OPTICAL TECHNOLOGY
APOLLO EXTENSION SYSTEM
PART I

FINAL TECHNICAL REPORT

VOLUME III

Section 4 - Technology Development Plan

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October 21, 1966

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SECTION IV
TECHNOLOGY DEVELOPMENT PLAN

14.0 INTRODUCTION

The technology development plan provides a step-by-step procedure for the advancement of the state-of-the-art in discrete areas of concern related to optical activities in space. The plan is intended to be implemented through the near-term OTES experiments and the associated ground activities in support of future space applications.

The purpose of the OTAES technology plan is dual. It assists in the definition of space experiments necessary for the development of optical technology for support of future space applications. Secondly, it recommends a research and development activity path as a prelude to the performance of space experiments established for the OTES and includes the availability of these experiments for flight integration into any vehicle.

The technology development plan is the produce of critical analysis within the bounds of the following guide lines:

a. The baseline state-of-the-art is the knowledge of the present scientific community.

b. The program objective is the advancement of the state-of-the-art in Optical Space Astronomy and Communication Technology.

c. Technological advances will result from the performance of OTES experiments.

Space testing is necessary in order to overcome the inhibiting parameters of the terrestial environment. A true gravity-free situation cannot be attained on earth, especially when extended periods of test time are required. In addition, viewing through the earth's atmosphere, would make impossible the determination of performance limits of telescope. In the area of telescope isolation it is virtually impossible in an earth-based test program to perform a comprehensive evaluation of the various means of telescope isolation from spacecraft disturbances. Verification of laser communication systems and hand-over performance affected by atmospheric degradations, vehicle perturbations, long transmission links and point ahead requirements, can only be validated from a space borne vehicle.

The post-flight analysis of each space experiment is not solely a demonstration or verification of a concept but collects required technological data from which the specific technology can be further evolved and a new base for progression established. Most of the included experiments consider alternatives which result in more than one type of prerequisite technology development.

The elements comprising the technology development plan are:

a. Major Objectives Development Plan

b. Prerequisite Technology Digests

c. OTES Experiment Development Schedules

d. The Master Planning Schedule (Experiment Integration Analysis)

The content of each of these elements, associated assumptions, and prerequisite background discussion will be included in the separate sub-sections of this volume.

15.0 MAJOR OBJECTIVES - TECHNOLOGY DEVELOPMENT PLAN

15.1 DISCUSSION OF GENERAL PROBLEMS

The OTES experiment technologies are being developed to implement flyable experiments for the advancement of optical technology. To advance the necessary technologies to the fullest, a goal with specific requirements must be known. In the case of OTAES, two major objectives or goals were selected for developing an overall development plan. The astronomy oriented goal is a three meter diffraction limited M.O.T. class telescope. The optical propagation oriented goal is planetary laser communication system. The OTAES experiments comprise a necessary step in the attainment of these planned goals. The astronomy-oriented requirements are:

a. A three meter diffraction-limited telescope operating in space.

b. The telescope must be capable of automatic operation but designed for manned intervention at any stage.

c. The basic telescope shall be a narrow field instrument to preserve the ultimate in resolution, and it should be capable of diffraction-limited photography of single celestial fields for exposures of at least 20 hours.

d. The telescope shall be capable of operating in the spectral region from 900 angstroms to 20 microns.

e. The telescope should be diffraction-limited at 1000 angstroms.

f. The telescope system must be capable of resolving to .03 seconds of arc.

The optical propagation-oriented requirements are:

a. A one meter diffraction-limited telescope operating in space.

b. The telescope must be capable of automatic operation.

c. Lasers, modulators, and receivers must be space qualified.

d. The telescope shall be capable of operating in the spectral region from .488 microns to 10.6 microns.

e. The telescope should be diffraction-limited at .6328 microns.

f. The system must be capable of tracking and pointing to 0.1 seconds of arc with point-ahead capability.

g. The atmospheric effect on optical propagation must be known.

h. Information capacities greater than 10^7 bits per second for interplanetary communications.

15.2 PATH OF EVOLUTION TO THE SOLUTION

In order to adequately define what specific technological advancements are necessary for the support of future space applications, a technology development program has been established which extends from the present day through to the availability of the two major optical systems defined in the previous section. In this plan space as well as required ground based development and tests are exhibited for both the astronomy-oriented and optical propagation-oriented milestones. (See figures 15.2-1 and 15.2-2. The major areas of required development included are: (1) Optical subsystems; (2) Telescope structure and mechanisms; (3) Control/Stabilization; (4) Detection and conditioning; (5) Auxiliary devices; (6) Optical transmission; (7) Optical reception; and (8) Supporting telescope technologies.

An analysis of the aforementioned figures will reveal that the technology advancements required to attain the long range goals are of such magnitude and complexity that a technology quantum jump approach does not appear feasible and that space experiments are a logical step to ensure continuous technology advancement in all disciplines.

Again by inspection it can be seen that the three-meter diffraction-limited telescope and broadband planetary communications are natural outgrowths of OTAES work and the additional technological advancements are but projections of the new "baseline" of technology established from OTAES experiment data. However, without the OTAES baseline, these technology projections would be quite superficial.

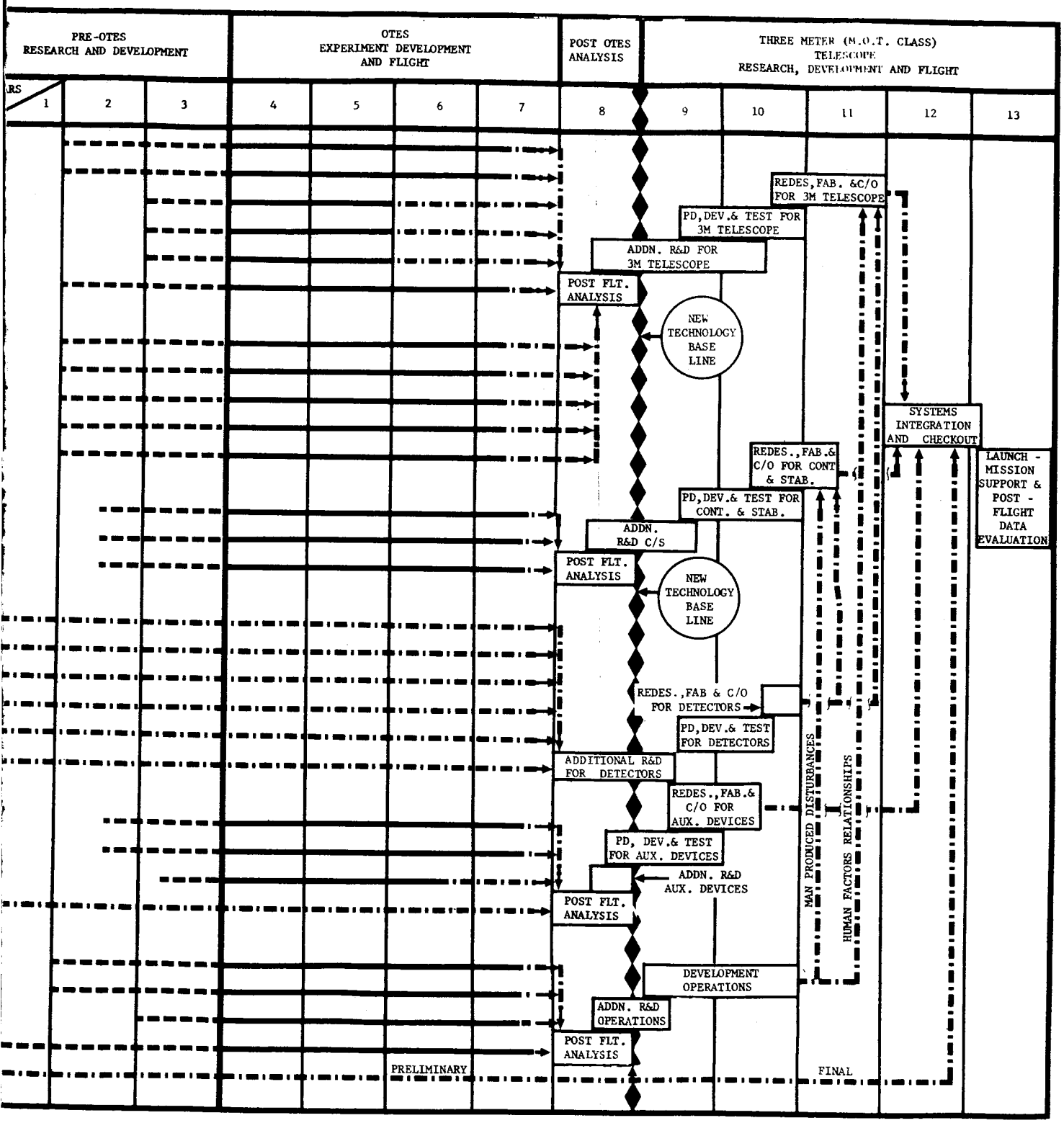
15.3 RELATIONSHIP OF OTES EXPERIMENTS TO TECHNOLOGY PROBLEM AREA

In order to make a reasonable assessment of the specific technology areas and the associated development requirements, an analysis of the problems to be solved must be made. Such a logical analysis has been made in the technology development plan. After the problem identification part of the analysis was made, major problems were classified by some thirteen major technology advancement areas as shown in figure 15.3-1. The major technology advancement areas were broken down to the next level of detail (sub-areas) and the OTES experiments, both proposed and identified, were matched with the problem areas to indicate impact and relevance in solving the problems associated with the specific technology advancement sub-areas. The results are shown in tables 15.3-1, 15.3-2 and 15.3-3. An analysis of these tables reveal the interdependence of the experiments and the need for simultaneous performance in order to fully utilize the experimental measurements and technological data. This fact indicates that although the experiments are designed to be flown singly and independently, much more could be gained by launching them in groups on a vehicle such as an OTAES spacecraft.

TECHNOLOGY AREAS	RELATED EXPERIMENTS AND GROUND DEVELOPMENT			
	OTES EXPERIMENTS	OTES RELATED GROUND DEVELOPMENT	OTHER GROUND DEVELOPMENT	YE/
I. OPTICAL SUB-SYSTEM				
A. MATERIALS	10,11,15	G	REQUIRED	
B. MIRROR FIGURE CONTROL	10,11,15	A,M	NOT REQD.	
C. CONTAMINATION		G	REQUIRED	
D. SURFACE DEGRADATION		G	NOT REQD.	
E. MIRROR COATING		G	REQUIRED	
F. THIN MIRROR	10,15	G	NOT REQD.	
II. TELESCOPE STRUCTURE AND MECHANISMS				
A. PASSIVE THERMAL CONTROL	10,11,15	A,M,N	REQUIRED	
B. SMALL DISPLACEMENT ACTUATORS	10,12,14,15	A,J,M,N	REQUIRED	
C. ALIGNMENT SENSORS	10,11,15	A,J,M,N	REQUIRED	
D. FOCUS SENSORS	10,11,15	A,J,M,N	REQUIRED	
E. REMOTE ALIGNMENT PROCEDURES	10,11,15	A,J,M,N	REQUIRED	
III. CONTROL/STABILIZATION				
A. TRACKING AND STABILIZATION	12,13		REQUIRED	
B. ISOLATION AND GIMBALLING	12,13		REQUIRED	
C. ACQUISITION	12	H	REQUIRED	
IV. DETECTION AND CONDITIONING				
A. HIGH RESOLUTION DETECTORS		C,P	REQUIRED	
B. DETECTORS SENSITIVE TO UV ONLY			REQUIRED	
C. BROAD BAND PHOTO ELECTRIC DETECTORS		K	REQUIRED	
D. HIGH DATA MAGNETIC TAPE STORAGE			REQUIRED	
E. LOW LEVEL PHOTO ELECTRIC TUBE		C,K	REQUIRED	
F. DRY DEVELOPMENT EMULSION		C	REQUIRED	
V. AUXILIARY DEVICES				
A. VARIABLE DISPERSION SPECTROGRAPHS	12,13	F,J	REQUIRED	
B. UV SPECTROGRAPH	12,13	F,J	REQUIRED	
C. INTERFERENCE SPECTROMETERS	14		REQUIRED	
D. BAFFLE SYSTEMS		E	REQUIRED	
VI. OPERATIONS				
A. ERECTION AND CHANGE-OVER PROCEDURES	10,11,14,15	A	REQUIRED	
B. LOGISTICS	10,11,14,15	C,E,G,N,	REQUIRED	
C. OPERATING MODES	13	S	REQUIRED	
D. LAUNCH ENVIRONMENT	ALL		REQUIRED	
E. OBSERVATION PROGRAM AND PLAN	NONE	NONE	REQUIRED	

NOTES: 1. SEE SECTION 16.0 FOR EXPERIMENT DEVELOPMENT DETAILS.

2. THIS FIGURE IDENTIFIES BUT DOES NOT SCHEDULE OTHER NEEDED GROUND DEVELOPMENT NOT SPECIFICALLY IN SUPPORT OF SPACE EXPERIMENTS.



KEY

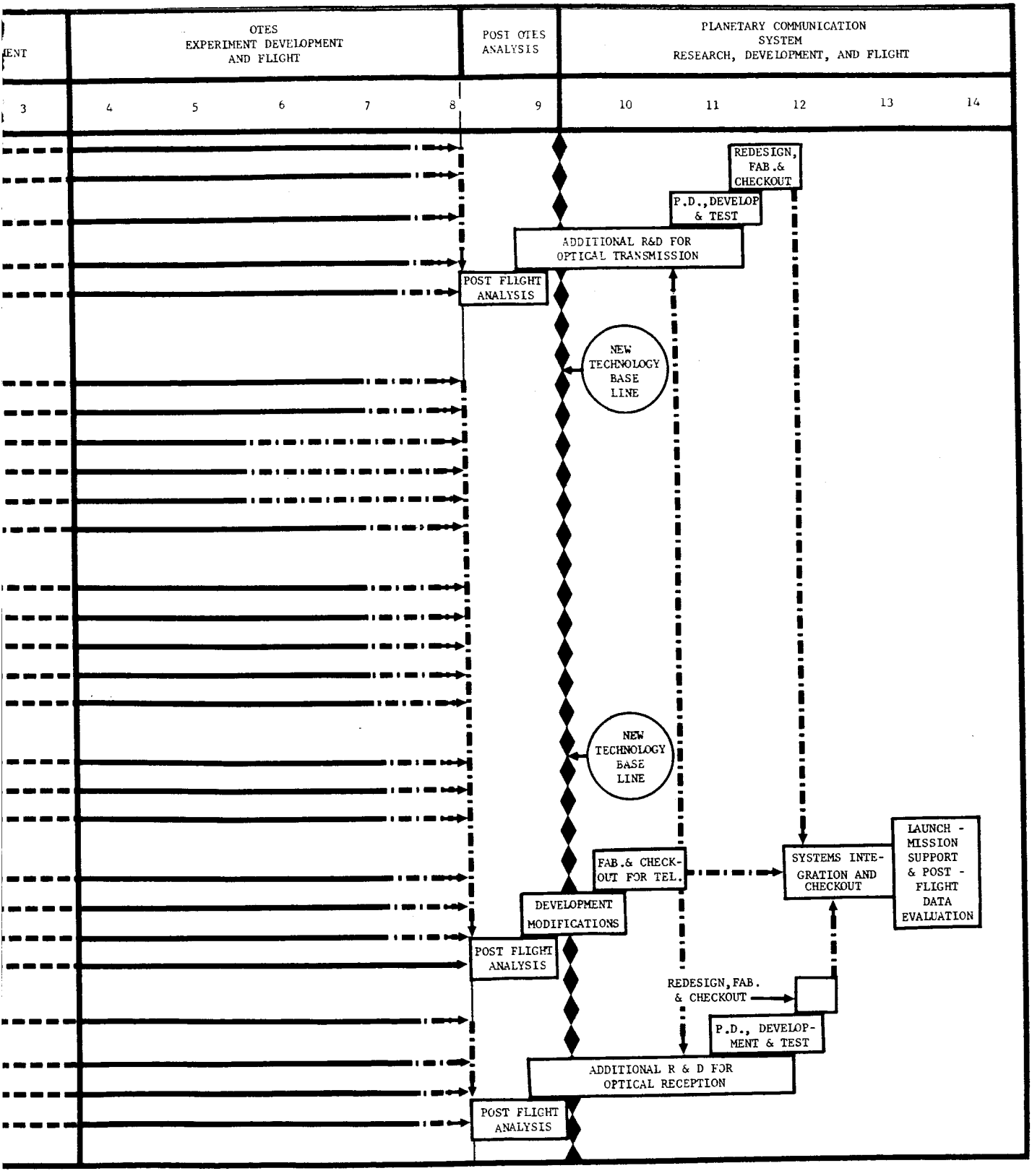
- OTES EXPERIMENT DEVELOPMENT & FLIGHT
- PRE-OTES RESEARCH & DEVELOPMENT
- GROUND DEVELOPMENT & DELAY TIME

Figure 15.2-1. Long Range Astronomical Technology Development Milestones

TECHNOLOGY AREAS	RELATED EXPERIMENTS AND GROUND DEVELOPMENT			PRE-OTES RESEARCH AND DEVELOP
	OTES EXPERIMENTS	OTES RELATED GROUND DEVELOPMENT	OTHER GROUND DEVELOPMENT	YEARS 1 2
I. OPTICAL TRANSMISSION				
A. PATH CHARACTERISTICS AND LINK DEGRADATION	1,2,3,4,5,8,9	B	REQUIRED	
B. MEANS OF TRANSMISSION	1,2,3,4,5,6,7 8,9	B	REQUIRED	
C. SPACE QUALIFIED SUPPORTING COMPONENTS	1,2,3,4,5,6,7 8,9		REQUIRED	
D. OPTIMAL TRANSMITTING FREQUENCIES	1,2,3,4,8,9		REQUIRED	
E. INFORMATION TRANSMISSION RATE	1,2,3,4		REQUIRED	
II. SUPPORTING TELESCOPE TECHNOLOGY				
A. OPTICAL SUB-SYSTEMS				
1. MATERIALS	10,11,15	G	REQUIRED	
2. MIRROR FIGURE CONTROL	10,11,15	A,M	NOT REQD.	
3. CONTAMINATION		G	REQUIRED	
4. SURFACE DEGRADATION		G	NOT REQD.	
5. MIRROR COATING		G	REQUIRED	
6. THIN MIRROR EVALUATION	10,15	G	NOT REQD.	
B. TELESCOPE STRUCTURE & MECHANISMS				
1. PASSIVE THERMAL CONTROL	10,11,15	A,M,N	REQUIRED	
2. SMALL DISPLACEMENT ACTUATORS	10,12,14,15	A,J,M,N	REQUIRED	
3. ALIGNMENT SENSORS	10,11,15	A,J,M,N	REQUIRED	
4. FOCUS SENSORS	10,11,15	A,J,M,N	REQUIRED	
5. REMOTE ALIGNMENT PROCEDURES	10,11,15	A,J,M,N	REQUIRED	
C. CONTROL AND STABILIZATION				
1. POINTING AND TRACKING	5,6,7	B,E,H	REQUIRED	
2. POINT AHEAD	6		REQUIRED	
3. ACQUISITION	5,7	B,H	REQUIRED	
D. OPERATIONS				
1. ERECTION AND CHANGE-OVER PROCEDURES	10,11,14,15	A	REQUIRED	
2. LOGISTICS	10,11,14,15	C,E,G,N	REQUIRED	
3. OPERATING MODES	13	S	REQUIRED	
4. LAUNCH ENVIRONMENT	ALL		REQUIRED	
III. OPTICAL RECEPTION				
A. TYPE OF RECEIVER	1,2,3,4,5,6, 7,8,9	K,R	REQUIRED	
B. MEANS OF DETECTION	1,2,3,4,6,9	K,R	REQUIRED	
C. OPTIMAL RECEIVING FREQUENCY	1,2,3,4,8,9	K	REQUIRED	
D. SIGNAL PROCESSING	1,2,3,4,6,7 8,9		REQUIRED	

NOTES: 1. SEE SECTION 16.0 FOR EXPERIMENT DEVELOPMENT DETAILS.

2. THIS FIGURE IDENTIFIES BUT DOES NOT SCHEDULE OTHER NEEDED GROUND DEVELOPMENT NOT SPECIFICALLY IN SUPPORT OF SPACE EXPERIMENTS.



KEY

TES EXPERIMENT DEVELOPMENT AND FLIGHT
RE-OTES RESEARCH AND DEVELOPMENT
ROUND EXPERIMENTS AND DELAY TIME

MILESTONES

Figure 15.2-2. Long Range Optical Propagation Technology Development Milestones

3-8

REQUIREMENTS

A. ASTRONOMY-ORIENTED

1. A 3-METER DIFFRACTION-LIMITED TELESCOPE OPERATING IN SPACE.
2. TELESCOPE TO BE CAPABLE OF AUTOMATIC OPERATION BUT DESIGNED FOR MANNED INTERVENTION AT ANY STAGE.
3. THE BASIC TELESCOPE SHALL BE A NARROW FIELD INSTRUMENT TO PRESERVE THE ULTIMATE IN RESOLUTION, AND IT SHOULD BE CAPABLE OF DIFFRACTION-LIMITED PHOTOGRAPHY OF SINGLE CELESTIAL FIELDS FOR EXPOSURES OF AT LEAST 20 HOURS.
4. THE TELESCOPE SHALL BE CAPABLE OF OPERATING IN THE SPECTRAL REGION FROM 900 Å TO 20 MICRONS.
5. THE TELESCOPE SHOULD BE DIFFRACTION-LIMITED AT 1000 Å. IT IS REALIZED THAT THIS IS WELL BEYOND PRESENT CAPABILITIES BUT THE IMPORTANCE OF WORK IN THE UV MAKE IT NECESSARY THAT THIS ULTIMATE GOAL BE CONSIDERED IN THE DEVELOPMENT OF MEASURING TECHNIQUES AND TELESCOPE DESIGN.
6. TELESCOPE SYSTEM TO BE CAPABLE OF RESOLVING TO .03 ARC SECONDS.

B. OPTICAL PROPAGATION-ORIENTED

1. A 1-METER DIFFRACTION-LIMITED TELESCOPE OPERATING IN SPACE.
2. TELESCOPE TO BE CAPABLE OF AUTOMATIC OPERATION.
3. LASER, MODULATORS, AND RECEIVERS MUST BE SPACE QUALIFIED.
4. THE TELESCOPE SHALL BE CAPABLE OF OPERATION IN THE SPECTRAL REGION FROM .488 MICRONS TO 10.6 MICRONS.
5. THE TELESCOPE SHOULD BE DIFFRACTION-LIMITED AT .6328 MICRONS.
6. SYSTEM TO BE CAPABLE OF TRACKING AND POINTING TO 0.1 ARC SECONDS WITH POINT-AHEAD CAPABILITY.
7. ATMOSPHERIC EFFECT ON OPTICAL PROPAGATION MUST BE KNOWN.

