABLE	REMOTE
2nd DATA	2	ENABLE	REMOTE
	4	LOCK	OFF

3. Tektronix 4010 – Power ON (Up means on)
   Wait 10 sec, then press PAGE on keyboard

   PDP 11 Press ENABLE-HALT
          Turn key on POWER

   173100 on switch register
          Press LOAD ADDRESS
          Lift ENABLE-HALT

   177344 on switch register
          Press START

   Wait for 30 sec.

4. For any demounting operation, turn dectape unit to LOCAL. Push fast rewind ← .

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Ground Procedures

Controls

40 to 50-Hz converter –	ON
400 Hz, 115 V –	ON
28 Vdc	ON
4 fans, 2 Wavetek, 1 scope –	ON
2 Regulation de Temperature --	ON
A/D Converter –	ON
Codeur -	ON
Filter unit –	ON
Amplisolator units –	ON
Decodeur –-	ON
Interface –-	ON

Chauffage gyro - switch ON (Down, on command panel, not U.S. Standard)
Chopping secondary and its synchronous detector – ON
Small TV monitor (ADD AS output) – ON

Telescope Checkout and Cleanup

Pump water in cavity, if any.
Take outside cover off.
Make aircraft tidy, secure tools, parts, etc.

Start Computer Procedure

Analog tape recorder on LOAD TAPE
Identify carefully new tape (time, date)
Analog tape recorder ON (note: time, date)
Video tape recorder ON (note: time, date)
Coffret de voies on RECORD (but not ON yet)
Paper recorder (Allco) ON (check roll of paper)
Write comments
Check speed, pens, sensitivities (need to know settings for all controls)
Chart recorder (HP) ON: check roll of paper, and connections
Check helium pressure

Check

Preamp ON
Diff. amp + PAR ON
Amplisolator units ON
Get reference for PAR
Check noise level on scope and paper
$\tau = 300$ msec.; PAR output on ∓ 10 V.; Noise level ~ 0.5 V peak to peak

Check

Correct reticle in camera
All reticles available

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Take-off Procedures

Chauffage gyro OFF on command panel (OFF is UP).
Press asservi cuve.

Check helium pressure.
Keep aircraft tidy.
Check outside cover and for water in cavity again.
Take seat; fasten seatbelt.
Make sure telescope shutter is closed (sun).

Television Procedures

Check sky brightness
Suiveur de spot – ON
Coffret de voies – ON
2 monitors – ON

Adjust high voltage on Nocticon.
Adjust focus only if it is really necessary (on TV camera body).
Adjust reticle illumination and position.

Reticle Subprocedure

Telescopes should be ground boresighted.
Check illumination of reticle on TV.
Control alignment / X = 0, Y = 0; Mark (X) = 8, Mark (Y) = 1.
Cam on 0.
Reticle motor on middle M.
Select proper reticle in ring.
Position ring on holder with marked point (with time correction if early).
Remount bulb.
Select rotation speed vs heading.
When FOV acquired, rotate reticle manually for exact coincidence with starfield.
Start rotation of reticle motor in proper sense vs heading.
Magnifier on position 3 (extreme right).

For reticle offsetting,
    1 division = 1 arc min
    1 turn   = 5 arc min

Push DEPART on suiveur de spot.
Check window on TV monitor.
Adjust window size (Example: 55 x 55).
If mapping, have isolator plug in amplisolator for B.

Data-Acquisition Procedures

1. Start analog tape.
    Push ENR and EFF simultaneously.
    Write end of tape time near keyboard (+3H) or on "pinger."
    Check levels.

2. Start video tape (play and record).
   Write end of tape time (+ 2H) or set on "pinger."

3. Start paper (Allcograph).
   Check sensitivities.
   Start HP chart recorder.

Inertial Pointing Procedures

Check light shutter open.
Check altitude (pointing OK above 30,000 ft).
Check or push on ASSLRVI CUVE (command panel).
Control box – switch to asservi cuve.