↓

TECHNOLOGY ADVANCEMENT AREAS

A. PRIMARY MIRROR
B. SYSTEM OPTICS
C. POINTING & CONTROL
D. DETECTION
E. TELESCOPE SYSTEM
F. MAN/TELESCOPE INTERFACE
G. SPACECRAFT/TELESCOPE INTERFACE
H. COMMUNICATION POWER LOSS
I. COMMUNICATION PATH CHARACTERISTICS
J. LASER TRANSMITTER
K. LASER RECEIVER
L. GROUND COLLECTOR
M. SIGNAL PROCESSING

→

APPLICATIONS

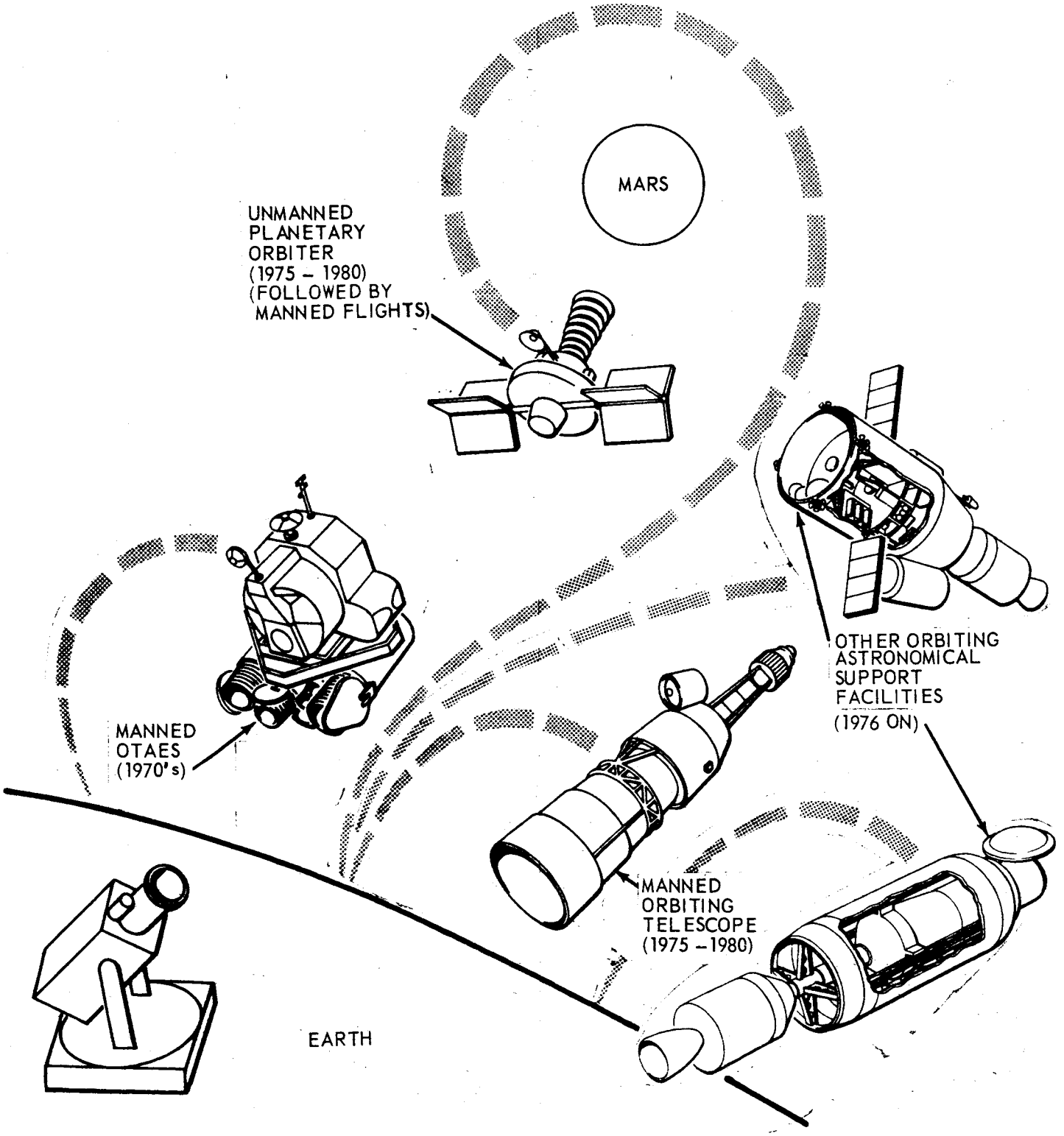


Figure 15.3-1. Major Technology Advancement Areas

TABLE 15.3-2

INDEX OF OTES EXPERIMENT NUMBERS

I. PROPOSED EXPERIMENTS

EXPERIMENT NUMBER	EXPERIMENT TITLE
1	Optical Heterodyne Detection on Earth
2	Optical Heterodyne Detection on the Spacecraft
3	Communication with 10 Megahertz Bandwidth
4	Direct Detection Space to Ground
5	Precision Tracking of a Ground Beacon
6	Point Ahead and Space-Ground-Space Loop Closure
7	Transfer Tracking from One Ground Station to Another
8	Atmospheric Measurements
9	Pulse Distortion Measurements
10	Primary Mirror Figure Test and Correction
11	Thin Mirror Nesting Verification
12	Fine Guidance
13	Comparison of Isolation Techniques
14	Interferometer System
15	Segmented Optics
POTENTIAL	Degradation of Optical Materials and Coatings
POTENTIAL	Interference Spectrometer

II. DISCARDED EXPERIMENTS

EXPERIMENT LETTER	EXPERIMENT TITLE
A	Erection and Alignment of Large Optics in Space
B	Earth Shine Effects on Acquisition and Tracking
C	Photo-Electro-Optical Experiment
D	Ground Resolution Measurements in Earth Orbit
E	Baffle Systems Comparison
F	Atmospheric Absorption Spectroscopy
G	Optical Telescope Mirror Coating in Space
H	Acquisition Comparison Experiment
J	Spectrograph Development
K	Cryogenic Cooling Experiment
L	Mirror Figure Correction by Means of Shutter Controlled Coupled Heat Radiation
M	Bi-Direction Mirror Correction Device
N	Remote Manual Optical Alignment
O	Visual Tracking Rating
P	Remote Sensing Ground Truth Validation
Q	Precision Measurement in the Infrared Spectrum
R	Iraser Preamplifier of IR Signals
S	Comparison of Image Motion Compensation Techniques
T	Electrostatically Controlled and Figured Optical Surfaces for Reflecting Telescopes

TABLE 15.3-2

OTES EXPERIMENT RELATIONSHIPS TO ASTRONOMY-ORIENTED TECHNOLOGY PROBLEMS

OTES PROPOSED EXPERIMENTS	TECHNOLOGY ADVANCEMENT AREAS
	I. TELESCOPES
	A. PRIMARY MIRROR
11,15,10,	1. Material
11,10,15,	2. Weight
15,11,10,8,9,4,3,2,1	3. Mirror figure control
	B. SYSTEM OPTICS
5,10,11,12,13,15	1. Automatic alignment and focus
10,11,15	2. Wavelength bandpass
- - -	3. Observation compatability (utilizing one scope for more than one experiment)
	C. POINTING AND CONTROL
13,12,8	1. Disturbance isolation
14,13,12,5,6,7,8,9,3,2,1	2. Fine error sensing
15,10,12,13	3. Actuators
	D. DETECTION
10,11,15	1. High-resolution photography
- - - -	2. High-resolution photo-electro-optical
- - - -	3. Radiation resistant films
- - - -	4. Dry development
14,13,12,9,6,5,4,3,2,1	5. UV, IR, VIS Sensors
12	6. Ion-beam technique for photo-cathode fab.
	E. TELESCOPE SYSTEM
8,9,4,3,2,1	1. Thermal Control
14,10,11,15,8	2. Mechanical Stability
- - - -	3. Baffle Design
	II. INTERFACES
	A. MAN/TELESCOPE INTERFACE
- - - -	1. Contamination
15,11,10,8,9,4,3,2,1	2. Refurbishment/Maintenance
13,12,8	3. Disturbances
10,11,15,8,9,4,3,2,1	4. Thermal Control
- - - -	5. Control/Display
	B. SPACECRAFT/TELESCOPE INTERFACE
1,2,3,4,10,11,15	1. Telescoping Structure (Volume Limit)
- - - -	2. Control Display
1,2,3,4,10,11,15	3. Mounting Provisions
12,13,8,9,3,2,1	4. Attitude Control Interface

TABLE 15.3-3

OTES EXPERIMENT RELATIONSHIPS TO OPTICAL PROPAGATION ORIENTED TECHNOLOGY PROBLEMS

OTES PROPOSED EXPERIMENTS	TECHNOLOGY ADVANCEMENT AREAS
	I. OPTICAL COMMUNICATION PROPAGATION
5,4,3,2,1	A. POWER LOSS (LINK) CALCULATIONS
	B. PATH CHARACTERISTICS
5,9,4,3,2,1	1. Fading
8,4,3,2,1	2. Error Rates
4,3,2,1	3. Alternate Technique Combinations
	a. Signal Sources
	b. Deceding
	c. Modulation forms
	II. COMMUNICATION COMPONENTS
	A. TRANSMITTER
5,6,7,8,9,4,3,2,1	1. Laser
	a. Single Frequency
	b. Space Qualified
5,6,7,8,9,4,3,2,1	2. Modulator
	a. Helium-Neon modulator
	b. Carbon dioxide modulator
	c. Power supplies 300 watt down to 30 watt
5,6,7,8,9,4,3,2,1	3. Optical Train
	a. Alignment
	b. Losses
5,6,7,8,9,4,3,2,1	4. Monitoring
	a. Boresight
	B. RECEIVER
5,6,7,8,9,4,3,2,1	1. Optical Train
5,7,8,9,4,3,2,1	2. Local Oscillator
	a. Low threshold argon
	b. Space qualification
9,7,6,5,4,3,2,1	3. Detectors
	a. Helium-neon, space qualified
	b. 10.6 micron wideband.
	C. OPTICAL COLLECTOR
9,3,2,1	1. One meter receiving telescope
3,2,1	2. 0.1 seconds of arc pointing requirements
6,4,3	3. Direct detection - eight meter dish
	D. SIGNAL PROCESSING
8,2,1	1. Phase correlation - Michelson like optics
9,2,1	2. Pulse distortion - Sampling oscilliscope techniques

16.0 OTES EXPERIMENT DEVELOPMENT

16.1 GENERAL DISCUSSION

Having established overall major objectives which the OTES experiments help attain and having analyzed the technological problem areas of specific technologies and their relationships to all of the OTES proposed and discarded experiments, the specific experiments within the OTES were analyzed in detail.

The recommended research and development activity path necessary as a prelude to the performance of the OTES space experiments is presented in the prerequisite technology digests. These digests identify the technology advances or milestones that comprise the threshold to OTES space experiment implementation, measurements and technical data acquisition. These are the activities that must be funded and accomplished before any further progress is made. Theoretical studies, lab experiments, methods development, ground testing and simulation, airborne and pre-OTAES spaceborne piggy-back testing are identified to present the most complete forecasted path of evolution as possible at this time.

The experiment development schedules support the technology digests and complete the experiment picture. The experiment development schedules contain a summary of the prerequisite technology advancements to determine which of these activities preceed and which can be performed concurrently with the experiment hardware evolution. A thorough analysis of each experiment from the research and development stage through preliminary design, development testing, final design, manufacturing to final assembly and checkout of the experiment hardware prior to flight integration is conducted. This analysis yields the identification of long lead items, spotlights restraining activities and their most efficient sequencing, and indicates the total time required to perform all tasks prior to experiment integration for flight. Each experiment is studied at the major assemblies or sub-systems level in order to present more specific and comprehensive results.

16.2 DIGESTS OF PREREQUISITE TECHNOLOGY ACTIVITIES

The prerequisite technology digests are listed in accordance with Table 15.3-1, "INDEX OF OTES EXPERIMENT NUMBERS". The time span to completion is the time required from the commencement of the initial study through the completion of the final prerequisite test. Each major activity time requirement was estimated based on the research of the principal investigator of the respective experiment.

Each experiment digest lists all the necessary research and development activity that is peculiar to that specific experiment. The technology advances required of support or interdependent systems are treated in prime experiment to avoid redundancy.

Any fact or explanation that is peculiar is included in the "Remarks" section of the digest. The digest format provides a concise, systematic treatment and is arranged by major area of development for quick reference.

16.2.1 Digest of Prerequisite Technology Activities

Experiment: Optical Heterodyne Detection of Earth (E-1)

Time Span to Completion: Thirty-six months

Research and Development:

a. Video modulators development for use at 10.6 microns wavelength. (24 months)

b. Infrared photo detectors development having high quantum efficiency at 10.6 microns and having a frequency response extending to at least 10 Megahertz (30 months). (Developments in tunable optical parametric oscillators may make it possible to overcome the Doppler shift encountered on interplanetary missions if a good video bandwidth detector is available at 10.6 microns.).
   (1) Analysis of semi-conductor materials or techniques capable of adequate frequency response.
   (2) Unit design and packaging studies for inclusion of IR detectors, dewars, high-frequency coupling structures and cooled optical filters.

c. Stable 10.6-micron laser development with emphasis on ruggedization. (24 months, now in process).
   (1) Study to devise rugged structures that are resistant to environmental factors.
   (2) Servo systems analysis for compensation of unavoidable changes.

d. Laser mode control and stabilization techniques development. (24 months now in process).

e. Space-qualified Helium-Neon and N_2-CO_2 Lasers development. (12 months)
   (1) Structural design analysis for gas lasers capable of remote alignment and tuning.
   (2) Studies to restrict heat radiation for the laser package.
   (3) Develop and test gas discharge tubes to withstand environmental factors and provide long-life, reliable performance.
   (4) Investigate both dc cold cathode and rf pumping systems.
   (5) Compact packaging and miniaturization studies.
   (6) Conduct shock and vibration tests on completed designs.

f. Ground-to-ground measurements program of atmospheric coherence diameters at 10.6 microns wavelength and pulse distortion measurement tests at .6328 microns where broad-band photodetectors are available. (12 months).

(1) Establish propagation test range(s) for one way tests (no mirrors or reflectors) with a capability of measuring a variety of test paths and a path length of at least two miles.
(2) Determine the dependence of effective receiver coherence diameter at 10.6 microns on weather conditions, site locations, etc.
(3) Determine the upper limit on bandwidth of signals that can be propogated at .6328 microns through pulse distortion measurements of the output of an AM-locked multimode laser.
(4) Conduct simultaneous tests utilizing 10.6 micron CW and .6328 micron fast pulse systems for more accurate comparative data.

g. Ground-to-ground tests of a complete optical communication system.

(1) Evaluate the communication system capabilities for various modulation and detection schemes under a variety of atmospheric conditions.
(2) Collect and analyze data on fading and fading rates for comparison with theory, for the design of an electronic system to simulate the effects of the atmosphere in the laboratory, and for comparison with data to be obtained on high angle slant paths.
(3) Evaluate performance and reliability of the 10.6 micron receiver system.

h. Laser stabilization development of ruggedized video bandwidth detectors for the visible spectrum video bandwidth modulators for the 10 micron band. (12 months).

i. Piggyback space-to-ground propagation experiment design and fabrication emphasizing pulse distortion measurements at .6328 microns and coherent aperture measurements at 10.6 microns wavelength. (30 months).

(1) Detail design of an operating laser system or systems that will make atmospheric diagnostic measurements. The systems will be configured to an AAP pallet package, allowing some preliminary testing of space hardware, of atmospheric properties, and of pointing and tracking system capabilities.
(2) Laser transmitter(s) accuracy requirements analysis for illumination of a ground receiving station.
(3) High-angle, space-to-ground path measurements of these signal properties that have been investigated on ground-to-ground paths.
(4) Fabrication of subsystems and components for a piggyback system.

j. Propagation tests at several laser wavelengths over high-angle atmospheric paths, using high-altitude balloons, platforms and satellites having usable corner reflectors at 10.6 microns wavelength.

(1) Perform upper-atmosphere to ground propagation measurements. Wavelengths of .6328 and 10.6 microns plus other new laser wavelengths will be used.

(2) Long path measurements of those parameters that have been measured in ground-to-ground tests. Measurement of atmospheric coherence diameters at 10.6 microns and of fast pulse distortion at .6328 microns will be compared under these conditions.

16.2.2 Digest of Prerequisite Technology Activities

Experiment: Optical Heterodyne Detection on the Spacecraft (E-2)

Time Span to Completion: Thirty-six months

Research & Development:

a. Low-power stable, single-frequency, laser local oscillators development, with emphasis on design of space qualification. (Developments in tunable optical parametric oscillators may make it possible to overcome the doppler shift encountered on interplanetary missions if a good video bandwidth detector is available.) (24 months).

b. Stable transmitter laser development with emphasis on ruggedization. (12 months).

c. Laser mode control and stabilization techniques development. (24 months, now in process.)

d. Rudimentary satellite piggyback transmission experiment development.

e. Ground-to-ground tests of a complete optical communication system, transmitting several wavelengths simultaneously. (9-12 months). See optical heterodyne detection on earth experiment.

f. Propagation tests at several laser wavelengths over high-angle atmospheric paths, using either high-altitude balloons or synchronous satellites. See optical heterodyne detection on earth experiment.

g. Space-simulation testing of lasers, modulators, and detectors. (6-9 months).

16.2.3 Digest of Prerequisite Technology Activities

Experiment: Communication with 10 Megahertz Bandwidth (E-3)

Time Span to Completion: Thirty-six months

Research & Development:

a. Wideband modulator development for 10.6 micron wavelength at 10 Megahertz bandwidth. (24 months)

   (1) Materials analysis
   (2) 10.6 micron wavelength development.

b. Wideband detector development for 10.6 micron wavelength at 10 Megahertz bandwidth. (36 months)

c. Laser (all-wavelengths) space-qualification thru simulation on the ground. (24 months)

d. 10.6 micron modulator space-qualification thru simulation on the ground. (12 months)

e. 10.6 micron detector space-qualification thru simulation on the ground. (18 months)

f. 10 Megahertz systems tests for ground link. (9 months)

g. 10 Megahertz systems tests, aircraft to ground link. (12 months)

Remarks: The present state-of-the-art for modulators and detectors at 0.488 microns, 0.6328 microns, and 1.06 microns is well beyond 10 Megahertz. It is possible that present modulators can be extended for operation at 3.39 microns; however, detectors for 3.39 microns and detectors and modulators for 10.6 microns wavelengths are not yet capable of 10 Megahertz frequency response. Additional advancements must be made in the area of cryogenic cooling for detectors.

16.2.4 Digest of Prerequisite Technology Activities

Experiment: Direct Detection Space to Ground (E-4)

Time Span to Completion: Twenty-four months

Research & Development:

a. Space Optical Modulation System

   (1) Electro-optic modulator and driver model studies and development. (24 months)
      (a) Development of two space-qualified service test models of a .6328 micron modulator and solid-state driver with

100 Megahertz video bandwidth developing 100 percent modulation with 10 watts signal power.

(b) Trade-off analyses of several electro-optic crystal materials including crystal optical damageability analysis and studies of optical surface quality characteristics and their retention.

(c) Studies of the transmittance characteristics of the optical components in the modulator as well as optimizing the anti-reflection coating techniques for internal heating minimization.

(d) Analysis of methods to minimize the modulator thermal birefringence.

(e) Review and summarization for various communication modulation formats (FM, FM-subcarrier, pulsed intensity modulation, pulsed polarization modulation, etc.) for impact on modulator design and crystal characteristics.

(f) Studies of launch survival and alignment retention in the space environment to minimize deflection and decollimation of the output beam.

(g) Measurement of the distortion of the emergent beam across its diameter.

(2) Prototype model development. (15 months)

(a) Design laboratory modulators and associated solid-state drive amplifiers to operate at 10.6 microns, and video bandwidth of 100 Megahertz.

(b) Trade-off analyses of electro-optic material characteristics (conductivity, thermally induced birefringence, transmittance, optical surface qualities and coatings and their retention) for applicability to planetary communication.

(3) Final model development. (15 months)

b. Ground-based Tracking Receiver

(1) Prototype development of 23 meter diameter model with a 0.5 milliradian maximum field of view. (24 months)

(a) Design, construction and installation of the optical collector, secondary, optics, narrow-band interference filters, optical demodulators, photodetectors, and associated electronics.

(b) Analysis of various means to acquire the remote laser transmitter, provide the tracking error input to the servo controlled mount, and provide an auxiliary pointing and tracking data input for radar or computer program control of the system.

(2) Horizontal path ground tests and air-to-ground tests to develop design parameters for full scale model.

(3) Final 8-10 meter diameter model development. (24 months)

(a) Design and construction of 8-10 meter direct detection

receiver based on prototype tests and experience.
(b) Installation of receiver at predetermined ground station site.

(4) Data recording, display, and reduction system analysis and development. (24 months)
(a) Requirements, analysis, design, and construction of display and recording facilities.
(b) Requirements analysis, design and construction of real time data processing equipment for signal fading information collection in experiment control.
(c) Data system integration with other experiment data and control systems.

Remarks: Extensive earth-based testing of the direct detection optical communication concept has already been accomplished over horizontal paths. Recent air-to-ground tracking experiments have been performed using a narrow laser beam pointed at a retroreflector mounted on an aircraft.

16.2.5 Digest of Prerequisite Technology Activities

Experiment: Precision Tracking of a Ground Beacon (E-5)

Time Span to Completion: Twenty-four months

Research & Development:

a. Systems Concept Studies - necessary prerequisite for establishing a 2-way tracking link. (24 months)

(1) Effect of atmosphere on coherence of laser beam. Spatial and temporal degradation analysis.
(2) Examination of other atmospheric effects. (Scintillation)
(a) Beam diversion
(b) Angular jitter (earth to space and space to earth).
(3) Human Factors studies (astronauts' mobility, isolation and function).
(4) Deep space simulation experiments.

b. 1 meter Telescope Analysis. (18 months)
(1) Boresight alignment (transmitter and tracking axes) studies.
(2) Optical test and interface with methods in space.
(3) Alignment of telescopes to one another.

c. 0.3 Meter Hardmounted Telescope Analysis (6 months)
(1) Boresight to 1 meter telescope.
(2) Study and definition of additional experiment tasks for incorporation.

d. 0.3 Meter Gimbal Telescope Analysis (9 months)
(1) Boresight to 1 meter telescope.
(2) Study and definition of additional experiment tasks for incorporation.

e. Acquisition Techniques Investigation.(15 months)
   (1) Probability comparison of various methods.
   (2) Combination of microwaves and sun line of sight for initial stabilization.
   (3) Hand-off of celestial targets in synchronous orbits for other applicable missions.
   (4) Planet tracker accuracy analysis
      (a) Tracking centroid of illumination
      (b) Geometrical center identification
      (c) Percentage accuracy as a function of range.

f. Laser Interface Studies (6 months)
   (1) Techniques for changing power distribution in beam group section, (for minimizing losses due to obscuration of bi-secondary mirrors etc.).
   (2) Achromatic collimating optics for optimizing wavelength range.

g. Beam Deflector Analysis (12 month)
   (1) Hybrid systems for minimizing non-linearity of deflectors by means of beam angling and translation.
   (2) Servo analysis required for stability and frequency response for hybrid systems.
   (3) Reflective, refractive and other studies.

h. Ground Array Interface Studies. (4 months)

16.2.6 Digest of Prerequisite Technology Activities

Experiment: Point-ahead and Space-to-Ground-to-Space Loop Closure (E-6)

Time Span to Completion: Twenty-four months

a. Experiment concepts and ground array systems studies. (24 months)

   (1) Number of telescopes, distribution of telescope array and loop closure and pointing correction studies.
   (2) Heterodyne vs. direct detection by photon bucket method comparison.
   (3) Beam pointing by direct detection (by four telescopes, or one telescope with super-inposed beam oscillation).
   (4) Calibration and individual telescope gain in distributed array studies.

      (a) Local oscillator control investigation.

      (b) Photo-multipliers tracker gain analysis.

Remarks: The other required technology advances required are those associated with the Precision Tracking of a Ground Beacon experiment and listed therein.

16.2.7 Digest of Prerequisite Technology Activities

Experiment: Transfer Tracking from one Ground Station to Another (E-7)

Time Span to Completion: Twenty-four months.

Research & Development:

a. Continuing system concept studies. (24 months)

   (1) Individual ground station coding.
   (2) Sequencing and synchronizing direct function between separate ground stations and spacecraft to ground station.
   (3) Number and location of ground tracking sites.

b. Ground station requirements analysis. (12 months)

c. Deep space simulation studies. (6 months)

Remarks: The other required technology advances are those associated with the Precision Tracking of a Ground Beacon experiment, and listed therein.

16.2.8 Digest of Prerequisite Technology Activities

Experiment: Atmospheric Measurement (E-8)

Time Span to Completion: Twelve months.

Research & Development:

a. Phase correlation receiver development. (12 months)

b. Model phase correlation receiver fabrication. (4 months)

c. Phase correlation test program using an airborne signal source (6 months)

d. Phase correlation tests using an earth orbiting signal source. (6 months)

Remarks: Except for the extension of phase perturbation measurements to other frequency bands no other great advances are required for this experiment except those specified in the associated experiments concerning beam pointing, diffraction limited telescope operations in space, and laser communications. Advances in the sensitivity of detectors, and the transmissivity of optical components at this frequency will increase the possibility of obtaining more accurate measurements under poor conditions of atmospheric transmissivity.

16.2.9 Digest of Prerequisite Technology Activities

Experiment: Pulse Distortion Measurements (E-9)

Time Span to Completion: Fourteen months

Research & Development:

a. Laser mode control and stabilization techniques development. (10 months, now in process)

b. Ground-to-ground measurements of pulse distortion at 0.6328 microns to test broadband detectors and display techniques. (6 months)

Remarks:

The other required technology advances required are those associated with laser transmitter development as indicated in the Optical Heterodyne Detection on Earth experiment and the ground link receivers development as indicated in both the Optical Heterodyne Detection on Earth and the Direct Detection from Space to Ground experiments.

16.2.10 Digest of Prerequisite Technology Activities

Experiment: Primary Mirror Figure Test and Correction (E-10)

Time Span to Completion: Twenty-four months.

Research & Development:

a. Continuing system experiment concept studies (including optical tolerance evaluation and allocation). (24 months)

b. Primary mirror model examination. (18 months)

   (1) Thermal Studies to determine need for mirror temperature control including ground tests for optimum thermal sensing and control configuration.
   (2) Scaling studies (analysis, fabrication and test of small model mirrors.
   (3) Material surveys.
   (4) Figure control implementation study.
   (5) Fabrication methods survey.
   (6) Study of mirror support methods.
   (7) Effects of launch and orbital environment of figure and optical quality.

c. Temperature actuators and control studies. (12 months)

   (1) Computer program for determination of influence co-efficients.
   (2) Actuators temperature sensor analysis.
   (3) Actuators material selection.
   (4) Thermal insulation problems investigation.
   (5) Thermal control servo loop analysis.

d. Implementation study of scatter-plate interferometer test in orbit. Study and development of other optical instrumentation for figure test in-orbit. (6 months)

e. Secondary mirror studies. (9 months)

   (1) Thermal Study.
   (2) Material Survey.
   (3) Study of in-orbit automatic erection and optical alignment devices.

f. Test facility requirements studies. (12 months)

16.2.11 Digest of Prerequisite Technology Activities

Experiment: Thin Mirror Nesting Verification (E-11)

Time Span to Completion: Twenty-four months.

Research & Development:

a. Continuing experiment concept studies (includes optical tolerance evaluation and allocation). (24 months)

b. Primary mirror and test studies. (18 months)

   (1) Thermal studies to determine need for temperature control including ground tests for optimum thermal sensing and control configuration.
   (2) Scaling studies (analysis, fabrication and test of small model mirrors).
   (3) Material surveys.
   (4) Fabrication methods investigation.

      (a) Mirror nest - mirror interface; selection of release agents and evaluation of release technique.

      (b) Distortion effect of polishing and figuring.

      (c) Determination of diameter to thickness ratio to meet requirements.

   (5) Zero-g simulation testing techniques and facility requirements.
   (6) Study of mirror support methods.

c. Penumatic suspension systems and alternate protection systems analysis, launch environment effects and model tests. (12 months)

d. Implementation study of scatter-plate interferometer and other optical instrumentation for figure test in-orbit. (6 months)

e. Secondary mirror and secondary mirror structure studies. (9 months)

   (1) Thermal study.
   (2) Material study.

f. Study of in orbit erection and/or alignment devices. (12 months)

   (1) Manual erection and human factors constraints.
   (2) Automatic erection investigation.
   (3) Optical alignment examination.

g. Test facility studies including optical bench and thermal control computer. (12 months)

16.2.12 Digest of Prerequisite Technology Activities

Experiment: Fine Guidance (E-12)

Time Span to Completion: Eighteen months

Research & Development:

a. Systems concept studies to establish sensing.(18 months)

   (1) Direct vs. offset tracking as a function of star magnitude studies.
   (2) Tracking capability relationship to background noise and star magnitude and color temperature investigation.
   (3) System effects of various orbits.
   (4) Analysis and allocations of errors.

b. Study of thermal behavior. (6 months)

c. Fine guidance telescope studies. (15 months)

   (1) Study of tertiary system configuration and alignment techniques.
   (2) Study of scanning methods.
   (3) Analysis of maximum resolution.

d. Fine sensor studies (Resolution stability). (12 months)

   (1) Four side Pyramidal deflector.
   (2) Image Dissector Tube.
   (3) Crossed-axis vibrating aperture.
   (4) Math-matching (large field scanner, using image orthicon or vidicon).

e. Study of actuation system, control moment gyros, reaction wheels and fine beam deflector (coarse, intermediate and fine) actuation and logic control system. (12 months)

f. Light detector analysis - diasporameters, cantilever mirror, sheared plate (sensitivity, spectral diamagnetic response). (12 months)

   (1) Solid state (silicon, gallium arsenide).
   (2) Photocathode with electron multipliers. Photo detectors with integral solid state multipliers.
   (3) Light Amplifiers.
   (4) Imaging devices.

g. Study of fine and coarse intermediate servo loops. (9 months)

h. Study of protect sensors and actuators. (9 months)

i. Earth-bound development tests. (12 months)

j. Test facility study. (12 months)

16.2.13 Digest of Prerequisite Technology Activities

Experiment: Comparison of Isolation Techniques (E-13)

Time Span to Completion: Twelve months.

Research & Development:

a. Hard mount oriented analysis.

(1) Theoretical analysis. (6 months)
(2) Laboratory tests. (6 months)

b. Spring mount oriented analysis.

(1) Dynamic environment analysis. (5 months)
(2) Static environment analysis. (4 months)
(3) Conductive spring materials analysis. (6 months)
(4) Motion detection optics analysis. (6 months)
(5) Damping mechanisms studies. (4 months)
(6) Analog simulation. (3 months)

c. Diamagnetic bearing oriented analysis.

(1) Magnetic field configuration optimization. (6 months)
(2) Electro-magnet utilization analysis. (6 months)
(3) Comparison of knuckle and gimbal configurations. (4 months)
(4) Diamagnetic materials survey. (6 months)
(5) Damper tecnniques comparison. (4 months)
(6) Position sensor analysis. (4 months)
(7) Analog simulation. (3 months)

d. Active system oriented analysis

(1) Electromagnetic linear actuator analysis. (4 months)
(2) Actuator configuration studies. (6 months)
(3) Comparison of low-threshold accelerometers. (3 months)
(4) Position sensor analysis. (4 months)
(5) Servo analysis. (2 months)
(6) Hybrid diamagnetic/active suspension configuration analysis. (3 months)
(7) Analog simulation. (4 months)

Remarks: The other required technology advances are those associated with the Fine Guidance experiment and listed therein.

16.2.14 Digest of Prerequisite Technology Activities

Experiment: Interferometer System (E-14)

Time Span to Completion: Nine months.

Research & Development:

a. Theoretical analysis of beam concepts. (6 months)

(1) Materials survey.
(2) Conceptual design and analysis.
(3) Computer analysis of performance.
(4) Compilation of weight/performance data.
(5) Environmental disturbances investigation.

b. Mirror fine alignment actuator analysis.(6 months)

(1) Survey and evaluation of techniques.
(2) Materials survey.
(3) Computer determination of performance coefficients.
(4) Insulation and power requirements investigation.

c. Laboratory experiments.

(1) Beam concept design.

(a) Model design.

(b) Model construction.

(c) Environmental tests and comparison.

(2) Mirror fine alignment actuators.

(a) Model design.

(b) Model construction.

(c) Environmental tests and comparison.

16.2.15 Digest of Prerequisite Technology Activities

Experiment: Segmented Optics (E-15)

Time Span to Completion: Twelve months.

Research & Development:

a. Theoretical study of the effect of segmentation on diffraction patterns. (6 months)

b. Experimental (lab) studies of the effect of sgementation on diffraction patterns. (6 months)

c. Number, size, and shape of segment studies. (6 months)

d. Segment position control actuator studies. (12 months)

e. Position sensor comparisons. (6 months)

16.3 EXPERIMENT DEVELOPMENT SCHEDULES

The experiment development schedules are listed in accordance with table 16.3-1, "INDEX OF EXPERIMENT DEVELOPMENT SCHEDULES". The flight available month is indicated as well as the number and title of the experiment. The flight available month represents the total amount of time required from the commencement of preliminary design of the first experiment peculiar major assembly/sub-systems to the completion of final assembly and checkout of the experiment. At this point the experiment hardware is available for integration into any chosen vehicle.

Long lead items are identified by noting the longest time duration for a major assembly/subsystem. Restraining activities and their most efficient sequencing are flagged. These restraints are the cause of the delay time indicated on some of the experiments.

Each experiment development schedule lists the major assemblies/subsystems that are experiment peculiar. All of the telescope associated experiments list the respective telescope(s) even though the specific experiment may not be the prime user of the telescope(s). Other support or interdependent subsystem are treated in the prime experiment to avoid redundancy where possible. Where it is possible to do so, references indicating specific support required appear in lieu of a relisting of the major assemblies/subsystems.

The experiment development schedules are included in figures 16.3-1 to 16.3-15 inclusive.

17.0 OTAES MASTER PLANNING SCHEDULE

17.1 GENERAL DISCUSSION

The Master Planning Schedule is a continuation of the analytical activity performed in the OTES Experiment Development Section. Each specific OTES experiment has been analyzed on an individual experiment basis. In this section these experiments are analyzed collectively. Although it has been indicated that the specific experiments can be made available for integration into almost any type of vehicle, many advantages can be gained by extending the experiment analysis within a fully operational spacecraft program. Throughout the master planning analysis the philosophy maintained has been that the individual experiments rather than spacecraft have dic-

INDEX
EXPERIMENT DEVELOPMENT SCHEDULES

FLT. AVAIL. MONTH	EXPERIMENT NUMBER	EXPERIMENT TITLE
46	1	Optical Heterodyne Detection on Earth
46	2	Optical Heterodyne Detection on the Spacecraft
46	3	Communication with 10 Megahertz Bandwidth
46	4	Direct Detection Space to Ground
43	5	Precision Tracking of a Ground Beacon
43	6	Point Ahead and Space-Ground-Space Loop Closure
43	7	Transfer Tracking from one Ground Station to Another
47	8	Atmospheric Measurements
46	9	Pulse Distortion Measurements
	DISCARD	
	A	Erection and Alignment of Large Optics in Space
	B	Earth Shine Effects on Acquisition and Tracking
	C	Photo-Electro-Optical Experiment
	D	Ground Resolution Measurements in Earth Orbit
	E	Baffle Systems Comparison
	F	Atmospheric Absorption Spectroscopy
	G	Optical Telescope Mirror Coating in Space
	H	Acquisition Comparison Experiment
	J	Spectrograph Development
	K	Cryogenic Cooling Experiment

FLT. AVAIL. MONTH	EXPERIMENT NUMBER	EXPERIMENT TITLE
43	10	Primary Mirror Figure Test and Correction
43	11	Thin Mirror Nesting Verification
41	12	Fine Guidance
42	13	Comparison of Isolation Techniques
33	14	Interferometer System
37	15	Segmented Optics
25	POTENTIAL	Degradation of Optical Materials and Coatings
	POTENTIAL	Interference Spectrometer
	DISCARD	
	L	Mirror Figure Correction by Means of Shutter Controlled Coupled Heat Radiation
	M	Bi-Direction Mirror Correction Device
	N	Remote Manual Optical Alignment
	O	Visual Tracking Rating
	P	Remote Sensing Ground Truth Validation
	Q	Precision Measurement in the Infrared Spectrum
	R	Iraser Preamplifier of IR Signals
	S	Comparison of Image Motion Compensation Techniques
	T	Electrostatically Controlled and Figured Optical Surfaces for Reflecting Telescopes

TABLE 16.3-1

tated the integration times. This ensures that the specific experiment technological advances are not subordinated to other integration factors. Having determined the availability dates for flight integration, experiment group-spacecraft-launch vehicle integration time frames can be identified. A detailed insight of possible constraints affecting flight hardware availability can be determined. Further study enables overall visibility of the time sequenced requirements of a total operational OTAES program. Finally, this complete analysis assists in the formulation of the preliminary philosophy and long range planning for possible development and operational phases although we are still engaged in a conceptual study phase.

In order to simulate a "real world" condition, certain assumptions must be made. These assumptions are manifested in an arbitrary preliminary set of ground rules. The ground rules are subject to changes in philosophy and merely serve as a hueristic point of departure for the continuation of the complete analysis. The number of ground rules has been kept to the minimum for clarity.

The preliminary ground rules are: (a) Prototype tests are required at the OTAES level (spacecraft integration level) for each experiment group; (b) Backup articles through the pre-launch phase are required; (c) Backup and prototype articles will be stripped and reconfigured as required for subsequent experiment groups; (d) Schedules for the basic manned spacecraft given in Volume V, Appendix "D", "Resource Analysis" (Phase I Final Report) are used as a base. The manned spacecraft concept was chosen for the integration analysis because it dictates the most complex alternative; (e) A boilerplate launch preceeds the first operational launch; (f) Launches are consistent with currently planned uprated Saturn I and Saturn V mission assignments.

17.2 EXPERIMENT AVAILABILITY SUMMARY

The experiment availability summary lists all of the proposed OTES experiments in a summary form to enable collective analysis. (See figures 17.2-1 and 17.2-2.) The data was assembled from the individual experiment development schedules. We can note from the summary that most of the experiments fit within the same time frame. If the experiment not directly associated with the telescopes (E-14 Interferometer System) is not considered, then the remaining experiments have a mere nine month differential in availability for flight implementation. Further analysis of the specific experiment development schedules will indicate that the cause of this condition is primarily due to the telescope(s) identification and the critical development and long lead item in each case. This points out again that having advanced telescope technology within the pre-OTAES and OTAES programs, the three meter telescope goal will then be an attainable goal within a very short time.

17.3 EXPERIMENT CANDIDATE GROUPS

The experiment candidate groups have been determined primarily by technical commonality and parametric trade-off analyses contained in other volumes of this report. The resultant candidate groups are: (a) Group "A", Experiments E-1 thru E-15 inclusive; (b) Group "B", Experiments E-1 thru E-9 inclusive; and (c) Group "C", Experiments E-10 thru E-13 inclusive plus

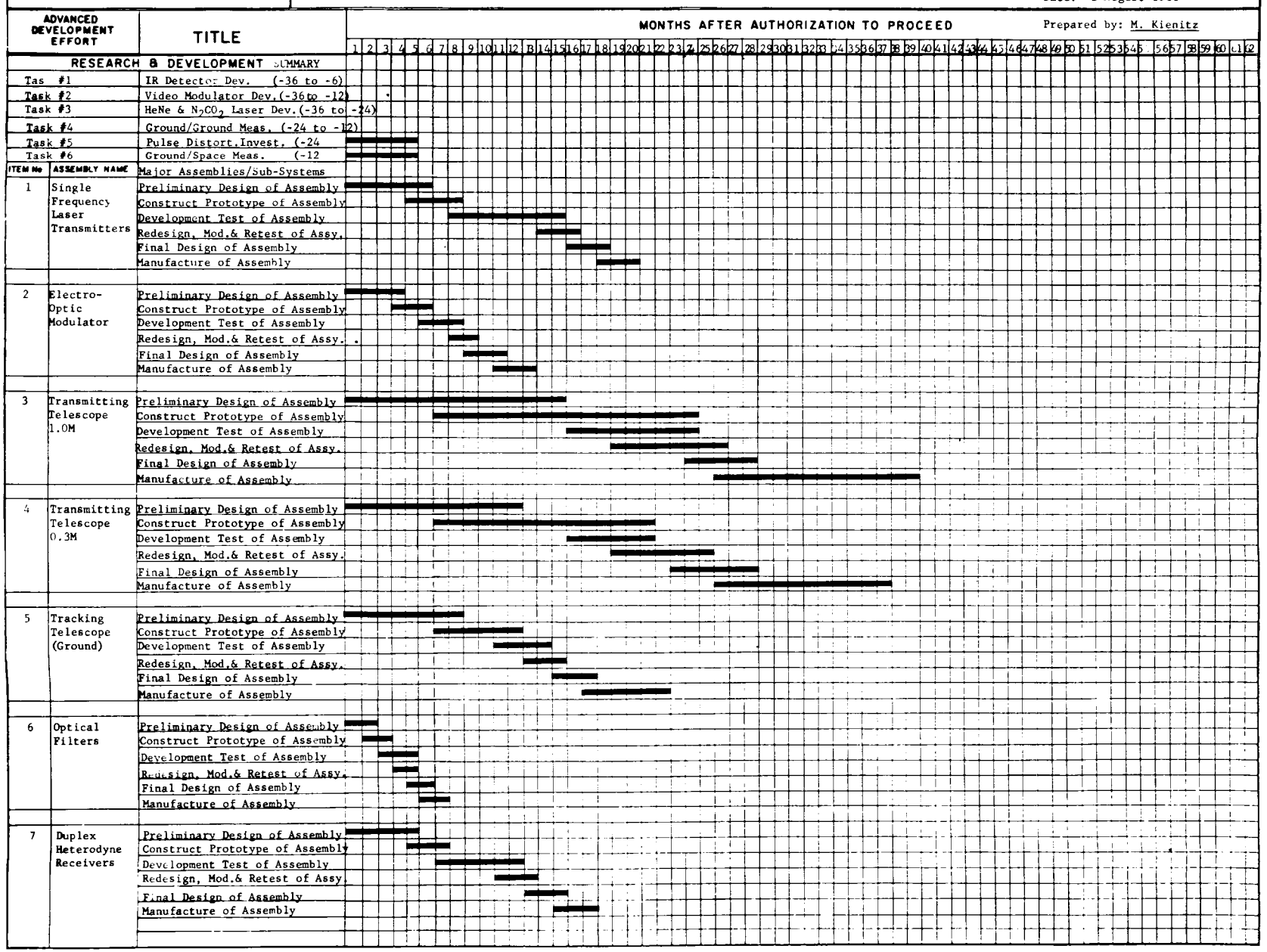
PROJECT: OTAES PH I EXTENSION

LEGEND: OPTICAL HETERODYNE DETECTION ON EARTH
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-1

Detail Schedule E-1
Sheet 1 of 2 Sheets
Date: 2 August 1980

Prepared by: M. Kienitz



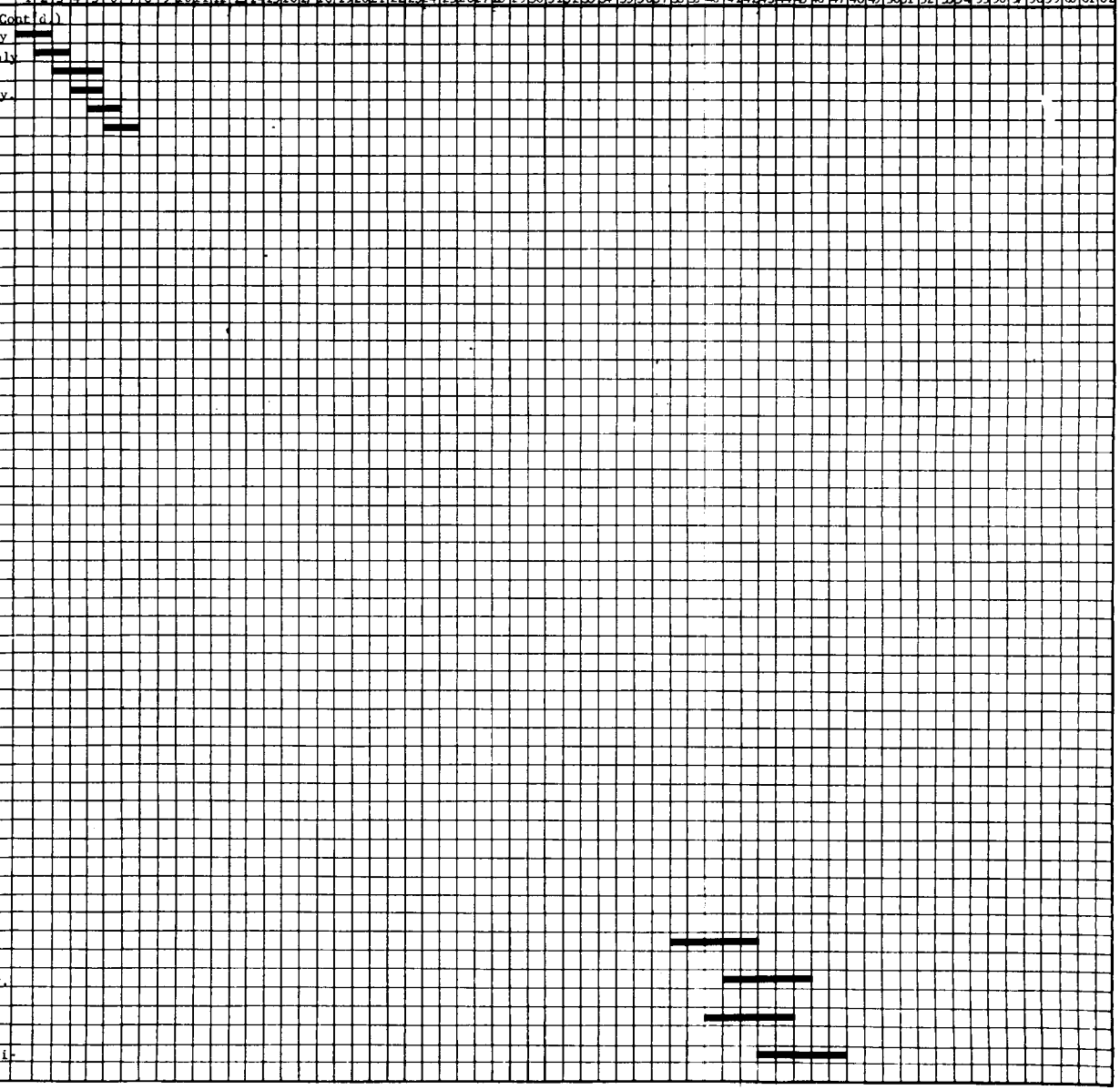
PROJECT: OTAES PH I EXTENSION

LEGEND: OPTICAL HETERODYNE DETECTION ON EARTH
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-1

Detail Schedule E-1
Sheet 2 of 2 Sheets
Date: 2 August 1966
Prepared by: M. Kienitz

ITEM No.	ASSEMBLY NAME	TITLE
8	Dichroic Mirrors	Major Assemblies/Sub-Systems (Cont'd)
		Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Exper. Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Experiment Backup Article

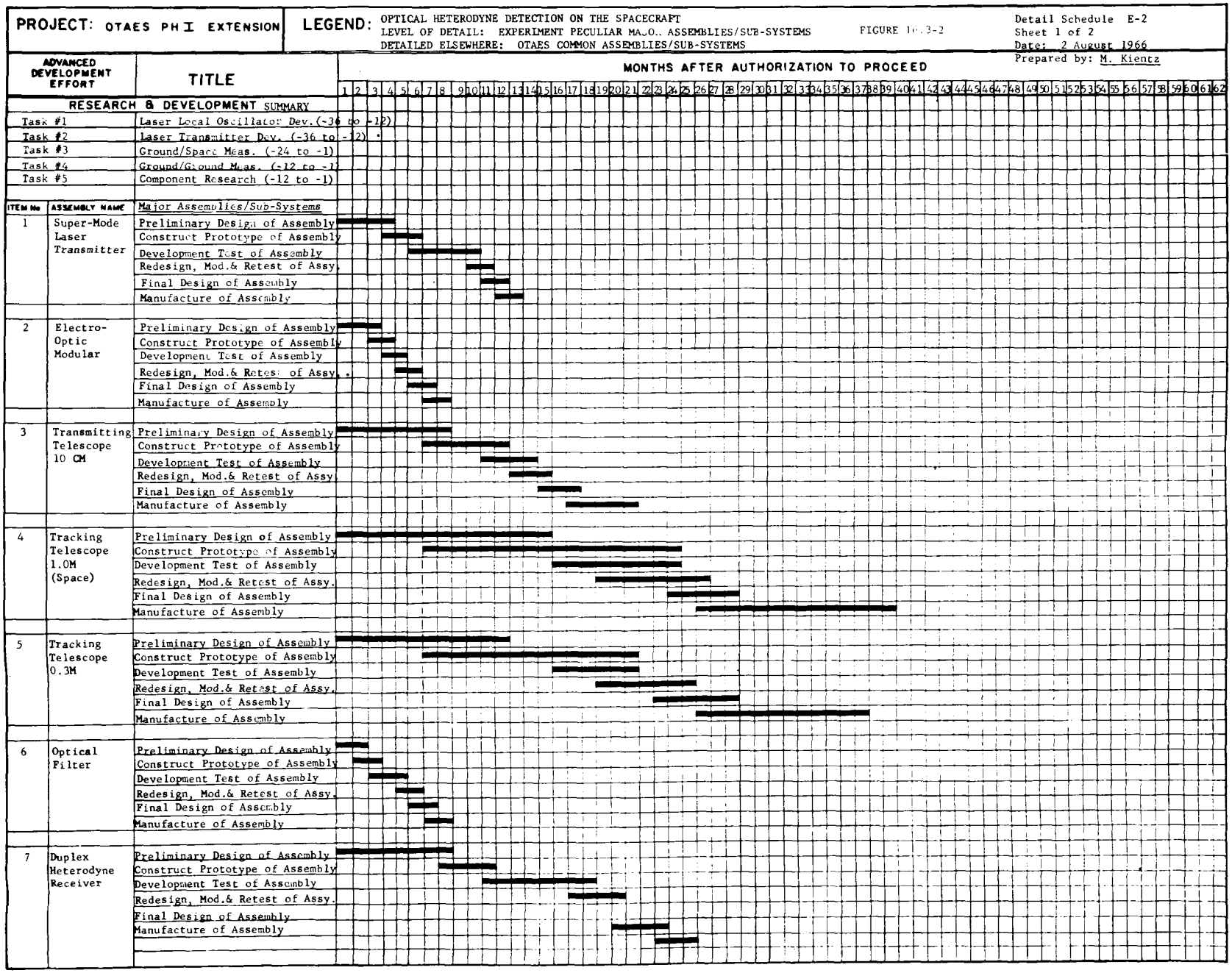


PROJECT: OTAES PH I EXTENSION

LEGEND: OPTICAL HETERODYNE DETECTION ON THE SPACECRAFT
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 10.3-2

Detail Schedule E-2
Sheet 1 of 2
Date: 2 August 1966
Prepared by: M. Kientz



PROJECT: OTAES PH I EXTENSION

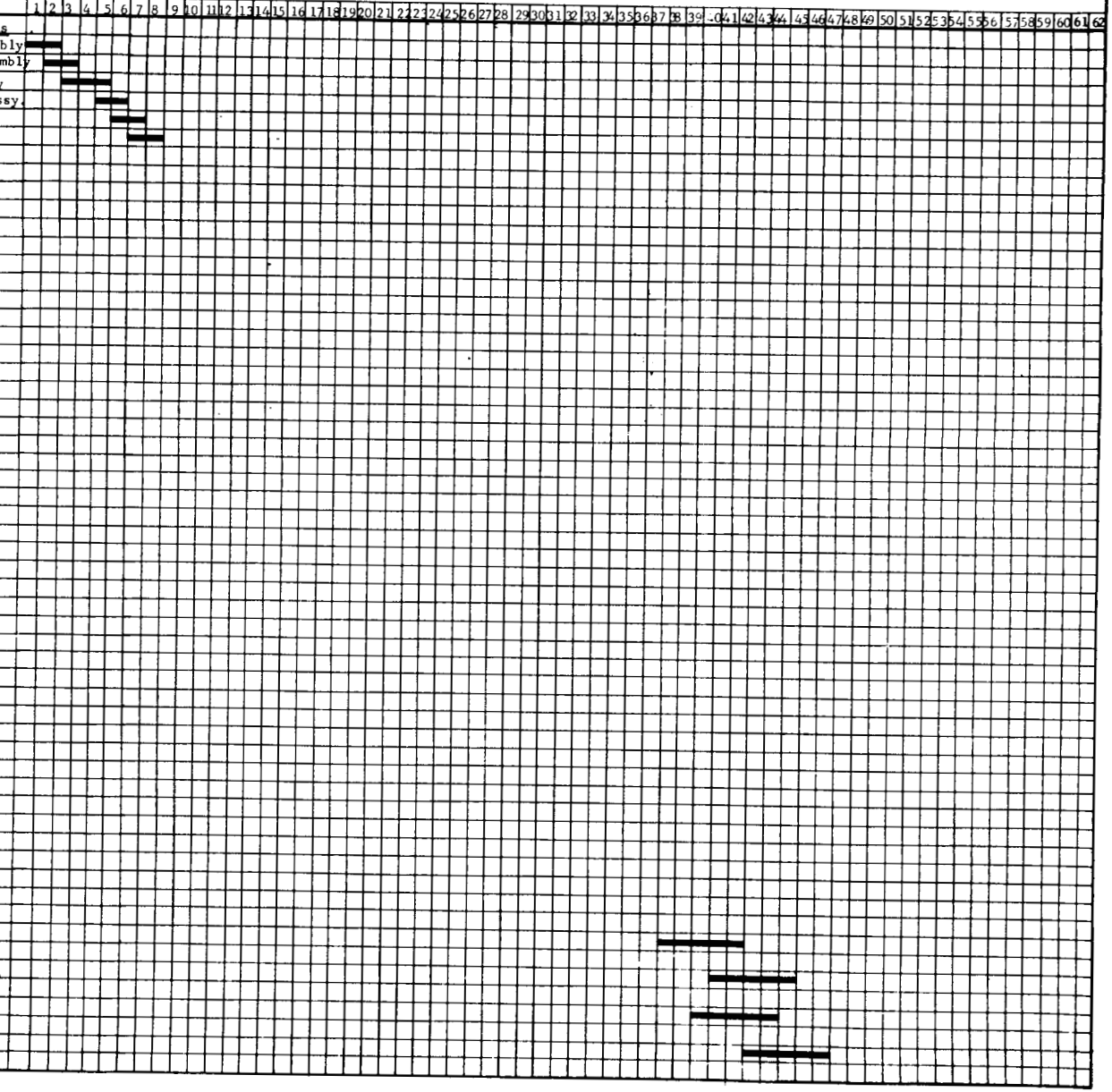
LEGEND: OPTICAL HETERODYNE DETECTION ON THE SPACECRAFT
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-2