Detect. Synchrone	X	ON	
Detect. Synchrone	Y	ON	
Asservissement	X	ON	
Asservissement	Y	ON	Within a few seconds
Unlock telescope (command panel)			
Detec. Synchrone	XG	ON	
Detec. Synchrone	YG	ON	Overload light goes on
2 ALIM. MOT. COUPL. Gyros		ON	Overloads go off
2 ALIM. TOUPIES		ON	Wait 30 sec

EO NOTE: In turn-off, do not turn off XG, YG, ALIM. MOT. COUPLS. X, Y till very end.

Object-Acquisition Procedures

Expected star field should be on screen.

1. Press MANUELLE on command panel.

2. Control box on MANUAL.

3. Adjust window size if necessary.

4. Adjust guide star to center of window (use joystick).

5. Push ACQUISITION on suiveur de spot (Correlation /3 pushed in).

6. Push SPOT on command panel.

7. Check reticle speed and position controls.

8. Adjust guide star to its right position with two potentiometers on suiveur de spot. Turn on PILOTE to tell pilots that object is acquired (verify they know this).

9. Be ready for primary, or secondary (or cam) scanning on computer request.

10. Cuve to AUTO, and switch below to ON.

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EO NOTE: Make hard copies of maps whenever possible in flight. Be sure to note time/date on all tapes, charts, etc. whenever starting them.

Tracking Failure Procedures

1. Push ASSERVI CUVE.

2. Grasp telescope if servo is inefficient.

3. If turbulence is very strong:

        Turn ALIM Toupie OFF
        Lock telescope
        Turn Asservi X OFF   } These three within 10 sec
        Turn Asservi Y OFF

4. If flight is smooth again:

        Turn Asservi X ON
        Turn Asservi Y ON   } Within 10 sec
        Unlock telescope

    Check elevation for a new object.
    Restart inertial pointing procedure (i.e., ALIM Toupie ON again; XG, YG, + 2 ALIM motor couples stay untouched).
    Restart object-acquisition procedure.

Shutdown Procedures

1. See separate sheet for pump.

2. Switch off amplisolators.

3. Switch off PAR lock-in.

4. Switch off PAR diff. amplif.

5. Switch off dewar low-noise preamp.

6. Switch off 220-V supply.

7. Turn down CIBLE (Nocticon) full anticlockwise.

Recharging Procedure for Battery-Powered Amplifier

1. Measure voltage of

    a. preamplifier (instruction on amplifier)
    b. diff. amplifier.

2. Recharging the low-noise amplifier will be performed by connecting it to the 60-V Delta supply, adjusted to 33 V and 22 mA. 33 V first. Then connect battery box. Then adjust to A switch and 22 mA.

3. Recharging the PAR diff. amplifier is performed when switched off but connected to the mains. The 220-V mains supply has to be ON and connected to mains.

System 1 (or 2) on Unit 0, Dectape on unit 1 or 2.

Cables

    1.   Electric power into 60 Hz 110 V (15 A) outlet in base.

    2.   Teletype lead into computer at back.

Teletype

    Button on LINE

    Start Computer as normal.

        173100   LD ADRS.
                          Lift EN. - HALT

        177344   START

    System writes:

        RT-11   V 0 1 - 15

To read names of files created (total files (57))

    Type: R-PIP (return)   - - wait

        System gives back *
        To read tape which is on   it 1.

    Type: DT1:/E (return)

        System gives names and unused files, then *

        For reading tape on Unit 2

    Type: DT2:/E (return)

To stop an unwanted listing

    Depr   CONTROL and type   Q

To ask for a new operation:

    Depress CONTROL and type   C

        Teletype prints   ●

To clean a tape

    Type: R PIP (return)

    Teletype gives *

    Type: or $\left\{ \begin{array}{l} DT2 \\ DT1 \end{array} \right\}$:/N:1/Z (return).

    Teletype gives

        DT2:/Z ARE YOU SURE?