Detail Schedule E-2
Sheet 2 of 2
Date: 2 August 1966
Prepared by: M. Kientz

ITEM No.	ASSEMBLY NAME	TITLE
8	Dichroic Mirror	Major Assemblies/Sub-Systems
		Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Exper. Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Exp. Backup Article

MONTHS AFTER AUTHORIZATION TO PROCEED

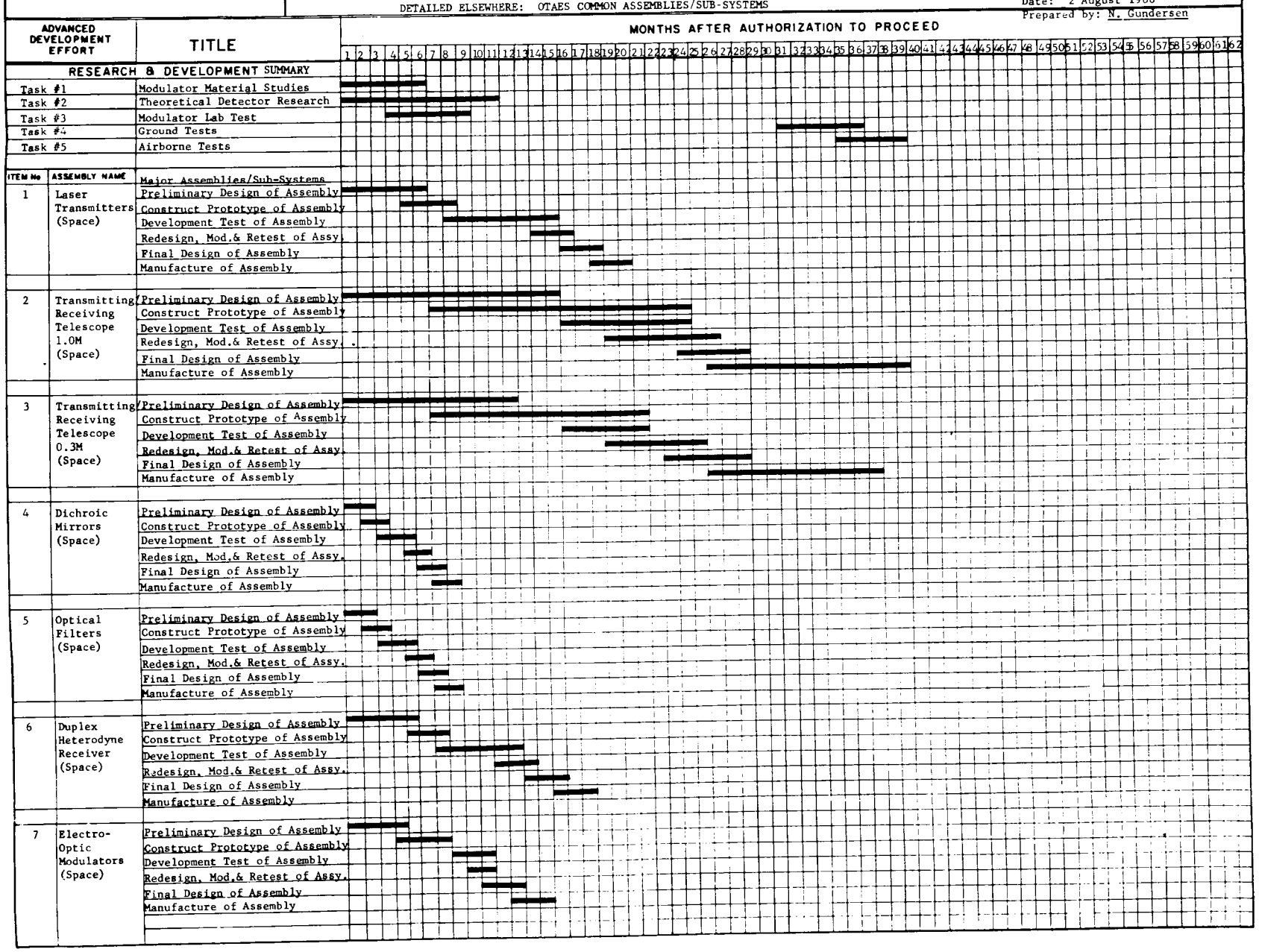


PROJECT: OTAES PH I EXTENSION

LEGEND: COMMUNICATION WITH 10 MEGAHERTZ BANDWIDTH
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-3

Detail Schedule E-3
Sheet 1 of 3
Date: 2 August 1966
Prepared by: N. Gundersen



PROJECT: OTAES PH I EXTENSION

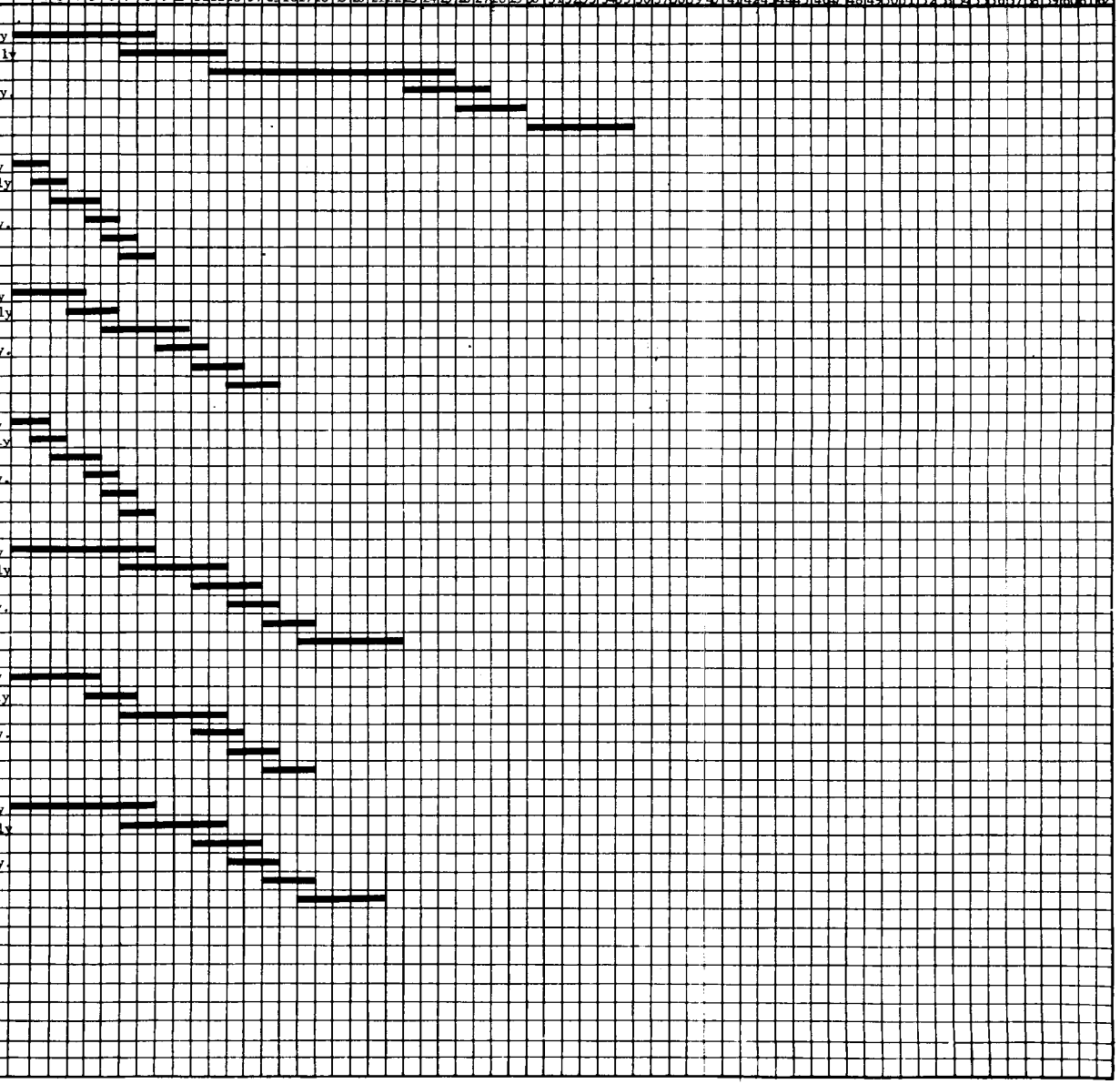
LEGEND: COMMUNICATION WITH 10 MEGAHERTZ BANDWIDTH
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-3

Detail Schedule E-3
Sheet 2 of 3
Date: 2 August 1966

Prepared by: N. Gunderson

ITEM No.	ASSEMBLY NAME	TITLE
8	Optical Collector 10.0M (Ground)	Major Assemblies/Sub-Systems
		Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
9	Optical Filters (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
10	Direct Detection Receiver (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
11	Dichroic Mirrors (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
12	Tracking Telescope (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
13	Duplex Heterodyne Receiver (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
14	Transmitting Telescope	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		(See Sheet 3 of 3)
TASK "B"		
TASK "C"		
TASK "D"		



PROJECT: OTAES PH I EXTENSION

LEGEND: COMMUNICATION WITH 10 MEGAHERTZ BANDWIDTH
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-3

Detail Schedule E-3
Sheet 3 of 3
Date: 2 August 1966
Prepared by: N. Gundersen

MONTHS AFTER AUTHORIZATION TO PROCEED

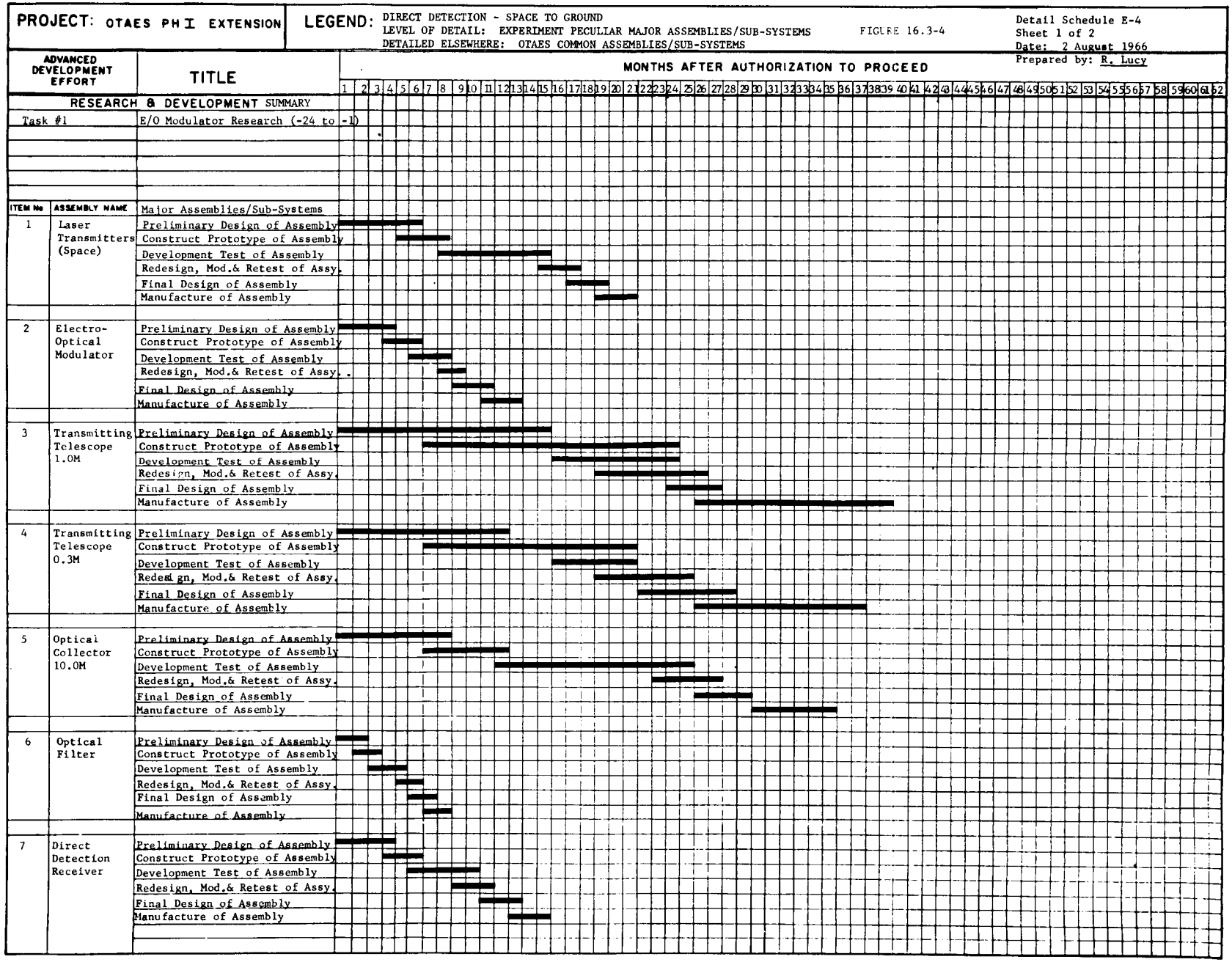
ITEM No.	ASSEMBLY NAME	TITLE
		Major Assemblies/Sub-Systems
15	Supermode Laser Transmitter (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
16	Electro-Optic Modulator (Ground)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Exp. Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article

PROJECT: OTAES PH I EXTENSION

LEGEND: DIRECT DETECTION - SPACE TO GROUND
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-4

Detail Schedule E-4
Sheet 1 of 2
Date: 2 August 1966
Prepared by: R. Lucy



PROJECT: OTAES PH I EXTENSION

LEGEND: DIRECT DETECTION - SPACE TO GROUND (CONTINUED)
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-4

Detail Schedule E-4
Sheet 2 of 2
Date: 2 August 1966
Prepared by: R. Lucy

MONTHS AFTER AUTHORIZATION TO PROCEED

ITEM No.	ASSEMBLY NAME	TITLE
8	Dichroic Mirror	Major Assemblies/Sub-Systems
		Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Exp. Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Exp. Backup Flight Article

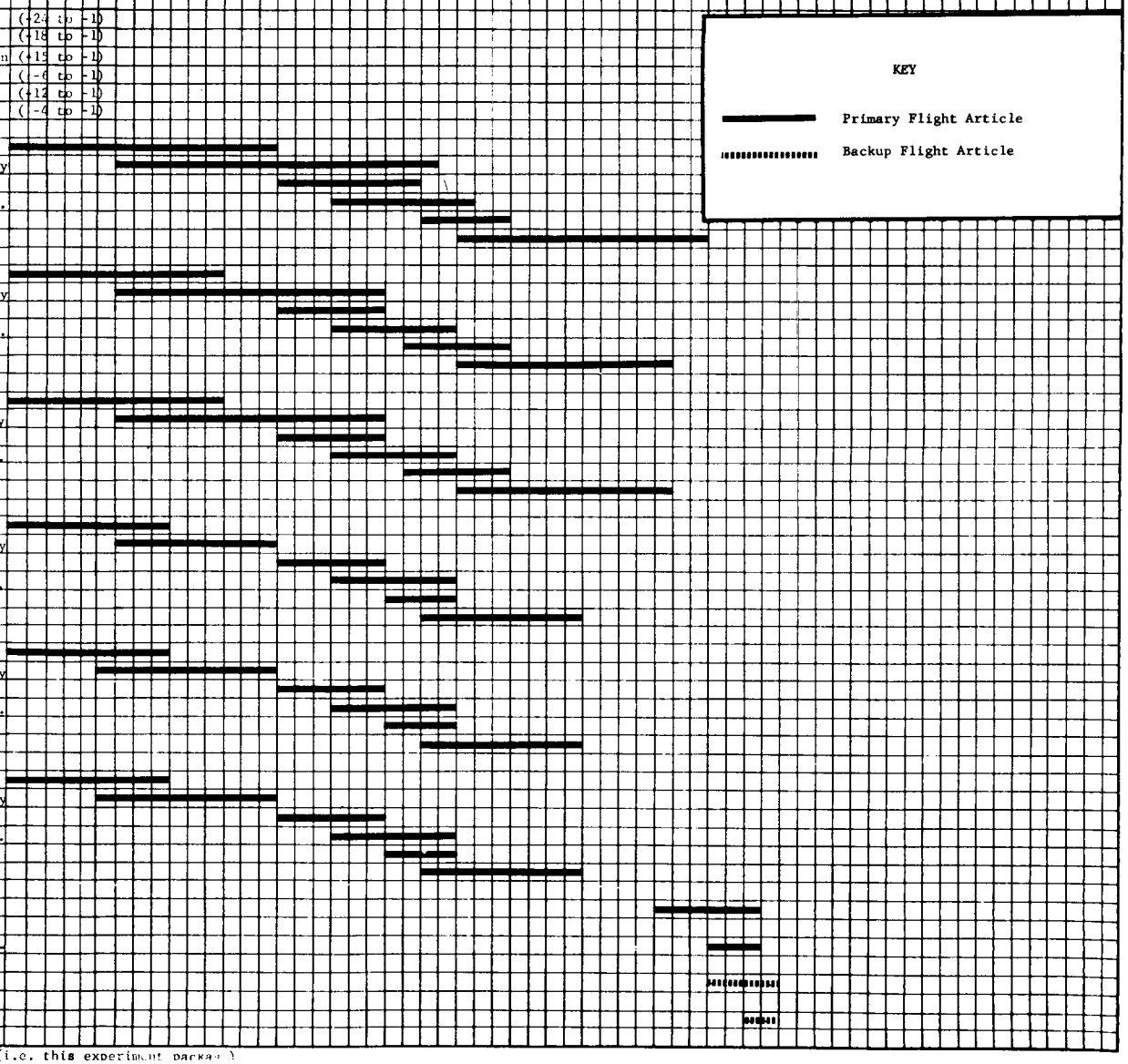
PROJECT: OTAES PH I EXTENSION

LEGEND: PRECISION TRACKING OF A GROUND BEACON
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-5

Detail Schedule E-5
Sheet 1 of 1 Sheet
Date: 3 August 1966
Prepared by: LF/MC

ADVANCED DEVELOPMENT EFFORT		TITLE
RESEARCH & DEVELOPMENT SUMMARY		
Task 1		System Concept Studies (+24 to -1)
Task 2		Telescope Oriented Analysis (+18 to -1)
Task 3		Acquisition Tech. Investigation (+15 to -1)
Task 4		Laser Interface Studies (-6 to -1)
Task 5		Beam Deflector Analysis (+12 to -1)
Task 6		Ground Array Interface Studies (-4 to -1)
ITEM No	ASSEMBLY NAME	Major Assemblies/Sub-Systems
1	1 Meter Telescope	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
2	0.3 Meter Hard Mounted Telescope	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
3	0.3 Meter Gimballed Telescope	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
4	Trackers (Star, Planet & Laser)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
5	Deflectors & Assoc. Optics	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
6	Electro-Mech. & Associated Hardware	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND - C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article



*This includes test of the integrated assemblies (i.e. this experiment package)

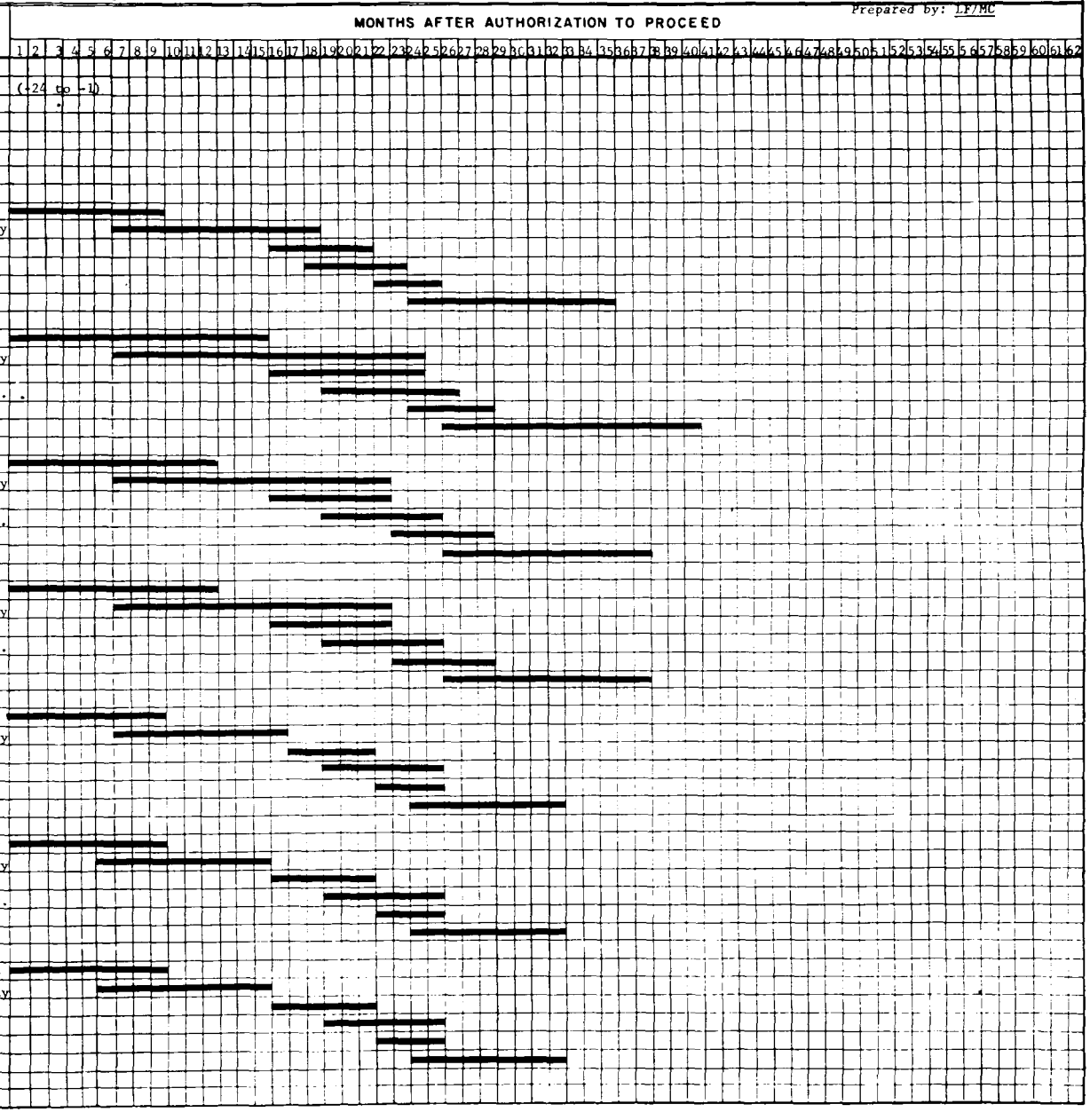
PROJECT: OTAES PH I EXTENSION

LEGEND: POINT AHEAD & SPACE-GROUND-SPACE LOOP CLOSURE
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEM
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-6

Detail Schedule E-6
Sheet 1 of 2 Sheets
Date: August 1966
Prepared by: LF/MC

ADVANCED DEVELOPMENT EFFORT		TITLE
RESEARCH & DEVELOPMENT SUMMARY		
Task #1		Experiment Concepts and Ground Array Systems Studies
ITEM No	ASSEMBLY NAME	Major Assemblies/Sub-Systems
1	Ground Array (16 f/5" Telescopes)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.&Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
2	Telescope 1.0M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
3	Hard-Mounted Telescope 0.3M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
4	Isolated Telescope 0.3M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
5	Trackers (Star, Planet, and Laser)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.&Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
6	Deflectors and Associated Optics	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
7	Electro-Mechanical & Associated Hardware	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign,Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly



PROJECT: OTAES PH I EXTENSION

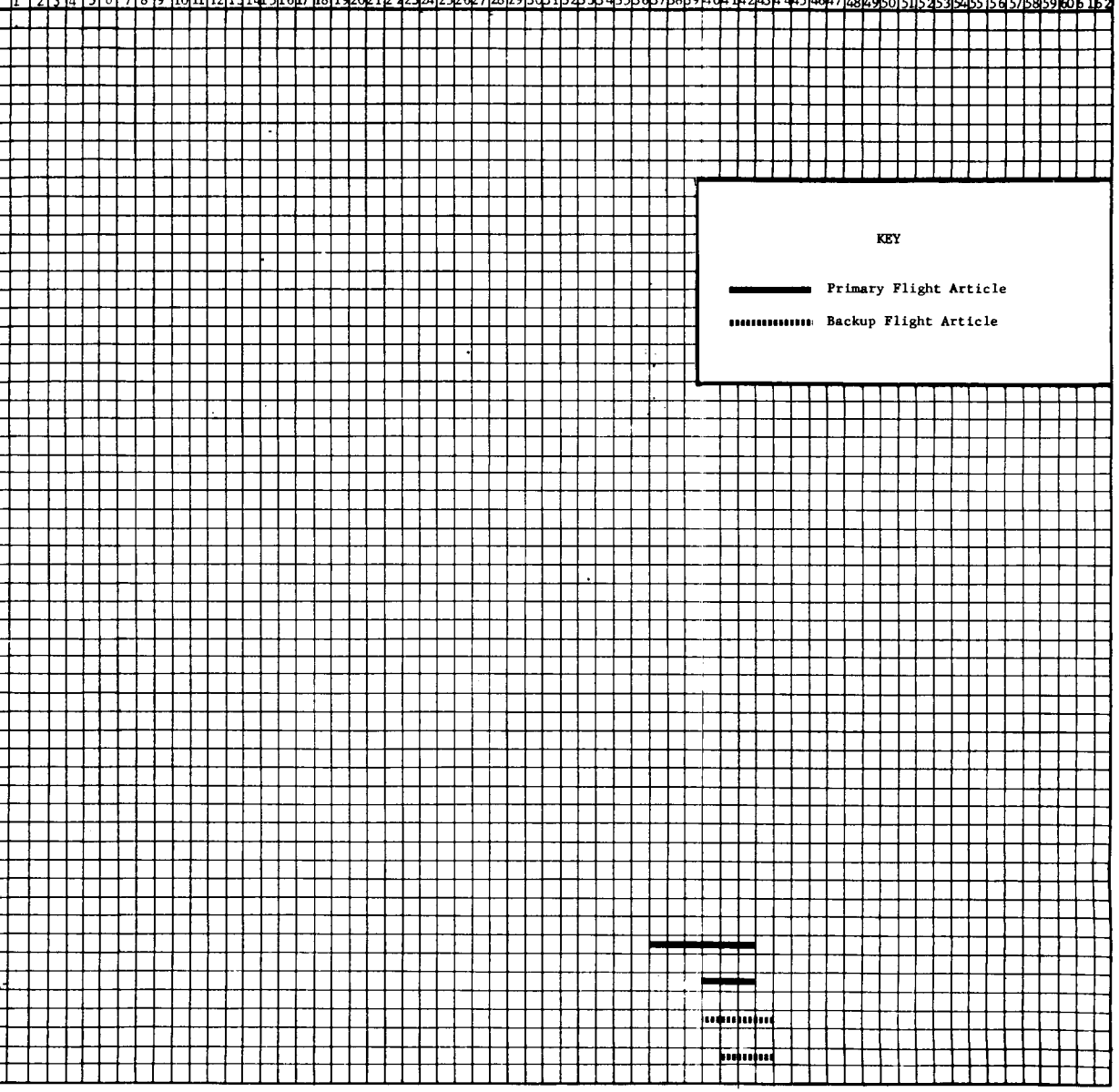
LEGEND: POINT AHEAD & SPACE-GROUND-SPACE LOOP CLOSURE (Continued)
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB SYSTEM
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-6

Detail Schedule E-6
Sheet 2 of 2
Date: August 1966
Prepared by: LF/MC

ITEM No.	ASSEMBLY NAME	TITLE
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article

MONTHS AFTER AUTHORIZATION TO PROCEED



PROJECT: OTAES PH I EXTENSION

LEGEND: TRANSFER TRACKING FROM ONE GROUND STATION TO ANOTHER
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-7

Detail Schedule E -7
Sheet 1 of 2
Date: 3 August 1966
Prepared by: M. Cohen

MONTHS AFTER AUTHORIZATION TO PROCEED

ADVANCED DEVELOPMENT EFFORT		TITLE
RESEARCH & DEVELOPMENT SUMMARY		
Task #1		System Concept Studies (~18 to
Task #2		Ground Station Req. Analysis (-12 to -1)
Task #3		Deep Space Simulation Studies (-6 to -1)
ITEM No	ASSEMBLY NAME	Major Assemblies/Sub-Systems
1	Ground Array (16 f/5" Telescopes)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
2	Telescope 1.0M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
3	Hard-Mounted Telescope 0.3M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
4	Isolated Telescope 0.3M	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
5	Trackers (Star, Planet, and Laser)	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
6	Deflectors and Associated Optics	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
7	Electro-Mechanical & Associated Hardware	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly

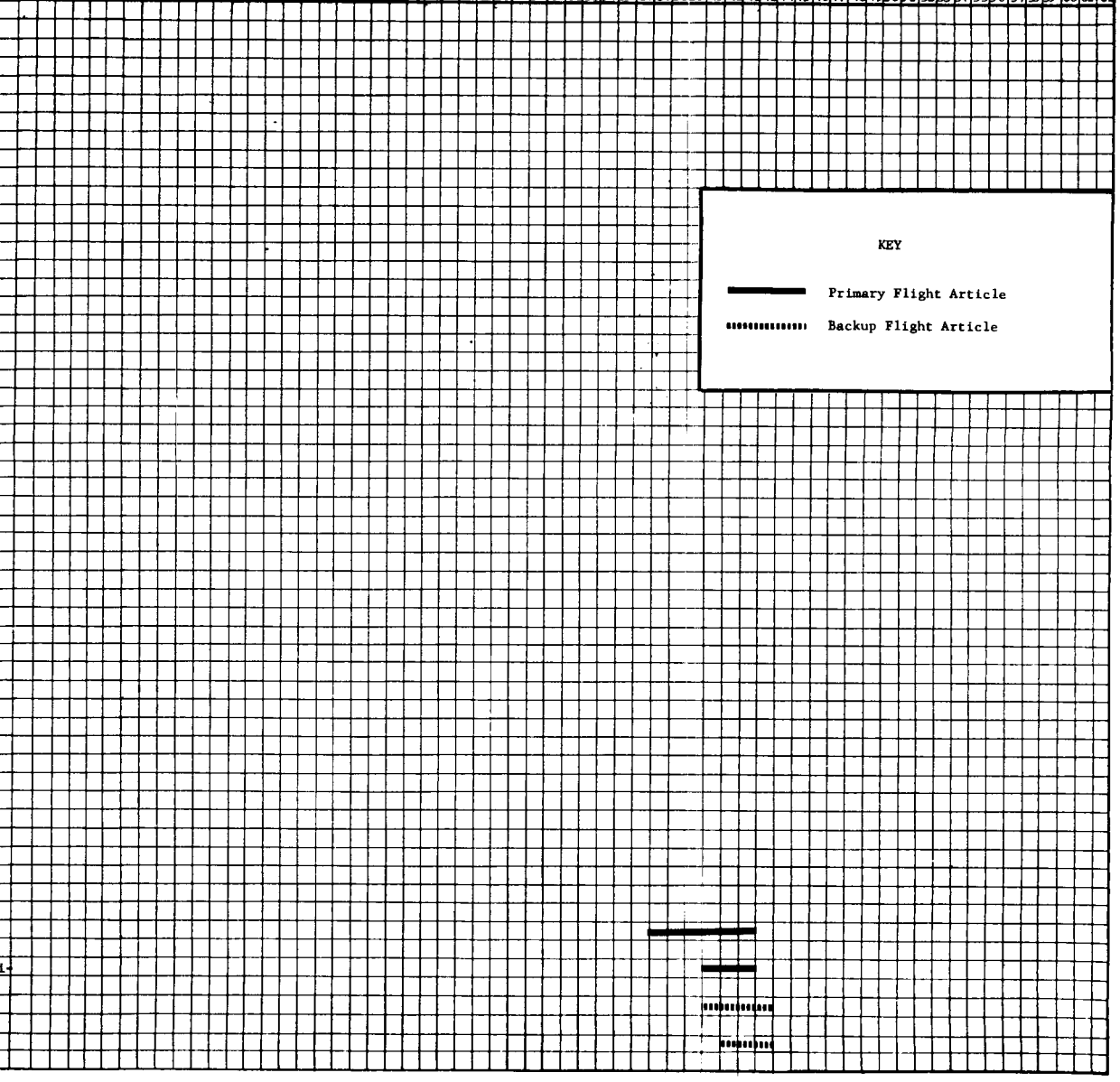
PROJECT: OTAES PH I EXTENSION

LEGEND: TRANSFER TRACKING FROM ONE GROUND STATION TO ANOTHER (Continued)
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-7

Detail Schedule E-7
Sheet 2 of 2
Date: 3 August 1966
Prepared by: M. Cohen

ITEM No.	ASSEMBLY NAME	TITLE
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article

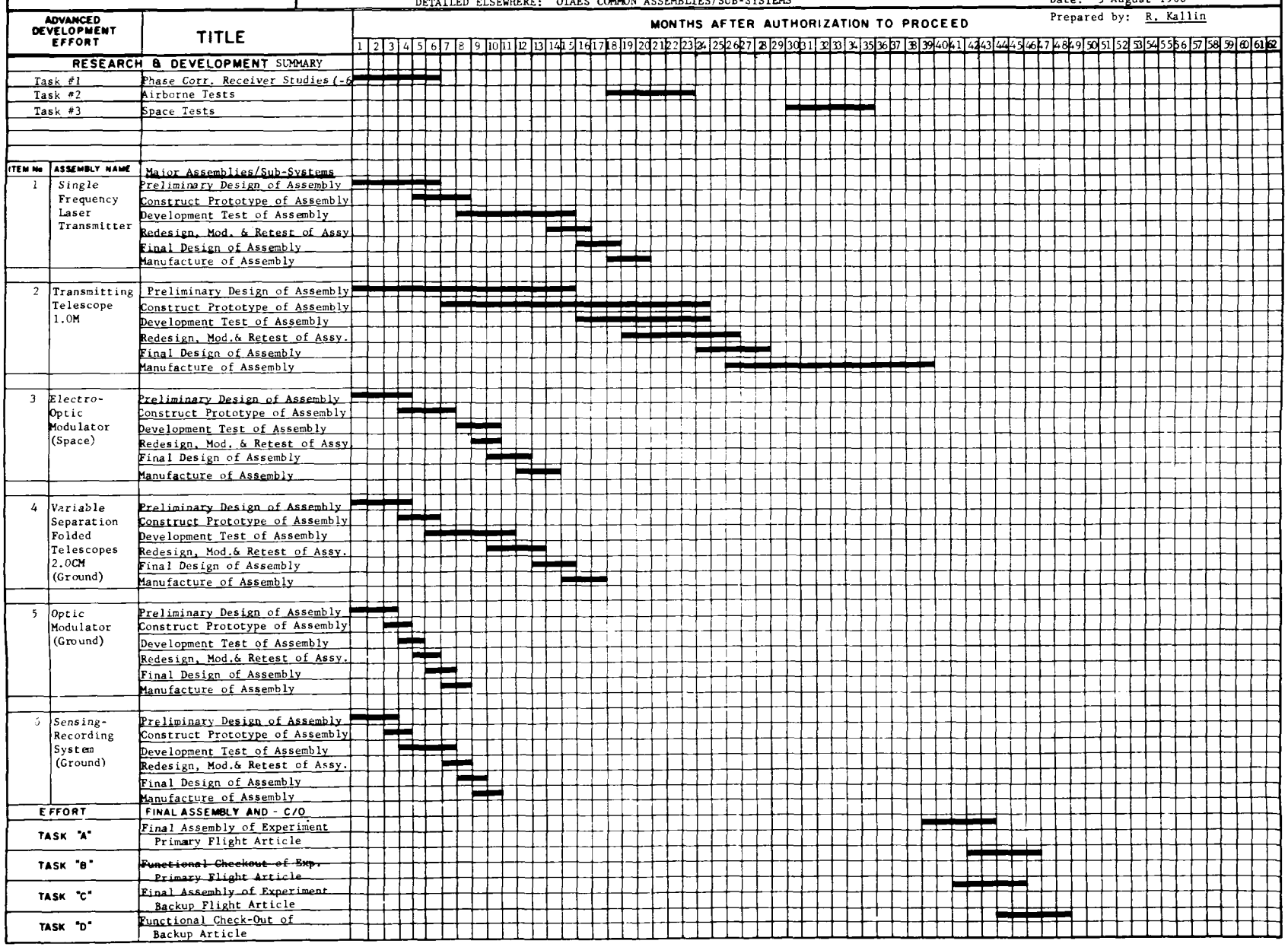


PROJECT: OTAES PH I EXTENSION

LEGEND: ATMOSPHERIC MEASUREMENTS
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-8

Detail Schedule E-8
Sheet 1 of 1
Date: 3 August 1966
Prepared by: R. Kallin

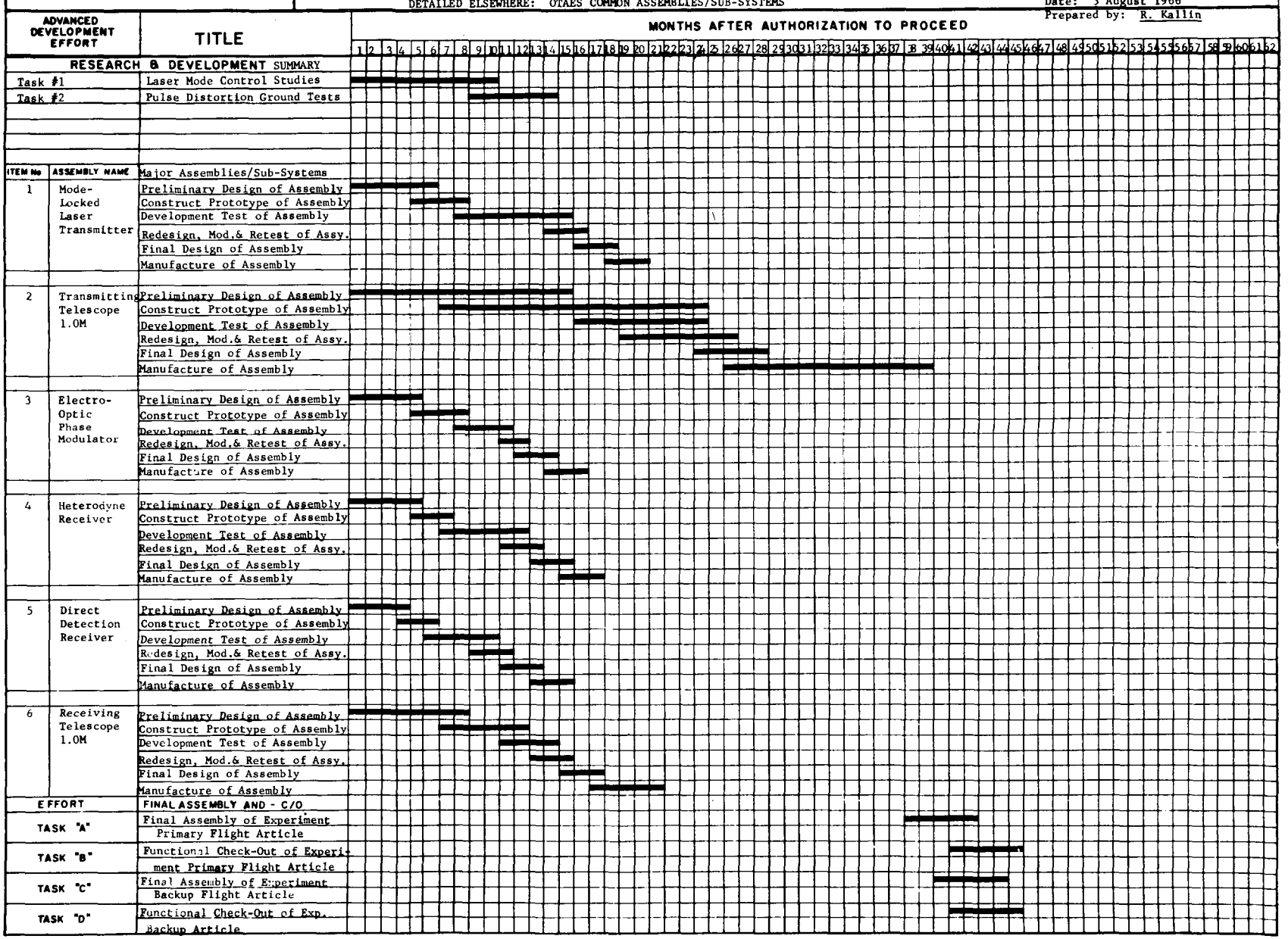


PROJECT: OTAES PH I EXTENSION

LEGEND: PULSE DISTORTION MEASUREMENTS
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-9

Detail Schedule E-9
Sheet 1 of 1
Date: 3 August 1966
Prepared by: R. Kallin



PROJECT: OTAES PH I EXTENSION	LEGEND: PRIMARY MIRROR FIGURE TEST & CORRECTION LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS	FIGURE 16.3-10	Detail Schedule E-10 Sheet 1 of 2 Sheets Date: 3 August 1966

Prepared by: LF/BJ

MONTHS AFTER AUTHORIZATION TO PROCEED

ADVANCED DEVELOPMENT EFFORT		TITLE	
RESEARCH & DEVELOPMENT SUMMARY			
Task 1		System Exper. Concept Studies	(-24 to -1)
Task 2		Primary Mirror Examination	(-18 to -1)
Task 3		Temp. Actuator & Control Study	(-12 to -1)
Task 4		Scatter-plt. Interferomtr Test	(-6 to -1)
Task 5		Secondary Mirror Studies	(- 9 to -1)
Task 6		Test Facility Studies	(-12 to -1)
ITEM No	ASSEMBLY NAME	Major Assemblies/Sub-Systems	
1	Primary Mirror Model(s)	Preliminary Design of Assembly	
		Construct Assembly	
		Development Test* of Assembly	
		Redesign, Mod.& Retest of Assy.	N/A
		Final Design of Assembly	N/A
		Manufacture of Assembly	(Model Utilized)
2	50" Flyable Primary	Preliminary Design of Assembly	
		Construct Prototype of Assembly	
		Development Test of Assembly	
		Redesign, Mod.& Retest* of Assy.	
		Final Design of Assembly	N/A
		Manufacture of Assembly	(Prototype Utilized)
3	Secondary Mirror, S/C Optical Instrument-ation, Etc.	Preliminary Design of Assembly	
		Construct Prototype of Assembly	
		Development Test of Assembly	
		Redesign, Mod.& Retest* of Assy.	
		Final Design of Assembly	
		Manufacture of Assembly	
4	Scanner, Scatter Plate, Interferom-eter, Etc.	Preliminary Design of Assembly	
		Construct Prototype of Assembly	
		Development Test of Assembly	
		Redesign, Mod.& Retest* of Assy.	
		Final Design of Assembly	
		Manufacture of Assembly	
[illegible]	Temp. Sensors, Control & Thermal Actuators	Preliminary Design of Assembly	
		Construct Prototype of Assembly	
		Development Test of Assembly	
		Redesign, Mod.& Retest* of Assy.	
		Final Design of Assembly	
		Manufacture of Assembly	
6	Mechanisms	Preliminary Design of Assembly	
		Construct Prototype of Assembly	
		Development Test of Assembly	
		Redesign, Mod.& Retest* of Assy.	
		Final Design of Assembly	
		Manufacture of Assembly	
		(See Sheet 2 of 2)	

* This includes test of the internal assemblies (i.e., [illegible] not [illegible])

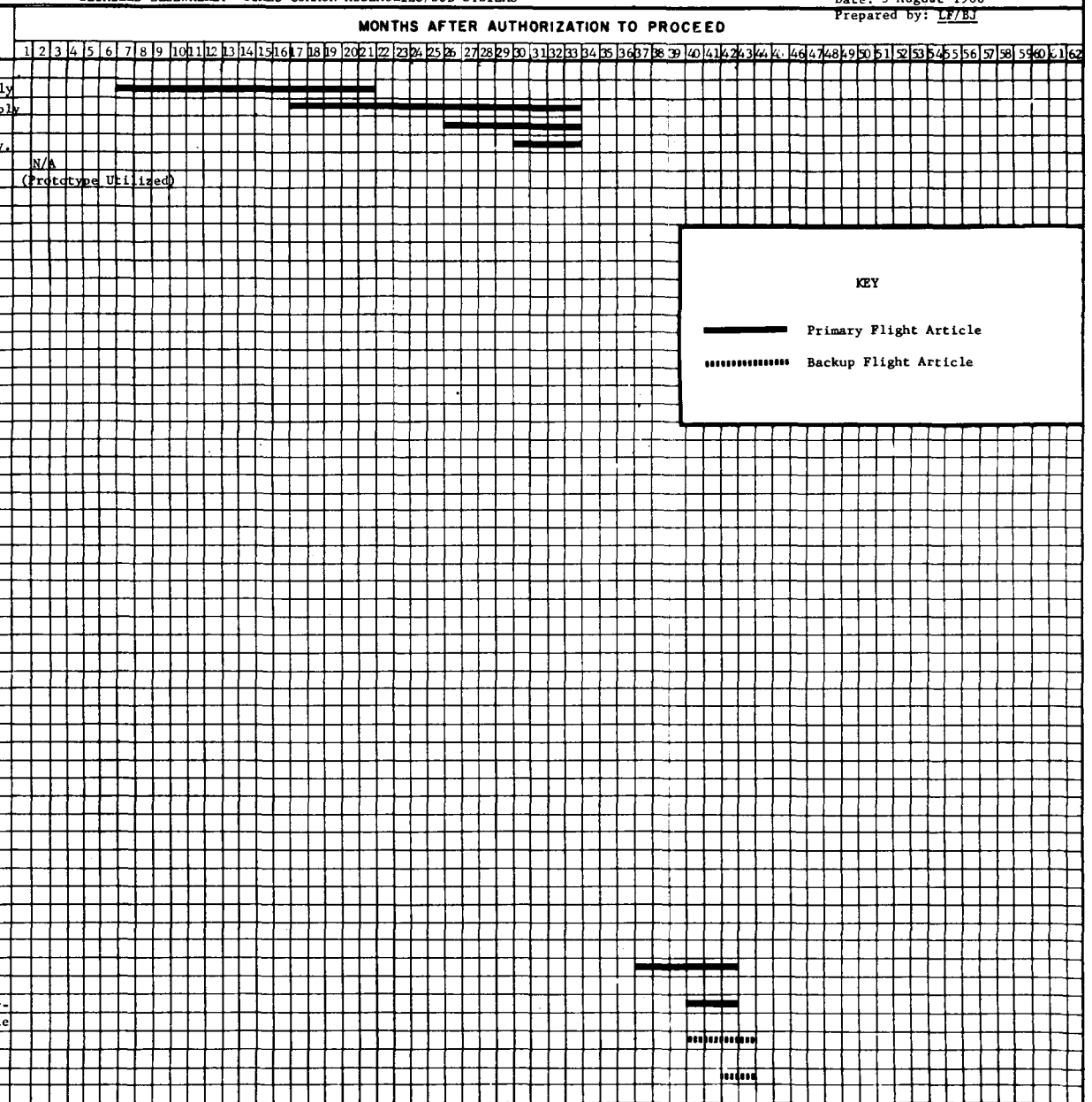
PROJECT: OTAES PH I EXTENSION

LEGEND: PRIMARY MIRROR FIGURE TEST & CORRECTION
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-10

Detail Schedule E-10
Sheet 2 of 2 Sheets
Date: 3 August 1966
Prepared by: LF/BJ

ITEM No.	ASSEMBLY NAME	TITLE
7	Special Test Equipment & Facilities	Major Assemblies/Sub-Systems
		Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod, & Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article