    Type: YES (return)

    Teletype gives: * (TAPE CLEAN)

To read data

    Obtain ● (e.g., by CONTROL and type C)

    Type: R LECT.ZT3

        (Go up to Tektronix)

    Type: Name of mission (return)
           (as given by teletype)

    Tektronix gives general data (make hard copy)

    Type: RETURN

    Tektronix gives MATRICES and stops on last one (make hard copy).

    Type: RETURN

    Tektronix gives next file details

        ETC.   ETC.

Queen Mary College

Queen Mary Training Plan

The QMC training plan submitted to the Mission Manager (mid-December 1974) was relatively informal, as shown on the following page. While the content and duration of primary EO training was defined, that for the secondary EOs was less specific, with the U.S. operator to be trained only at Ames. Two levels of training and operator performance were proposed for implementation: "short training" of secondary EOs for nominal operation only, and "long training" of the primary EO for operation, maintenance and preliminary data evaluation. The latter effort was inc cated to require about 4 weeks in the home laboratory.

Since the training of European EOs was funded by ESA and monitored by their representative on the mission planning group (MPG), the Mission Manager had only to negotiate schedules for these EOs to train on their assigned U.S. experiments, and to keep informed of training progress at QMC and in the U.S.

The final result at QMC was 18 days of training for the primary and 8 days for the secondary EO, although not all of this time was used as effectively as the EOs would have liked.

Training Plans

One of the operators (B) spent two and a half weeks in November 1974 at Q.M.C. He studied the theory of the instrument, important parts of the instrument (detector and beam splitter box). The physical problem which will be studied, the reasons for some technical and experimental choices, the expected results and difficulties, have all been the subject of numerous informal talks with him.

Operator B's training will be completed in March 1975 when, for a period of about 10 days, he will be able to operate the complete instrument in the flight configuration.

Operator A has also visited during November and will be doing so again at the end of January 1975, as observer.

The training of the other operators will be done at Ames during the assembly of the instrument prior to the flights. This training will be short in time, but the experience of the operators is expected to compensate for this.

We can also say that there are two possible levels of training: one for the running of the experiment (short training) and a second for running the experiment plus keeping the instrument in the best working condition (long training). We reckon that it should be enough to have on the aircraft one operator who has had the long training.

Evaluation Criteria

For the first level (short training), the evaluation criteria will be the ability to start up the experiment from the assembled but unpowered condition, and then run interferograms to a written schedule of mirror settings.

For the second level (long training), the evaluation criteria will be the ability

i)   to start up the experiment
ii) to replace components with spares
iii) to determine if the measured interferograms contain the wanted information (in signal-to-noise ratio) about some spectral features.

Interferometer Experiment Operating Procedures

Major events in experiment operation and their timing for each flight are summarized below, followed by detailed procedures in each category.

EO-PI Consultation (T - 5½ hr)

1.   Detector and Preamplifier

Input Test Switch	Bias Test Switch	Socket	Result	Name
ON	ON	Bias test	8·1 V	Bias battery check
ON	ON	Input test	≼ 0·1 V	Bolometer bias

Note: Preamplifier batteries inside box, check only if amplifier left on unintentionally or trouble suspected. See values on label inside preamp. box.

2.   Cryostat vacuum space pumped down to 100 μm Hg

3.   Pump He can; should reach 300 μm; vent (with air)

Note: Do this only when vacuum space is known to be evacuated.

4.   Visual check of blackbody windows for rupture

5.   Chopper reference signal on scope; to lock with main frequency

6.   Chart recorder, check pen condition, ink refill

7.   EO reports to PI on above tests and action decided

8.   PI reports to EO on data transforms

9.   Schedule agreed

Preflight Meeting (T - 6½ hr)

Priming of Equipment (T - 4½ hr)

1.   T - 3 hr.   Station 12 power ON. ADC will then be powered.
     T - 3 hr.   Precool dewar with liquid N_2.

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2. T - 2.10 hr.   Transfer helium to dewar.
                   Generous smear of grease on O-ring and other vacuum connections at neck.

3. T - 1.40 hr.   Install dewar on interferometer.
                   Switch on pump, check pump lines for leaks.

4. T - 1.30 hr.   Start pumping on dewar. Monitor pressure from here on; use valve to keep
                   pressure on pump side at about 30 torr until dewar pressure starts to register
                   on low-pressure gauge. Then open up.

5. T - 1.15 hr.   Start N_2 purge to interferometer.

6. T - 1.05 hr.   Put ice into right-hand blackbody after syphoning the water out.

7.   Switch on mirror drive; move mirror to marked central maximum position.

8. T - 0.45 hr.   Stow loose items.

9. T - 0.30 hr.   Log He pressure (expected to be < 10 torr).

Takeoff under Instruction of Mission Manager

1. Check bolts overall.

2. Turn power OFF (see sequence in appendix).

3. When pump power OFF close valve, vent pump. Pressure may rise several torr.

4. When pump power ON again, close vent, open valve.

Just after Takeoff

1. Switch power ON (see sequence in appendix).

2. Check and log Helium pressure.

3. Detector switches on.

4. Stabilized mirror electronics ON.

End of Flight

1. Turn electronics OFF (see sequence in appendix).

2. Turn preamp and bias of detector OFF (to avoid battery drain).

3. Stow loose items.

After Landing

1. Under instruction from mission manager:

    a. Pump-power-OFF procedure
    b. Followed by pump-power-ON procedure

2. When ready to bring temperature of cryostat up to 4.2K:

    a. Close pump valve
    b. Pur He balloon on sidearm
    c. Vent to dewar

    NOTE: If He is not available when vent procedure becomes necessary at any time, controlled air vent is acceptable.

3. Strip chart roll and log book to PI.

Switch-on Sequence

1. Station 11 power; analog-digital connector (ADC) will then come on (switch is inside door but no need to operate this).

2. Mirror drive

3. Station 12 power:

    a. Right-hand amplifier
    b. Right-hand PSD
    c. Mirror-drive clock
    d. Phase shifter

4. Beam-switch control box

5. Oscilloscope

6. Interferometer power supply

Switch-off Sequence

Reverse of above

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Detailed Procedures

Between-Flight Check (without ADDAS)

ADC   ON

Detector Checkout Procedure

Input Test Switch	Bias Test Switch	Socket	Result	Name
OFF	OFF	Bias test	≥ 8.8 V	Bias battery check
ON	OFF	Input test	$R \simeq 89.3\ \Omega$	Room temp. detector resistance
ON	ON	Bias test	$DCV \simeq 50$ mV	Bolometer bias

1. Check preamplifier battery.

2. Check cryostat pumped down (pump if necessary to 100 μm Hg).

3. Check blackbody windows for rupture.

4. Check interferometer mirror movements:

    a. Speed change
    b. Movement left and right
    c. Sampling pulses by observing DVM triggers

5. Input mirror checks:

    a. Check angular change (with offset on console)
    b. INS response should have been prechecked
    c. Check zero setting if possible

6. DVM checks:

    a. Check digits with button.
    b. Quick response check; use known source voltage (?)

7. Turn on chopper.

8. Check reference signal on scope: to lock with mains frequency.

9. Precool detector cryostat with N_2.

10. Pass cassette to PI and re-fill recorder with clean cassette.

11. Service chart recorder.

12. Check switch positions on panels.

Briefing Procedure

1. EO reports on between-flight checkout tests (above)

2. PI reports on data transforms

3. Schedule agreed

Pre-takeoff Priming of Equipment

1. Transfer helium to dewar

2. Check detector resistance:

   a. Input test switch on
   b. Bias test switch off
   c. Input socket ($R \approx 3K\Omega$ ($4.2°K$); use $200k\Omega$ range)

3. Start pump down

4. Check ADC switched on

5. Purge interferometer from N_2 gas supply (not needed if N_2 blackbody used)

6. Cool down the ice blackbody; cool down the LN_2 blackbody (not always used)

7. Switch window heater on

8. Switch thermocouple amplifiers on

9. Check temperature on thermocouples (3 through ADDAS)

   a. Blackbody (ice); output $1 \div 2$
   b. Blackbody (LN_2); output $1 \div 3$
   c. Inside aircraft window; output $1 \div 4$
   d. Outside aircraft window