*This includes test of the integrated assemblies (i.e. this experiment package)

PROJECT: OTAES PH I EXTENSION

LEGEND: THIN MIRROR NESTING VERIFICATION
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-11

Detail Schedule E-11
Sheet 1 of 1 Sheet
Date: 3 August 1966
Prepared by: LF/BJ

MONTHS AFTER AUTHORIZATION TO PROCEED

ADVANCED DEVELOPMENT EFFORT		TITLE
RESEARCH & DEVELOPMENT SUMMARY		
Task 1		Experiment Concept Studies (-24 to -1)
Task 2		Primary Mirror & Nest Studies (-18 to -1)
Task 3		Protection Systems Analysis (-12 to -1)
Task 4		Interferometer Implement Study (-6 to -1)
Task 5		Secondary Mirror Studies (-9 to -1)
Task 6		Orbit Erection/Alignment (-12 to -1)
ITEM No	ASSEMBLY NAME	Major Assemblies/Sub-Systems
1	Model Primary Mirror (For Simul. Round Evaluation Test)	Preliminary Design of Assembly
		Construct Assembly
		Development Test* of Assembly
		Redesign, Mod.& Retest of Assy. N/A
		Final Design of Assembly N/A
		Manufacture of Assembly (Model Utilized)
2	Primary Mirror & Nest	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly N/A
		Manufacture of Assembly (Prototype Utilized)
3	Pneumatic Suspension	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
4	Scanner, Scatter Plate & Associated Hardware	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
5	Secondary Mirror S/C Optical Instrumentation, Etc.	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod. & Retest* of Assy.
		Final Design of Assembly
		Manufacture of Assembly
6	Special Test Equipment & Facilities	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest* of Assy.
		Final Design of Assembly N/A
		Manufacture of Assembly (Prototype Utilized)
EFFORT		FINAL ASSEMBLY AND - C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Backup Article

KEY

Primary Flight Article

Backup Flight Article

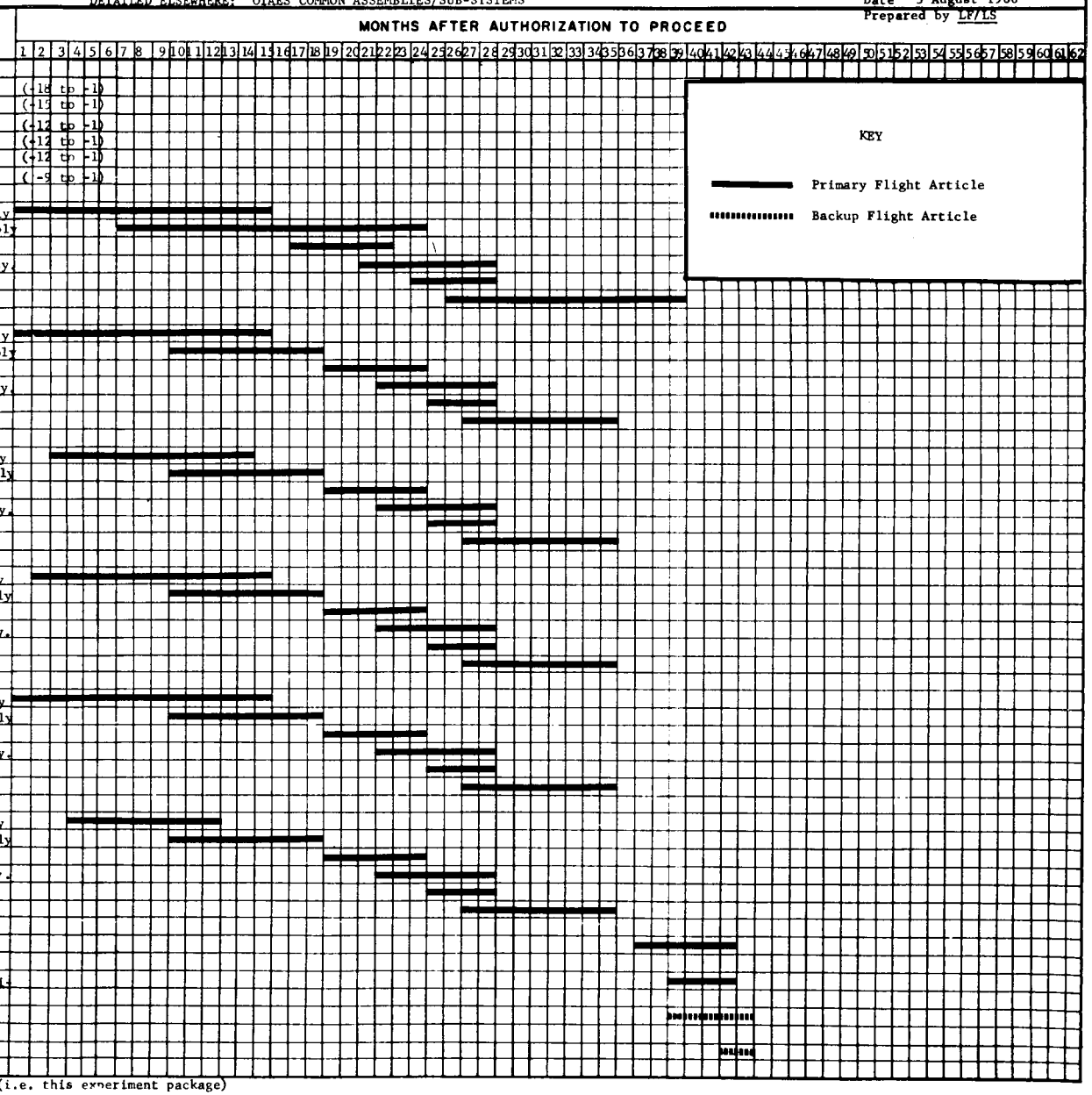
* This includes test of the integrated assemblies (i.e., this experiment package).

PROJECT: OTAES PH I EXTENSION

LEGEND: FINE GUIDANCE
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-12

Detail Schedule E- 12
Sheet 1 of 1
Date 3 August 1966
Prepared by LF/LS



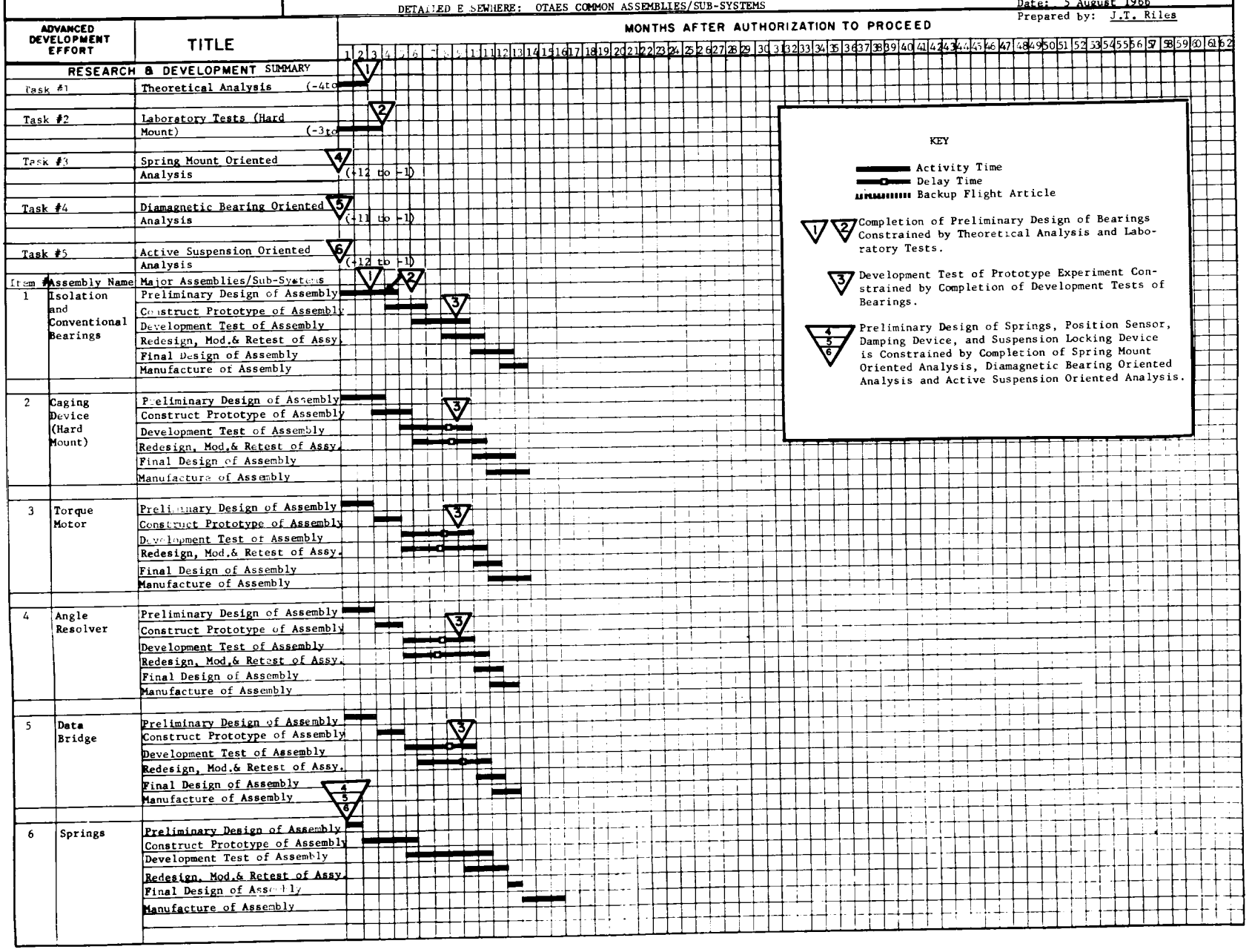
*This includes test of the integrated assemblies (i.e. this experiment package)

PROJECT: OTAES PH I EXTENSION

LEGEND: COMPARISO OF ISOLATION TECHNIQUES
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-13

Detail Schedule E-13
Sheet 1 of 2
Date: 5 August 1966
Prepared by: J.T. Riles



PROJECT: OTAES PH I EXTENSION

LEGEND: COMPARISON OF ISOLATION TECHNIQUES (CONTINUED)
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

FIGURE 16.3-13

Detail Schedule E-13
Sheet 2 of 2
Date: 5 August 1966
Prepared by: J.T. Riles

MONTHS AFTER AUTHORIZATION TO PROCEED

ITEM No.	ASSEMBLY NAME	TITLE
		Major Assemblies/Sub-Systems
7	Position Sensor	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
8	Damping Device	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
9	Suspension Locking Device	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
10	Motion Detection Optics	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
11	Special Test Equipment	Preliminary Design of Assembly
		Construct Prototype of Assembly
		Development Test of Assembly
		Redesign, Mod.& Retest of Assy.
		Final Design of Assembly
		Manufacture of Assembly
EFFORT		FINAL ASSEMBLY AND C/O
TASK "A"		Final Assembly of Experiment Primary Flight Article
TASK "B"		Functional Check-Out of Experiment Primary Flight Article
TASK "C"		Final Assembly of Experiment Backup Flight Article
TASK "D"		Functional Check-Out of Experiment Backup Article

PROJECT: OTAES PH I EXTENSION

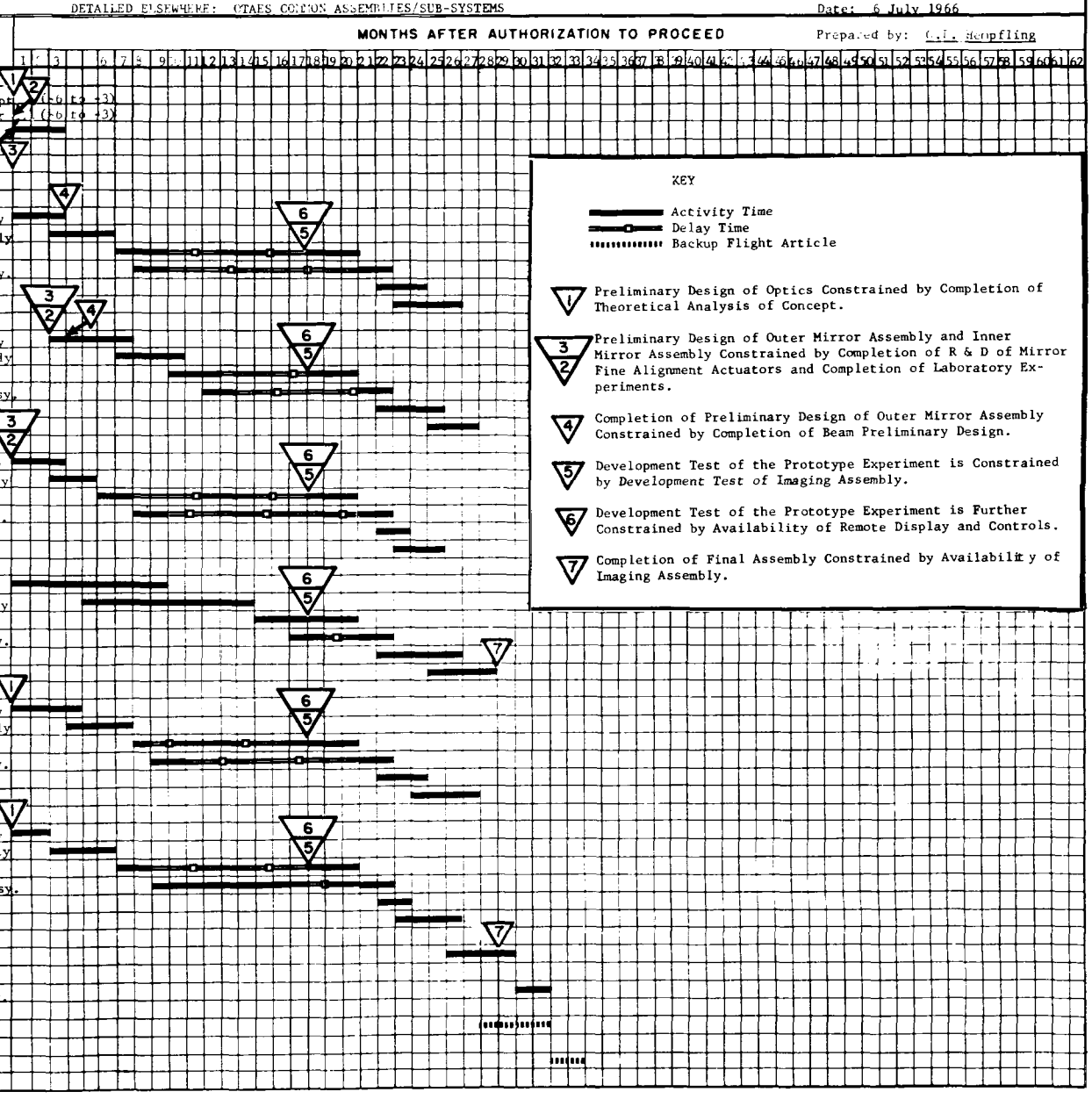
LEGEND: INTERFEROMETER SYSTEM
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS FIGURE 16.3-14
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

Detail Schedule E-14
Sheet 1 of 1
Date: 6 July 1966

Prepared by: C.L. Hoepfling

MONTHS AFTER AUTHORIZATION TO PROCEED

ADVANCED DEVELOPMENT EFFORT	TITLE
RESEARCH & DEVELOPMENT SUMMARY	
Task No. 1	Theoretical Analysis of Concept (-6 to +3)
Task No. 2	Mirror Fine Alignment Actuator (-6 to +3)
Task No. 3	Laboratory Experiments (-6
ITEM No / ASSEMBLY NAME	Major Assemblies/Sub-Systems
1 Beam	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod.& Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
2 Outer Mirror Assembly	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod. & Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
3 Inner Mirror Assembly	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod.& Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
4 Imaging Assembly	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod.& Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
5 Telescope Cover Positioning Mechanism	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod.& Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
6 Optics	Preliminary Design of Assembly
	Construct Prototype of Assembly
	Development Test of Assembly
	Redesign, Mod. & Retest of Assy.
	Final Design of Assembly
	Manufacture of Assembly
EFFORT	FINAL ASSEMBLY AND - C/O
TASK "A"	Final Assembly of Experiment Primary Flight Article
TASK "B"	Functional Check-Out of Exper. Primary Flight Article
TASK "C"	Final Assembly of Experiment Backup Flight Article
TASK "D"	Functional Check-Out of Exp. Backup Article



KEY

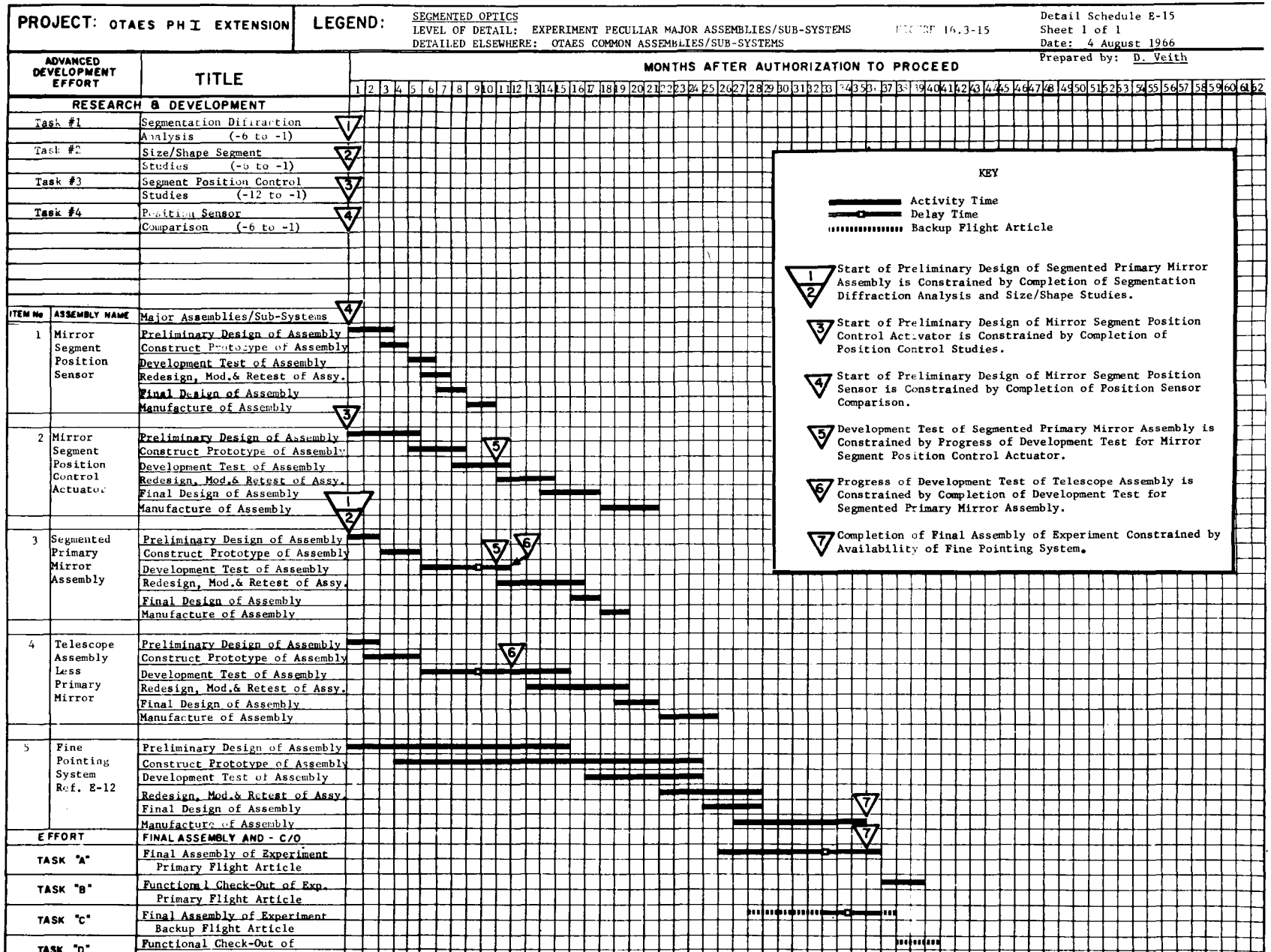
- Activity Time
- Delay Time
- Backup Flight Article

1. Preliminary Design of Optics Constrained by Completion of Theoretical Analysis of Concept.
2. Preliminary Design of Outer Mirror Assembly and Inner Mirror Assembly Constrained by Completion of R & D of Mirror Fine Alignment Actuators and Completion of Laboratory Experiments.
3. Completion of Preliminary Design of Outer Mirror Assembly Constrained by Completion of Beam Preliminary Design.
4. Development Test of the Prototype Experiment is Constrained by Development Test of Imaging Assembly.
5. Development Test of the Prototype Experiment is Further Constrained by Availability of Remote Display and Controls.
6. Completion of Final Assembly Constrained by Availability of Imaging Assembly.

PROJECT: OTAES PH I EXTENSION

LEGEND: SEGMENTED OPTICS
LEVEL OF DETAIL: EXPERIMENT PECULIAR MAJOR ASSEMBLIES/SUB-SYSTEMS
DETAILED ELSEWHERE: OTAES COMMON ASSEMBLIES/SUB-SYSTEMS

Detail Schedule E-15
Sheet 1 of 1
Date: 4 August 1966
Prepared by: D. Veith



Experiment E-15. Figure 17.3-1 indicates the availability of each candidate group collectively and determines the earliest date for group integration into a spacecraft. This candidate group identification will be retained throughout the remainder of the integration analysis. The additional time beyond individual experiment availability results from incorporating the necessary activities such as experiment: (a) Packaging; (b) Shipment; (c) Receiving inspection and (d) Pre-installation acceptance activities.

17.4 EXPERIMENT INTEGRATION CONCEPTS

Having determined collective flight integration availability times for each of the three proposed experiment groups, spacecraft integration for typical candidate missions can be implemented. For this study four candidate missions have been chosen which utilize the three candidate groups most efficiently. The candidate missions are:

	Approach	Type of Orbit	Spacecraft	Experiment Group Utilized
(a)	I	Synchronous	Manned	Group "A"
(b)	II	Synchronous	Unmanned	Group "B"
(c)	III (Dual)	Synchronous Low Earth	Unmanned Manned	Group "B" Group "C"
(d)	IV	Low Earth	Manned	Group "C"

Spacecraft preliminary design, development, final design and facilities erection, tooling and manufacturing plans time requirements have been determined in Phase I Final Report, Appendix "D" and are merely summarized for a "basic" OTAES in Figure 17.4-1. The fabrication, assembly, installation and modifications of major support equipment (other than experiment peculiar) are given for each approach. Final articles (less experiments) for structural and long-term environmental tests, as well as boilerplate, fully operational, and backup flight article fabrication are also included in this figure.

Time-frame phasing-in of prototype articles, structural and other qualification test articles, boilerplate flight and primary flight articles cannot be randomly planned, but must follow the most logical efficient process when analyzing alternate approach alternatives. Figure 17.4-2 indicates the constraint impact of these elements when integrated into an overall operational system. This diagram was specifically devised as a planning network tool for Approach I. Similar diagrams were analyzed for the other alternate approaches. The figures following 17.4-2 are a product of a group of in-house specialists along with the principal investigators where applicable, and reflect similar organized planning.