10. Check He pressure $\leqslant$ 8 torr

11. Check detector resistance (~ 100 kΩ at ~ 8 torr)

12. Check phasing, using LN_2 blackbody (vs aircraft window); phasing will act as total system check

13. Switch computer units OFF

14. Switch stabilized mirror electronics OFF

15. Check safety valves on pumping line are open

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Power Switchover Procedures

Before switchover from ground power to aircraft power:

    a.   Turn power OFF (to everything except pump)
    b.   Mission manager will shut off power to pump

2.   Engage safety clamping where applicable

3.   Mission manager reactivates pump power

4.   Open safety clamps when pump on line

Just after Takeoff

1.   All power ON when mission manager directs

2.   Switch computer ON

3.   Check He pressure ($\leqslant 8$ torr)

4.   Check detector resistance [~ 100 kΩ]

5.   Check bolometer bias voltage [? ?]

6.   Check system noise level

Preinterferogram Procedures

1.   Stabilized mirror on and check its operations

2.   Check signal at central max:

    a.   Sky - ICE
    b.   Sky - LN_2

3.   Check "Line Rejection" on amplifier is OUT, and "Fast Filter" on P.S.D. is IN

4.   Adjust amplifier to span DVM (+ ve and − ve)

5.   Check noise in "wings" on chart

6.   Set variables for 1st scan

Independent

Optical filter in lightpipe → Sampling interval → Integration Time Constant

Max. path difference → Speed of scan

Duration of total run

Stabilized mirror elevation

Blackbody 1 or 2

Gain (re-check)

Initiation and Labeling of Interferogram

1.   Check detector pressure

2.   Check stabilized mirror is on

3.   Check and refill black bodies

4.   Log parameters, noting the TV reference number

5.   Read and record voltage bias and input test (Switch off Keithley afterwards.)

6.   Check:

    a.   Switch in EXTERNAL position on ADC
    b.   Cassette capacity
    c.   The scanning mirror is at the end of its movement
    d.   Tapes labeled
    e.   Switch ON for ADDAS

7.   Set timer and initiate scan and start minicomputer

Termination of Scan

1.   Moving mirror -- STOP

2.   Minicomputer -- OFF

3.   Switch for ADDAS -- OFF

4.   Stabilized mirror electronics -- OFF (if approaching turn)

Landing Procedures

1.   Stabilized mirror -- OFF

2.   Computer -- OFF

3.   Check detector valves are OPEN

Switch Off

1.   Remaining electronics -- OFF

2.   Preamp and bias of detector -- OFF

3. Close pumping line

4. Vent dewar

5. Thermocouple amplifier — OFF

6. Empty ice blackbody of water

Appendix A-3 · Training Chronology: Operator B

DATE	LOCATION	ACTIVITY
Mid September until 10th October 1974	Southampton University	Study of theory behind airglow experiment. Study of television camera and associated electronics.
Friday, 11th October	Southampton	Meeting with ESA manager (concerning experimental training and operational procedures).
Monday, 14th October	Southampton	Experimental Training.
Tuesday, 15th	Southampton	Experimental Training.
Wednesday, 16th	Southampton	Preparation of preliminary check of equipment after shipment.
Thursday, 17th	Southampton	" " "
Friday, 18th	Southampton	Preparation of an alignment procedure for the TV camera.
Monday, 21st	Southampton	Preparation of flight experimental procedure.
Tuesday, 22nd	London, Queen Mary College	Visit to PI at QMC to discuss operator training program.
Wednesday, 23rd	Southampton	Background study for QMC experiment.
Thursday, 24th	Southampton	Final compilation and check out of Southampton's experimental procedures.
Friday, 25th	Southampton	Meeting with Southampton experimenters and ESA manager.
Monday, 28th	Southampton	Experimental training.
Tuesday, 29th through November 6th	London, Queen Mary College	Study of QMC experiment.
Thursday, November 7th	Queen Mary College	Unpacking and assembly of the interferometer.
Friday, 8th	Queen Mary College	Assembly of the interferometer.
Monday, 11th	Queen Mary College	Meeting of QMC experimenters and European Operators with scientist from N.P.L. Familiarization with equipment.
Tuesday, 12th	Queen Mary College	Study of experimental techniques.

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DATE	LOCATION	ACTIVITY
Wednesday, 13th	Queen Mary College	Study of interferograms and spectra.
Thursday, 14th	Queen Mary College	Meeting of QMC team with ESA manager. Travel to Groningen.
Friday, 15th	Groningen	Introduction to Groningen detector system. Returned to England.
Monday, 18th	Southampton	Travel to Paris.
Tuesday, 19th	Paris (ESA)	Mission Planning Group Meeting.
Wednesday, 20th	Paris	Second Experimenter Group Meeting.
Thursday, 21st	Paris	Second Experimenter Group Meeting continued
Friday, 22nd	Meudon	Familiarization with telescope and supporting electronics.
Saturday, 23rd	Meudon	Familiarization with telescope and supporting electronics.
Monday, 25th	Meudon	Packing of equipment and travel to Bretigny Airport.
Tuesday, 26th	Bretigny	Installation of equipment into Caravelle.
Wednesday, 27th	Bretigny	Equipment check. Discussion over experimental procedures.
Thursday, 28th	Bretigny	Study of equipment.
Friday, 29th	Bretigny	Preparation for Caravelle flight. Observation during Caravelle flight.
Monday, December 2nd	Paris	Visit to ESA Headquarters. Travel to Southampton
Tuesday, December 3rd until Monday, January 20th	Southampton	Scientific training.
January 21st through February 1st	Southampton	Preparation of observational report on Southampton experiment.
February 2nd	Southampton/USA	20 hour journey to Fairbanks, Alaska.

DATE	LOCATION	ACTIVITY
February 3rd	University of Alaska	Introduction to the experiment and the Institute.
February 4th 0930 - 1500	Alaska	Study of the optics of the 1m Ebert spectrometer.
1700 - 1900		Familiarization with 1m Ebert Analog Data System.
2030 - 0030		Operation of 1m spectrometer to obtain OH rotational temperature measurement.
February 5th 0900 - 1200	Alaska	Review of previous nights data, and theory of analysis.
1230 - 1500		Study of Airglow Spectrum 3100 A - 10,000 A (J.A.R. Jan. '68).
1500 - 1600		Interview of team for local newspaper.
1600 - 1800		Preparation for that night's experimentation.
1900 - 2200		Study of PI's thesis on experiment.
February 6th 0800 - 1130	Alaska	Review of previous spectra measurements.
1130 - 1330		Review of training program and description of experiment objectives and configuration for flight.
1400 - 1700		Calibration of spectrometer cams.
1700 - 1730		Set up spectrometer for night time experiment.
2000 - 0030		Observation of OH data until excessive aurora obscured measurements.
February 7th 0830 - 1230	Alaska	Analysis of resolution of 1m Ebert.
1400 - 1800		Re-alignment of 1m Ebert by adjustment of main mirror only.
February 10th 1000 - 1300	Alaska	Start assembly and alignment of 1/2m Ebert.
1400 - 1545		Lecture on the control electronics for the 1m Ebert.
1600 - 1730		Continuation of assembly of 1/2m Ebert.
1900 - 2100		Study of theoretical background.
February 11th 0930 - 1230	Alaska	Continuing instruction of 1/2m Ebert.
1330 - 1730		Final alignment of 1/2m Ebert.
1920 - 0530		Night run of 1m Ebert and preliminary connections made with the new computer system.