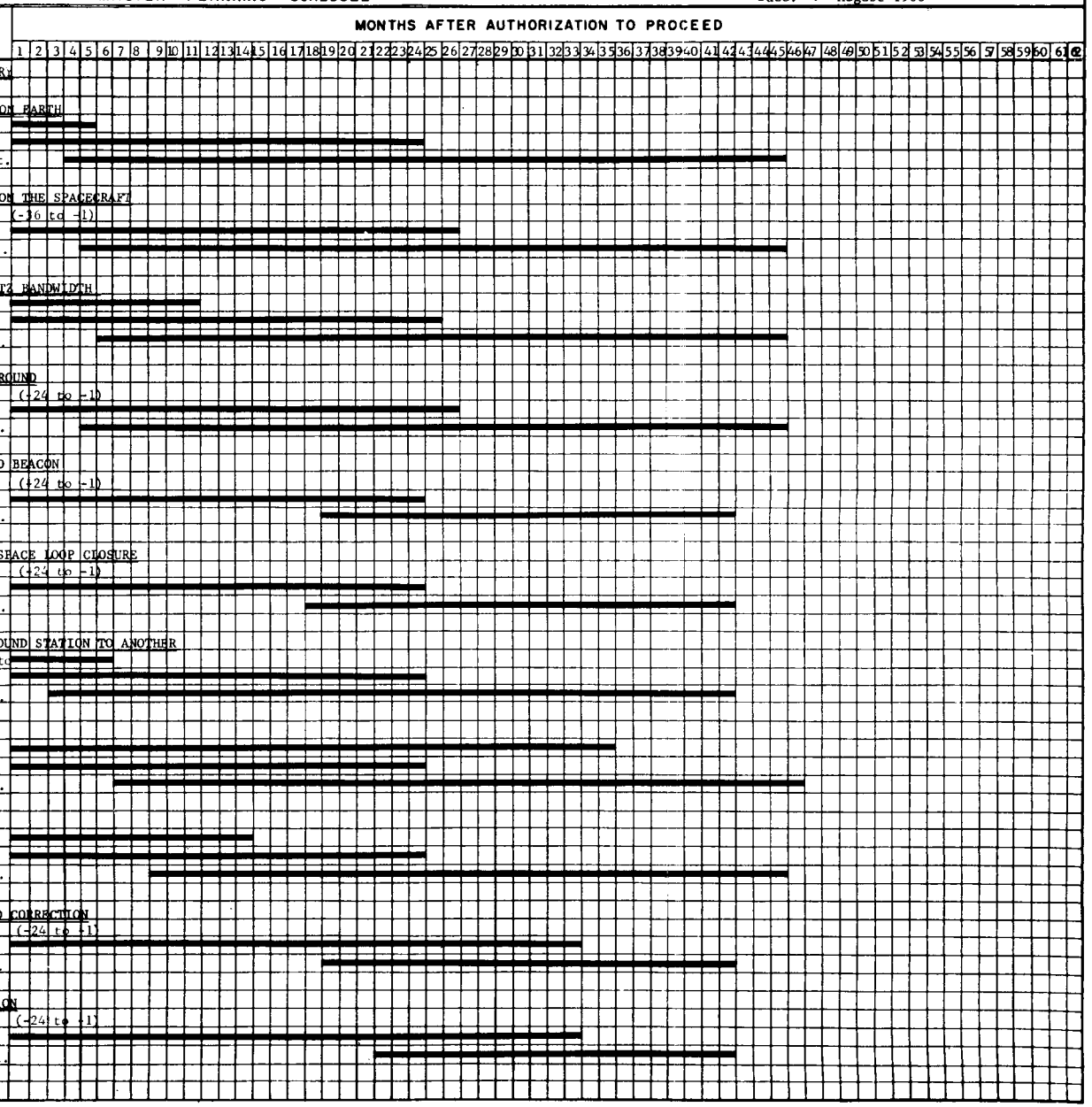
Integration and system checkout time requirements have been determined on Figure 17.4-3. For each approach, scheduling has been determined for: (a) Final article delivery to structural test; (b) Prototype flight article delivery to environmental test; (c) Boilerplate flight article delivery to Kennedy Space Center; (d) Primary and backup flight srticle shipment to Kennedy Space Center.

PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM MASTER PLANNING SCHEDULE

Figure 17.2-1
Date: 18 August 1966

MASTER SCHED. ITEM	DETAIL SCHED. REFERENCE	TITLE
1.0		EXPERIMENT AVAILABILITY SUMMARY
1.1	E-1	OPTICAL HETERODYNE DETECTION ON EARTH
1.1.1		Research & Development (-36
1.1.2		PD, Fab. & Test Prototype
1.1.3		Redesign, Fab. & C/O Flt.Art.
1.2	E-2	OPTICAL HETERODYNE DETECTION ON THE SPACECRAFT
1.2.1		Research & Development (-36 to -1)
1.2.2		PD, Fab.& Test Prototype
1.2.3		Redesign, Fab.& C/O Flt. Art.
1.3	E-3	COMMUNICATION WITH 10 MEGAHERTZ BANDWIDTH
1.3.1		Research & Development
1.3.2		PD, Fab.& Test Prototype
1.3.3		Redesign, Fab.& C/O Flt. Art.
1.4	E-4	DIRECT DETECTION - SPACE TO GROUND
1.4.1		Research & Development (-24 to -1)
1.4.2		PD, Fab.& Test Prototype
1.4.3		Redesign, Fab.& C/O Flt. Art.
1.5	E-5	PRECISION TRACKING OF A GROUND BEACON
1.5.1		Research & Development (-24 to -1)
1.5.2		PD, Fab. & Test Prototype
1.5.3		Redesign, Fab.& C/O Flt. Art.
1.6	E-6	POINT AHEAD AND SPACE-GROUND-SPACE LOOP CLOSURE
1.6.1		Research & Development (-24 to -1)
1.6.2		PD, Fab.& Test Prototype
1.6.3		Redesign, Fab.& C/O Flt. Art.
1.7	E-7	TRANSFER TRACKING FROM ONE GROUND STATION TO ANOTHER
1.7.1		Research & Development (-18 to
1.7.2		PD, Fab. & Test Prototype
1.7.3		Redesign, Fab.& C/O Flt. Art.
1.8	E-8	ATMOSPHERIC MEASUREMENTS
1.8.1		Research & Development
1.8.2		PD, Fab. & Test Prototype
1.8.3		Redesign, Fab.& C/O Flt. Art.
1.9	E-9	PULSE DISTORTION MEASUREMENTS
1.9.1		Research & Development
1.9.2		PD, Fab. & Test Prototype
1.9.3		Redesign, Fab.& C/O Flt. Art.
1.10	E-10	PRIMARY MIRROR FIGURE TEST AND CORRECTION
1.10.1		Research & Development (-24 to -1)
1.10.2		PD, Fab. & Test Prototype
1.10.3		Redesign, Fab.& C/O Flt. Art.
1.11	E-11	THIN MIRROR NESTING VERIFICATION
1.11.1		Research & Development (-24 to -1)
1.11.2		PD, Fab. & Test Prototype
1.11.3		Redesign, Fab.& C/O Flt. Art.



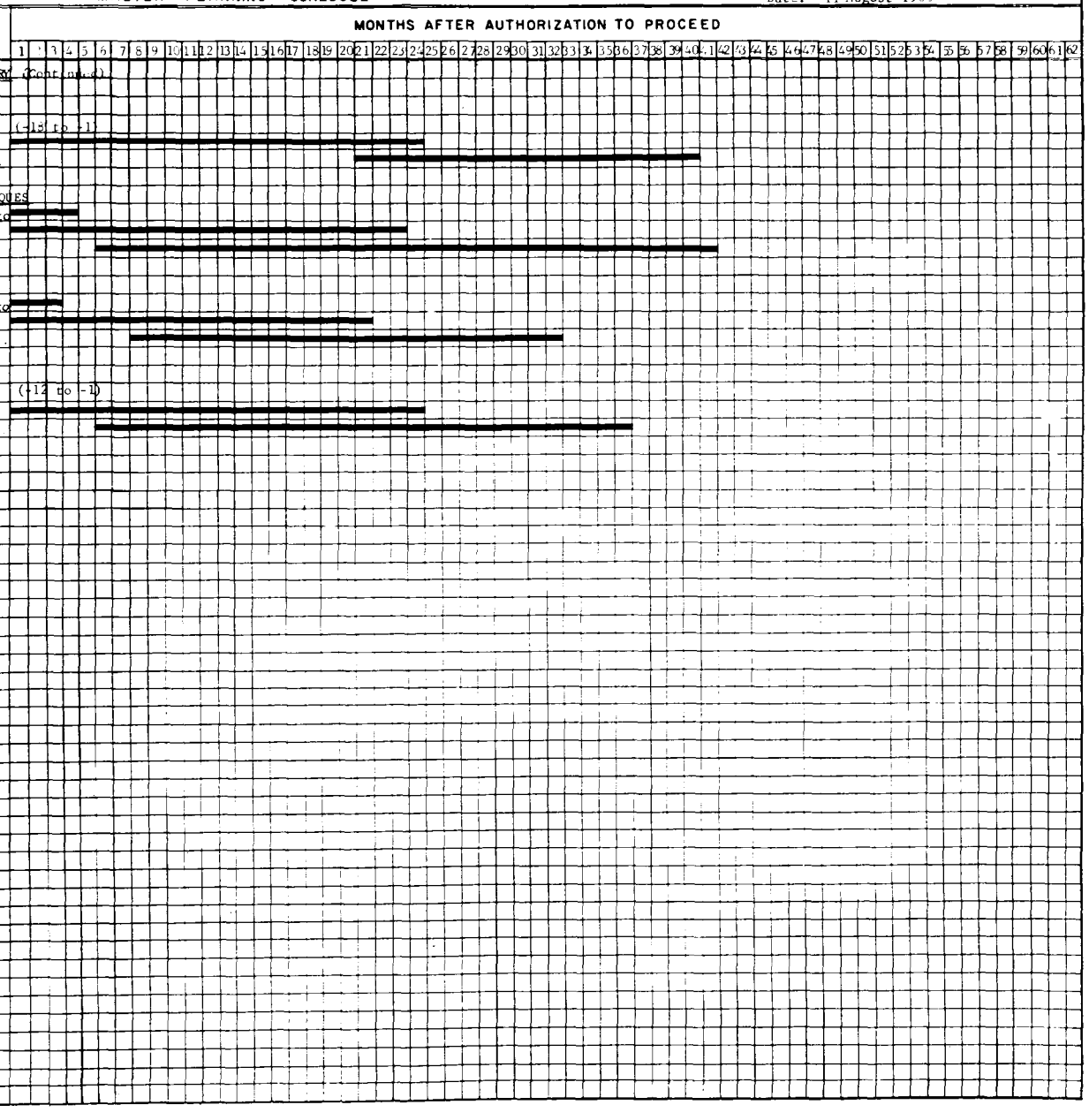
PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM

MASTER PLANNING SCHEDULE

Figure 17.2-2
Date: 11 August 1966

MASTER SCHED. ITEM	DETAIL SCHED REFERENCE	TITLE
1.0(Continued)		EXPERIMENT AVAILABILITY SUMMARY (Continued)
1.12	E-12	FINE GUIDANCE
1.12.1		Research & Development (-15 to -1)
1.12.2		PD, Fab. & Test Prototype
1.12.3		Redesign, Fab.& C/O Flt. Art.
1.1	E-13	COMPARISON OF ISOLATION TECHNIQUES
1.13.1		Research & Development (-12to
1.13.2		PD, Fab.& Test Prototype
1.13.3		Redesign, Fab.& C/O Flt. Art.
1.14	E-14	INTERFEROMETER SYSTEM
1.14.1		Research & Development (-6to
1.14.2		PD, Fab. & Test Prototype
1.14.3		Redesign, Fab.& C/O Flt. Art.
1.15	E-15	SEGMENTED OPTICS
1.15.1		Research & Development (-12 to -1)
1.15.2		PD, Fab. & Test Prototype
1.15.3		Redesign, Fab.& C/O Flt. Art

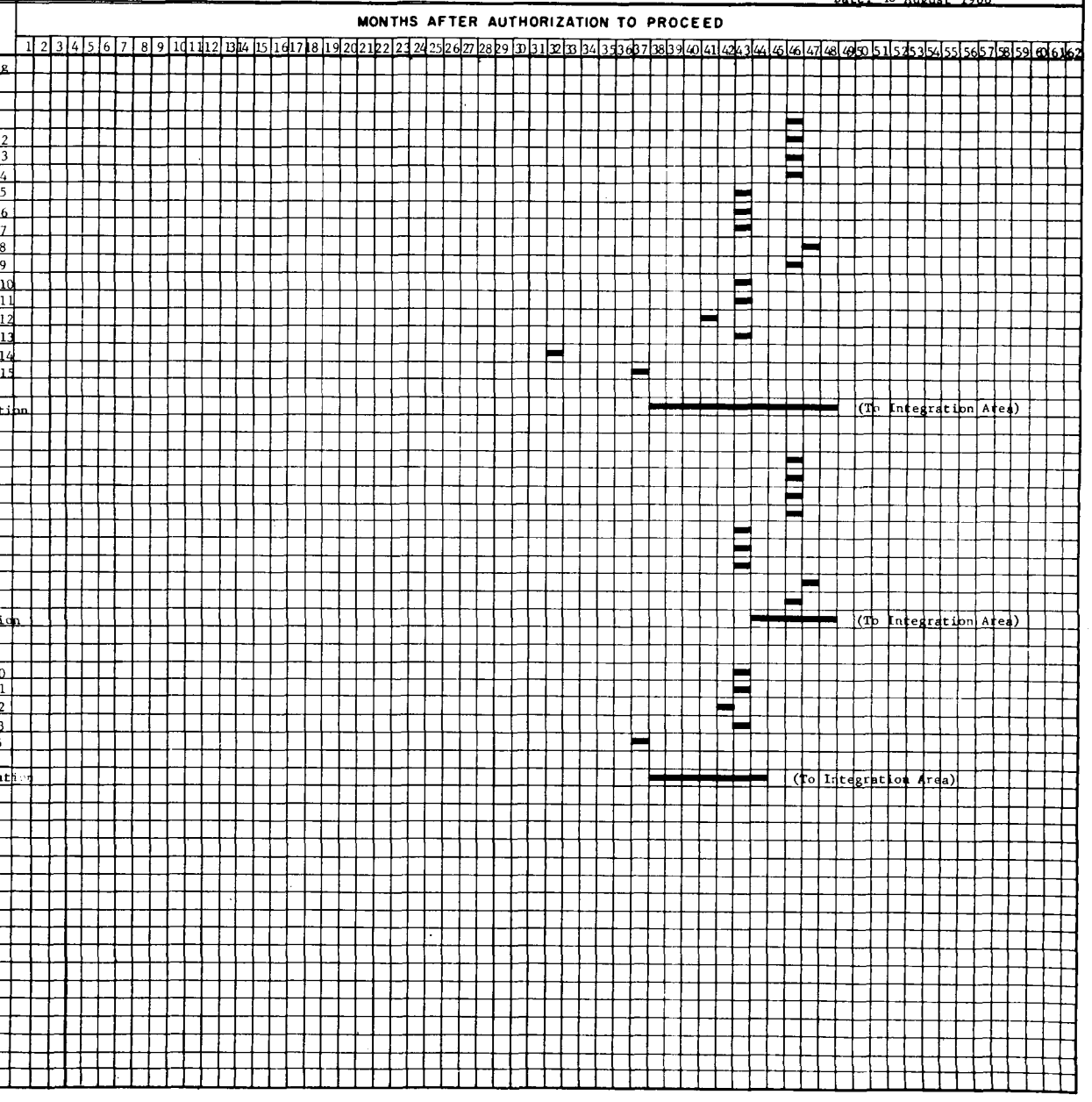


PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM
MASTER PLANNING SCHEDULE

Figure 17.3-1
Date: 18 August 1966

MASTER SCHED. ITEM	DETAIL SCHED. REFERENCE	TITLE
2.0		Experiment Candidate Grouping
2.1		Candidate Group "A"
2.1.1	1.1.3	Pkg,Ship,Rec.& PIA Exp. #E-1
2.1.2	1.2.3	Pkg.,Ship, Rec.& PIA Exp. #E-2
2.1.3	1.3.3	Pkg.,Ship, Rec.& PIA Exp. #E-3
2.1.4	1.4.3	Pkg.,Ship, Rec.& PIA Exp. #E-4
2.1.5	1.5.3	Pkg.,Ship, Rec.& PIA Exp. #E-5
2.1.6	1.6.3	Pkg.,Ship, Rec.& PIA Exp. #E-6
2.1.7	1.7.3	Pkg.,Ship, Rec.& PIA Exp. #E-7
2.1.8	1.8.3	Pkg.,Ship, Rec.& PIA Exp. #E-8
2.1.9	1.9.3	Pkg.,Ship, Rec.& PIA Exp. #E-9
2.1.10	1.10.3	Pkg.,Ship, Rec.& PIA Exp. #E-10
2.1.11	1.11.3	Pkg.,Ship, Rec.& PIA Exp. #E-11
2.1.12	1.12.3	Pkg.,Ship, Rec.& PIA Exp. #E-12
2.1.13	1.13.3	Pkg.,Ship, Rec.& PIA Exp. #E-13
2.1.14	1.14.3	Pkg.,Ship, Rec.& PIA Exp. #E-14
2.1.15	1.15.3	Pkg.,Ship, Rec.& PIA Exp. #E-15
2.1.16	1.17.3	Del. Exp.Group "A" to Integration
2.2		Candidate Group "B"
2.2.1	1.1.3	Pkg.,Ship, Rec.& PIA Exp.#E-1
2.2.2	1.2.3	Pkg.,Ship,Rec.& PIA Exp. #E-2
2.2.3	1.3.3	Pkg.,Ship,Rec.& PIA Exp. #E-3
2.2.4	1.4.3	Pkg.,Ship,Rec.& PIA Exp. #E-4
2.2.5	1.5.3	Pkg.,Ship,Rec.& PIA Exp. #E-5
2.2.6	1.6.3	Pkg.,Ship,Rec.& PIA Exp. #E-6
2.2.7	1.7.3	Pkg.,Ship,Rec.& PIA Exp. #E-7
2.2.8	1.8.3	Pkg.,Ship,Rec.& PIA Exp. #E-8
2.2.9	1.9.3	Pkg.,Ship,Rec.& PIA Exp. #E-9
2.2.10		Del.Exp.Group "B" to Integration
2.3		Candidate Group "C"
2.3.1	1.10.3	Pkg.,Ship,Rec.& PIA Exp. #E-10
2.3.2	1.11.3	Pkg.,Ship,Rec.& PIA Exp. #E-11
2.3.3	1.12.3	Pkg.,Ship,Rec.& PIA Exp. #E-12
2.3.4	1.13.3	Pkg.,Ship,Rec.& PIA Exp. #E-13
2.3.5	1.15.3	Pkg.,Ship,Rec.& PIA Exp. #E-15
2.3.6		Del. Exp. Group "C" to Integration



Detailed time duration requirements for the environmental testing of structural test models and specific prototype flight articles for each of the four alternative approaches have been projected on figure 17.4-4.

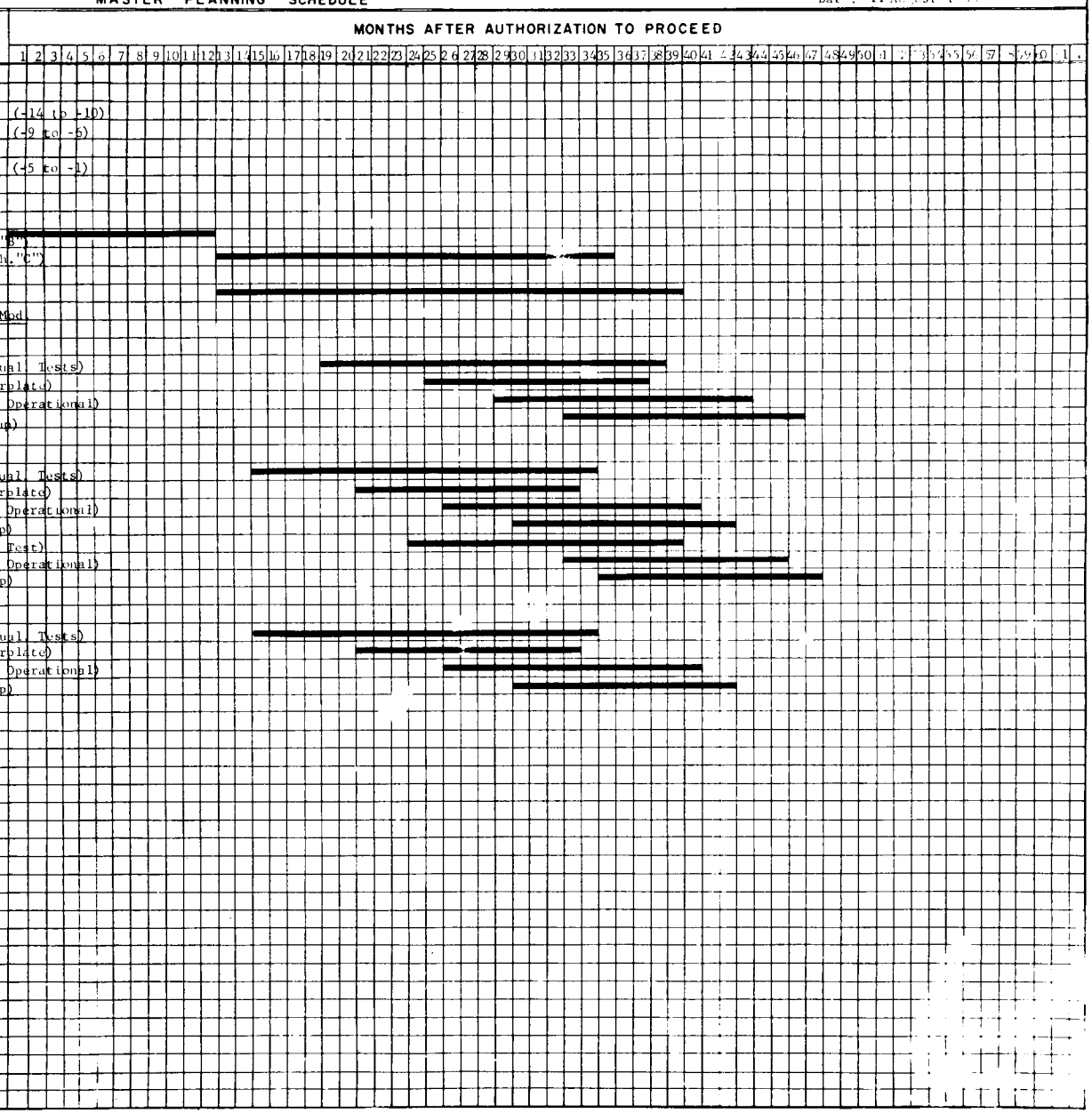
The final phase of experiment integration includes the pre-launch check-out and mission support activity requirements. The following specific activities are included for Approach I with Group "A" experiments, Approach II with Group "B" experiments, Approach III with both Group "B" and Group "C" experiments, and Approach IV with Group "C" experiments: (a) Final experiments and launch systems checkout; (b) Launch capability points; (c) Range and mission support checkout, and (d) Mission support for respective experiment group launches. Projections for associated prerequisite boilerplate missions are likewise included. See Figure 17.4-5.

PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM
MASTER PLANNING SCHEDULE

Figure 17.4-1
Date : 14 August 1966

MASTER SCHED. ITEM	DETAIL SCHED. REFERENCE	TITLE
3.0		OTAES STUDY (NASA PH. "A")
3.1	NAS8-20256	PHASE I
3.2	NAS8-20256	PHASE I EXTENSION
3.3		PHASE II
4.0	3.1	BASIC OTAES
4.1	3.1	Preliminary Design (NASA Ph. "B")
4.2	3.1	Detail Design & Dev. (NASA Ph. "C")
4.3	3.1	Manufacture (NASA Ph. "D")
4.3.1	3.1	Facilities, Tool & Plan
4.3.2	3.1	Fab., Assemble, Install & Mod.
4.3.2.1	3.1	Approach I & II
4.3.2.1.1	3.1	Final Articles #1 & 2 (Qual. Tests)
4.3.2.1.2	3.1	Flight Article #3 (Boilerplate)
4.3.2.1.3	3.1	Flight Article #4 (Fully Operational)
4.3.2.1.4	3.1	Flight Article #5 (Backup)
4.3.2.2		Approach III
4.3.2.2.1	3.1	Final Articles #1 & 2 (Qual. Tests)
4.3.2.2.2	3.1	Flight Article #3 (Boilerplate)
4.3.2.2.3	3.1	Flight Article #4 (Fully Operational)
4.3.2.2.4	3.1	Flight Article #5 (Backup)
4.3.2.2.5	3.1	Final Article #6 (Qual. Test)
4.3.2.2.6	3.1	Flight Article #7 (Fully Operational)
4.3.2.2.7	3.1	Flight Article #8 (Backup)
4.3.2.3		Approach IV
4.3.2.3.1	3.1	Final Articles #1 & 2 (Qual. Tests)
4.3.2.3.2	3.1	Flight Article #3 (Boilerplate)
4.3.2.3.3	3.1	Flight Article #4 (Fully Operational)
4.3.2.3.4		Flight Article #5 (Backup)



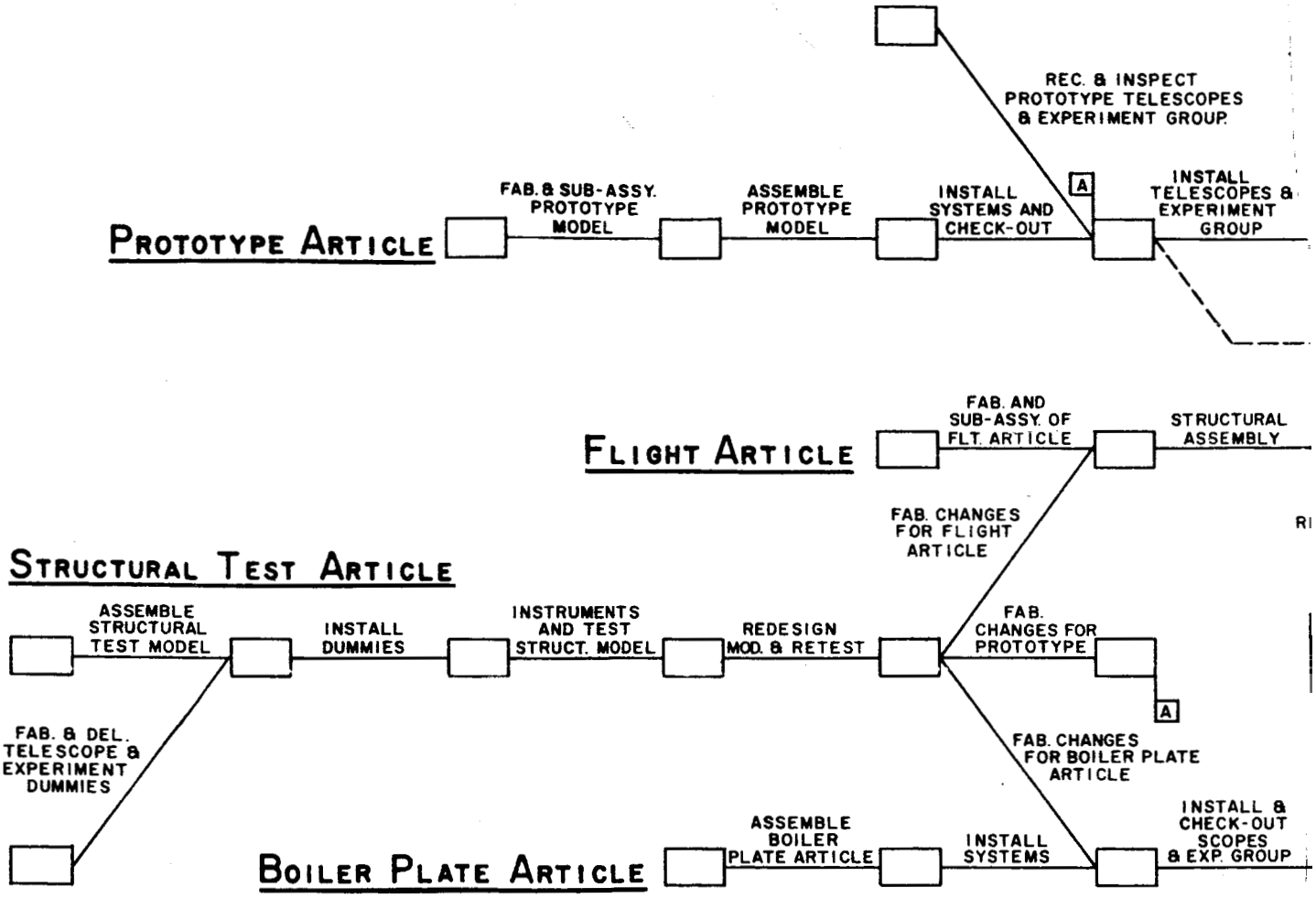
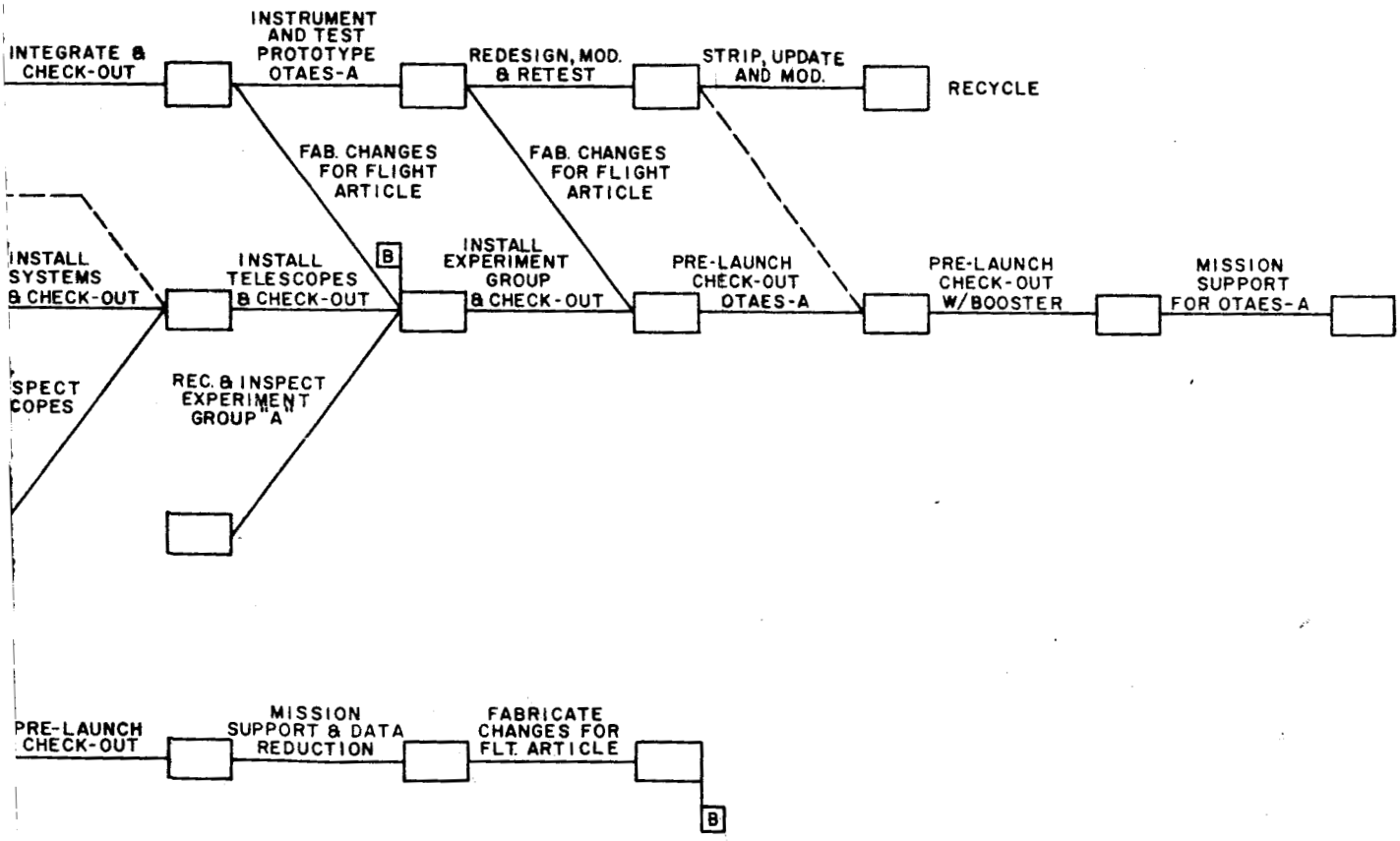

REC. & INSPECT PROTOTYPE TELESCOPES & EXPERIMENT GROUP
A
PROTOTYPE ARTICLE
FAB. & SUB-ASSY. PROTOTYPE MODEL
ASSEMBLE PROTOTYPE MODEL
INSTALL SYSTEMS AND CHECK-OUT
INSTALL TELESCOPES & EXPERIMENT GROUP
FLIGHT ARTICLE
FAB. AND SUB-ASSY. OF FLT. ARTICLE
STRUCTURAL ASSEMBLY
FAB. CHANGES FOR FLIGHT ARTICLE
STRUCTURAL TEST ARTICLE
ASSEMBLE STRUCTURAL TEST MODEL
INSTALL DUMMIES
INSTRUMENTS AND TEST STRUCT. MODEL
REDESIGN MOD. & RETEST
FAB. CHANGES FOR PROTOTYPE
A
FAB. & DEL. TELESCOPE & EXPERIMENT DUMMIES
FAB. CHANGES FOR BOILER PLATE ARTICLE
ASSEMBLE BOILER PLATE ARTICLE
INSTALL SYSTEMS
INSTALL & CHECK-OUT SCOPES & EXP. GROUP
BOILER PLATE ARTICLE

FIGURE 17.4-2
CONSTRAINT IMPACT ANALYSIS DIAGRAM



SPACE DIVISION CHRYSLER CORPORATION

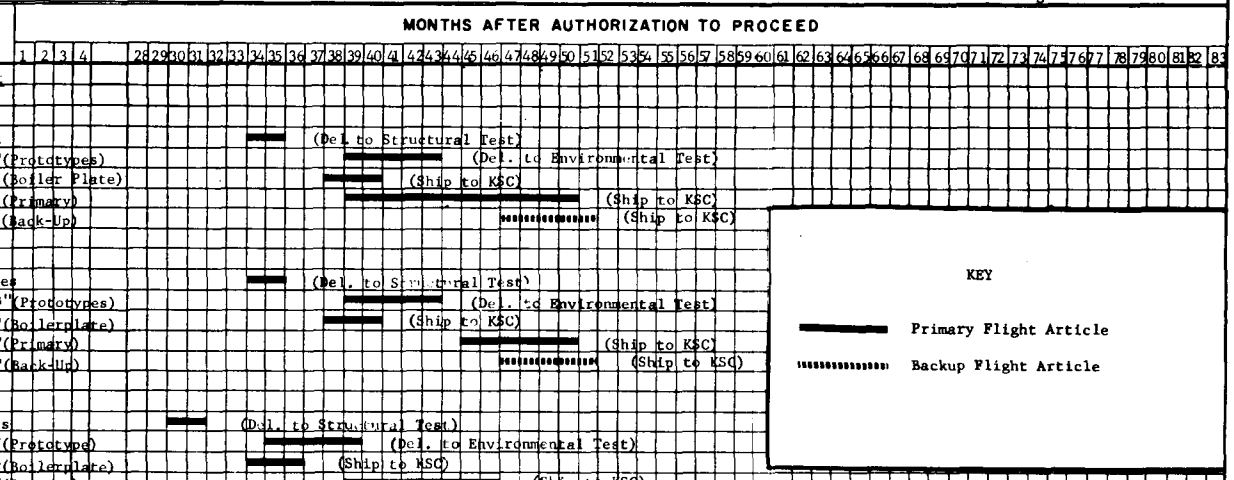
Figure 17.4-2. Constraint Impact Analysis Diagram

PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM
MASTER PLANNING SCHEDULE

Figure 17.4-3
Date: 10 August 1966

MASTER SCHED. ITEM	DETAIL SCHED. REFERENCE	TITLE
5.0		Integration & System Check-Out
5.1		Approach I
5.1.1	4.3.2.1.1	Final Article #1 w/Exp.Dummies
5.1.2	4.3.2.1.1	Flight Article #2 w/Exp.Gp."A"(Prototypes)
5.1.3	4.3.2.1.2	Flight Article #3 w/Exp.Gp."A"(Boiler Plate)
5.1.4	4.3.2.1.3/ 4.3.2.1.7	Flight Article #4 w/Exp.Gp."A"(Primary)
5.1.5	4.3.2.1.4	Flight Article #5 w/Exp.Gp."A"(Back-Up)
5.2		Approach II
5.2.1	4.3.2.1.1	Final Article #1 w/Exp. Dummies
5.2.2	4.3.2.1.1	Flight Article #2 w/Exp.Gp. "B"(Prototypes)
5.2.3	4.3.2.1.2	Flight Article #3 w/Exp.Gp."B"(Boilerplate)
5.2.4	4.3.2.1.3/ 4.3.2.1.10	Flight Article #4 w/Exp.Gp."B"(Primary)
5.2.5	4.3.2.1.4	Flight Article #5 w/Exp.Gp."B"(Back-Up)
5.3		Approach III
5.3.1	4.3.2.2.1	Final Article #1 w/Exp. Dummies
5.3.2	4.3.2.2.1	Flight Article #2 w/Exp.Gp."C"(Prototype)
5.3.3	4.3.2.2.2	Flight Article #3 w/Exp.Gp."C"(Boilerplate)
5.3.4	4.3.2.2.3/ 4.3.2.2.7	Flight Article #4 w/Exp.Gp."C"(Primary)
5.3.5	4.3.2.2.4	Flight Article #5 w/Exp.Gp."C"(Backup)
5.3.6	4.3.2.2.5	Flight Article #6 w/Exp.Gp."B"(Prototype)
5.3.7	4.3.2.2.6/ 4.3.2.2.10	Flight Article #7 w/Exp.Gp."B"(Primary)
5.3.8	4.3.2.2.7	Flight Article #8 w/Exp.Gp."B"(Back-Up)
5.4		Approach IV
5.4.1	4.3.2.3.1	Final Article #1 w/Exp.Dummies
5.4.2	4.3.2.3.1	Flight Article #2 w/Exp.Gp."C"(Prototypes)
5.4.3	4.3.2.3.2	Flight Article #3 w/Exp.Gp."C"(Boilerplate)
5.4.4	4.3.2.3.3/ 4.3.2.3.7	Flight Article #4 w/Exp.Gp."C"(Primary)
5.4.5	4.3.2.3.4	Flight Article #5 w/Exp.Gp."C"(Backup)

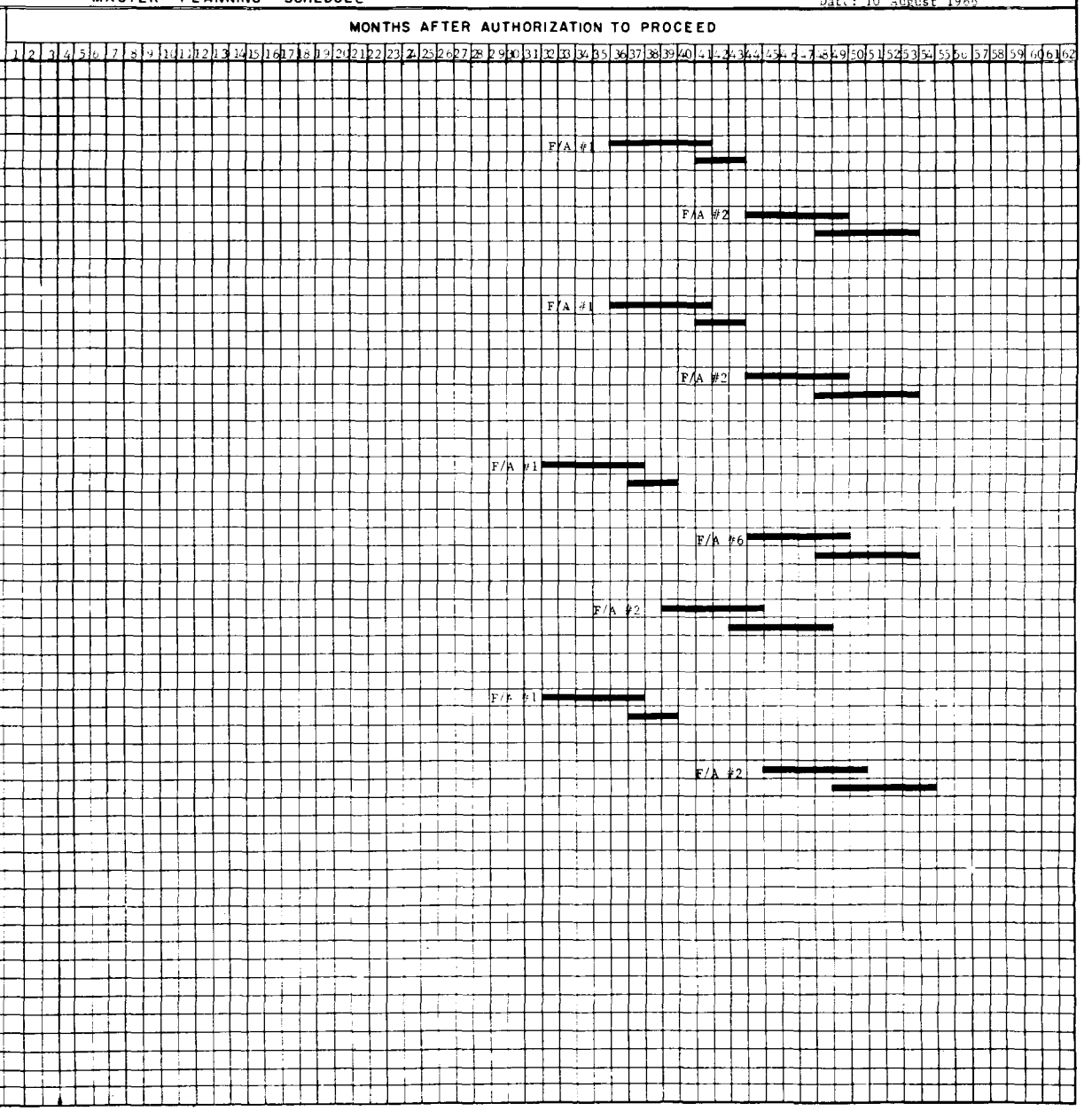


PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM
MASTER PLANNING SCHEDULE

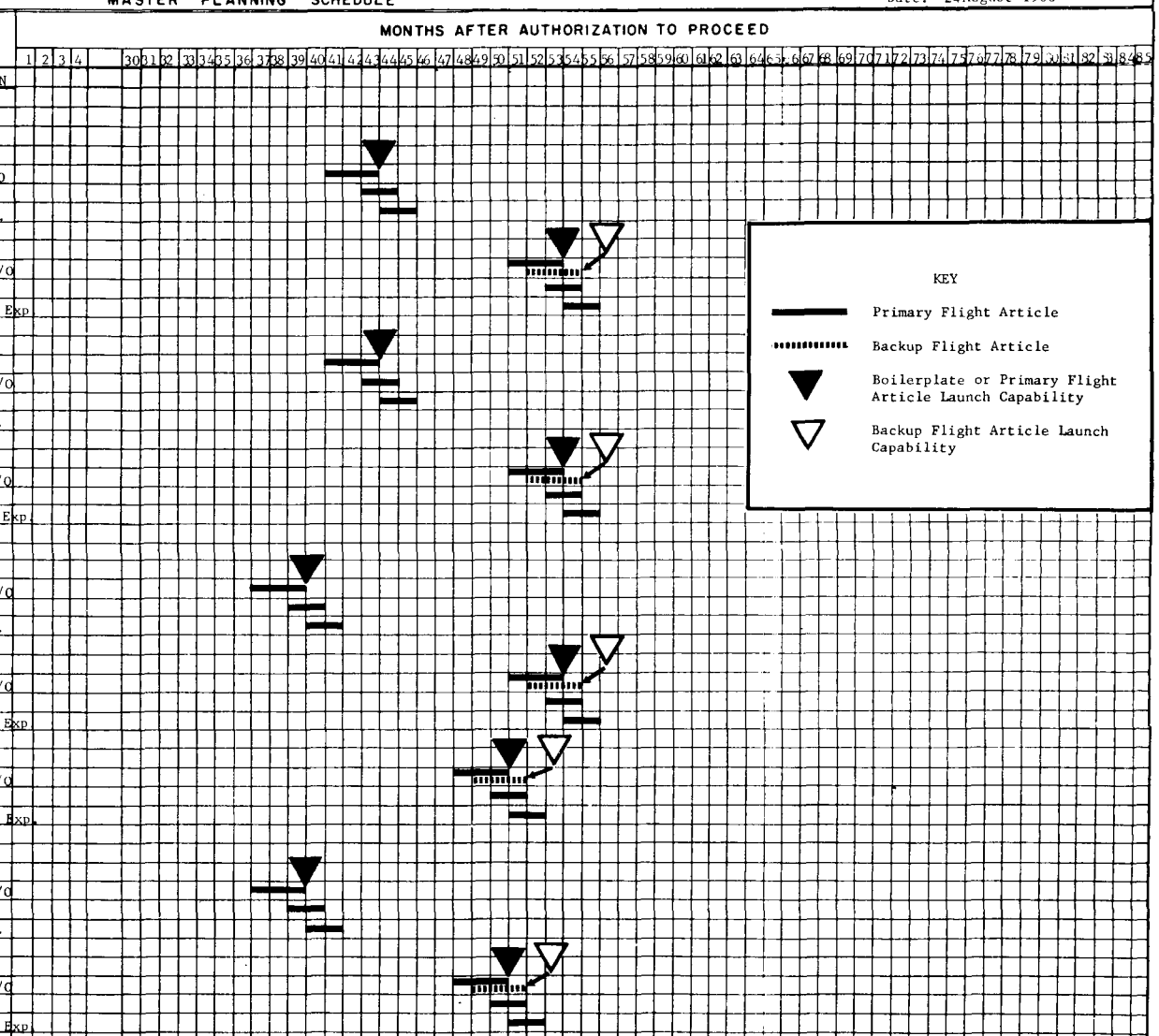
Figure 17.4-4
Date: 10 August 1966

MASTER SCHED. ITEM	DETAIL SCHED REFERENCE	TITLE
6.0		Environmental Testing
6.1		Approach I
6.1.1		Structural Test Model
6.1.1.1	5.1.1	Instrument & Test
6.1.1.2		Redesign, Mod.& Retest
6.1.2		OTAES-A Prototype
6.1.2.1	5.1.2	Instrument & Test
6.1.2.2		Redesign, Mod.& Retest
6.2		Approach II
6.2.1		Structural Test Model
6.2.1.1	5.2.1	Instrument & Test
6.2.1.2		Redesign, Mod. & Retest
6.2.2		OTAES-B Prototype
6.2.2.1	5.2.2	Instrument & Test
6.2.2.2		Redesign, Mod. & Retest
6.3		Approach III
6.3.1		Structural Test Model
6.3.1.1	5.3.1	Instrument & Test
6.3.1.2		Redesign, Mod. & Retest
6.3.2		OTAES-B Prototype
6.3.2.1	5.3.6	Instrument & Test
6.3.2.2		Redesign, Mod. & Retest
6.3.3		OTAES-C Prototype
6.3.3.1	5.3.2	Instrument & Test
6.3.3.2		Redesign, Mod. & Retest
6.4		Approach IV
6.4.1		Structural Test Model
6.4.1.1	5.4.1	Instrument & Test
6.4.1.2		Redesign, Mod. & Retest
6.4.2		OTAES-C Prototype
6.4.2.1	5.4.2	Instrument & Test
6.4.2.2		Redesign, Mod. & Retest



PROJECT: OTAES PH. I EXTENSION

LEGEND: OPTICAL TECHNOLOGY APOLLO EXTENSION SYSTEM
MASTER PLANNING SCHEDULE

Figure 17.4-5
Date: 24 August 1966

MASTER SCHED. ITEM	DETAIL SCHED. REFERENCE	TITLE
7.0		PRE-LAUNCH CHECK-OUT & MISSION SUPPORT
7.1		Approach I
7.1.1		Boiler Plate Mission
7.1.1.1	5.1.3	Experiments & Launch Sys. C/O
7.1.1.2		Range & Mission Support
7.1.1.3		Mission Support for B/P Exp.
7.1.2		OTAES-A Mission
7.1.2.1	5.1.4/5.1.5	Experiments & Launch Sys. C/O
7.1.2.2		Range & Mission Support C/O
7.1.2.3		Mission Support for OTAES-A Exp.
7.2		Approach II
7.2.1		Boiler Plate Mission
7.2.1.1	5.2.3	Experiments & Launch Sys. C/O
7.2.1.2		Range & Mission Support
7.2.1.3		Mission Support for B/P Exp.
7.2.2		OTAES-B Mission
7.2.2.1	5.2.4/5.2.5	Experiments & Launch Sys. C/O
7.2.2.2		Range & Mission Support C/O
7.2.2.3		Mission Support for OTAES-B Exp.
7.3		Approach III
7.3.1	5.3.3	Boiler Plate Mission
7.3.1.1		Experiments & Launch Sys. C/O
7.3.1.2		Range & Mission Support C/O
7.3.1.3		Mission Support for B/P Exp.
7.3.2		OTAES-B Mission
7.3.2.1	5.3.7/5.3.8	Experiments & Launch Sys. C/O
7.3.2.2		Range & Mission Support
7.3.2.3		Mission Support for OTAES-B Exp.
7.3.3		OTAES-C Mission
7.3.3.1	5.3.4/5.3.5	Experiments & Launch Sys. C/O
7.3.3.2		Range & Mission Support
7.3.3.3		Mission Support for OTAES-C Exp.
7.4		Approach IV
7.4.1		Boiler Plate Mission
7.4.1.1	5.4.3	Experiments & Launch Sys. C/O
7.4.1.2		Range & Mission Support
7.4.1.3		Mission Support for B/P Exp.
7.4.2		OTAES-C Mission
7.4.2.1	5.4.4/5.4.5	Experiments & Launch Sys. C/O
7.4.2.2		Range & Mission Support
7.4.2.3		Mission Support for OTAES-C Exp.