DATE	LOCATION	ACTIVITY
February 12th	Alaska	
1430 - 1700		Study papers on planetary spectra.
1930 - 0200		Waiting to see if computer-system debugging successful.
February 13th	Alaska	
1100 - 1200		Discussion of training plan for the next few days.
1330 - 1545		Background study of spectroscopy.
1545 - 1700		Seminars on Space Shuttle payloads.
2000 - 2300		Visit to Ester Dome Observatory to inspect the auroral television system there.
February 16th	Alaska	
1000 - 1300		Background study of spectroscopy.
1400 - 1600		Lecture on computer system used with the 1 m Ebert.
1600 - 1700		Seminar on auroral-particles.
February 17th	Alaska	
0900 - 1200		Discussion on further modifications for 1m system.
1200 - 1600		Tuition on I.P.S. star tracking system that will be used on the plane.
1600 - 1700		Revision of I.P.S. tracking system and schematics.
2300 - 0300		Waiting to see if computer-system debugged.
February 18th	Alaska	
1300 - 1600		Final discussion of the flight system and experiment objectives.
February 19th		
2030 - 0900		Travel to San Francisco and Ames.
1000 - 1200	Ames	Introduction to Ames and discussion of Alaska experiment spectrometer mounting requirements.
1400 - 1600		Study of heliostat and ADDAS.
February 20th	Ames	
0930 - 1100		Demonstration of heliostat.
1130 - 1415		Discussion of Alaska experiment with NASA observing team.
1325 - 1600		Demonstration of and introduction to the ADDAS system.
February 21st		
Morning		Travel to Los Angeles.
1400 - 1700	JPL	Meeting of research group with PI to ascertain future program.

DATE	LOCATION	ACTIVITY
February 24th	JPL	
0830 - 1000		Introduction to experiment from PI.
1000 - 1245		Interconnection of equipment components and a trial run.
1330 - 1720		Spectra taken of sunlight -- troubleshooting for source of excessive noise.
February 25th	JPL	
0815 - 1300		Noise troubleshooting in the detector circuits.
1430 - 1700		Further discussion and runs on analog system.
February 26th	JPL	
0830 - 1230		Study of equipment manuals.
1400 - 1700		Discussion of flight system and procedures.
February 27th	JPL	
0900 - 1230		Inspection and study of 8 inch cassegrain telescope.
1330 - 1700		Calibration of photomultiplier tubes, and hands-on experience.
1900 - 2330		
February 28th	JPL	
0900 - 1300		Study of technical information.
1400 - 1800		Design and rewiring of a PMT voltage supply.
March 2nd	JPL	
1400 - 1900		Study of PMT design. Time line arrangement for QMC and Southampton experiment.
March 3rd		
0800 - 1030	JPL	Packing equipment for trip to Table Mountain.
1030 - 1700		Travel to Table Mountain and installation of equipment.
1900 - 2300	Table Mountain	Observation of spectra of Sirius and Saturn.
March 4th	Table Mountain	
1000 - 1200		Experimentation to define polarization axis of the tunable optical filter.
1300 - 1430		Discussion on the proposed ADDAS interfaces.
1900 - 2300		Background astronomy study.
March 5th	Table Mountain	
AM		Background astronomy study.
1200		Driven off mountain by blizzard.
March 11th	New Mexico	
1730 - 2230		General discussion of experiment with PIs. Operator C present all week also.

DATE	LOCATION	ACTIVITY
March 12th	New Mexico	
0900 - 1200		General explanation of experiment by PI and showing of movies of past data.
1330 - 1730		Explanation and examination of various components of experiment — especially cameras, 35-mm, 16-mm, and photomultiplier tubes.
1730 - 2230		General discussion of mission with ESA manager who also observed training here.
March 13th	New Mexico	
0900 - 1200		Reading instruction manuals and examining equipment.
1330 - 1500		Working on strip chart recorder and how to troubleshoot it.
1500 - 1730		Working with 35-mm camera motor drive and instruction on loading both 35- and 16-mm cameras.
1730 - 2130		Discussion of aircraft problems and experimentation between EOs and PIs.
March 14th	New Mexico	
1000 - 1100		Operator C discusses OH radical theory.
1100 - 1200		Run through of startup and operational procedures.
1330 - 1730		EOs practice total operation of equipment from startup to completion.