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VIKING 75 PROJECT
SCIENCE REQUIREMENTS,
OBJECTIVES, AND CONSTRAINTS ON MISSION DESIGN

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Viking Project Office

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VIKING 75 PROJECT
SCIENCE REQUIREMENTS, OBJECTIVES, AND CONSTRAINTS ON MISSION DESIGN

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PREFACE

This document contains the Science Requirements, Objectives, and Constraints (SROC) on Mission Design which shall be utilized in the development of the preflight operational Mission Design. The document is limited to the definition of science requirements, objectives, and constraints on the preflight design of the trajectories, orbits, and flight sequences of events; that is, this document does not include science requirements on operations. The science requirements on operations will be documented in the Science Operations Requirements Document (SORD) - IR-3720154.

To aid the mission designer in using this document, both the requirements and objectives which are related to a specific topic are combined and listed under the heading of "Requirements and Objectives." The words "shall be, must, etc." are utilized to denote requirements and similarly, the words "it is desired that, should, etc." are used to denote objectives. The objectives are listed following the requirements and are usually a separate paragraph. A following section then lists "Additional Objectives." The objectives of a given investigation are therefore not prioritized. Any necessary prioritization will be accomplished through science team reviews during the preflight mission design process.

This document is approved with the recognition that the resources to implement the science requirements and objectives are fixed, and that it represents the current knowledge as to what requirements can be accommodated. If additional information shows that particular requirements cause a resource problem, a reevaluation and appropriate adjustment of the requirements will be necessary.

VIKING 75 PROJECT
SCIENCE REQUIREMENTS, OBJECTIVES, AND CONSTRAINTS ON MISSION DESIGN

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TBD/OPEN ITEM
STATUS OF 2/15/73

This TBD/Open Item section is under configuration control and therfore changes require VPO/CCB authorization. This section shall be maintained by the Viking Project Office.

The entry in the Responsibility column indicates the participant responsible to initiate action to complete the TBD/Open Item.

The due date column indicates the date by which concurrence to a document change by all affected project participants is required to complete the TBD/Open Item. Technical Coordination must precede this date.

Item		Responsibility	Due Date
1.	Paragraph 2.2 Establish Viking landing sites	VPO	April 16, 1973
2.	Paragraph 3.1.2.1.e.1 Establish the number of days between VIS monitoring of white cloud areas	JPL/VO	June 30, 1973
3.	Paragraph 3.3.1.1.b Establish requirements for interplanetary observations of Phobos and Deimos	JPL/VO	June 30, 1973
4.	Paragraph 3.5 Establish site certification and reconnaissance requirements		April 30, 1973
5.	Paragraph 3.7.1.1.g Establish scan platform alignment calibration procedures	JPL/VO	June 30, 1973
6.	Paragraph 4.0.1.a Develop Table 4.0.1-1 which lists sequence of surface sampler operations	VPO	April 30, 1973
7.	Table 4.2.1.1-1 Establish the list of imaging sequences for preflight mission design	VPO	April 30, 1973
8.	Paragraph 4.2.8.1.d.3.c Determine location for stereo viewing of acquired surface sample	VPO	April 30, 1973
9.	Paragraph 4.2.8.1.f.2.b Determine time required for SSAU to obtain surface temperature measurement	VPO	April 30, 1973
10.	Paragraph 4.2.10.1.c.5 Establish sample residence time in cavity prior to starting analysis sequence	VPO	February 23, 1973

EXCEPTIONS

The following is a list of exceptions to the requirements and objectives as stated in this document. These items will be addressed and when resolved, will be removed from this list through the Change Control System.

Item	Page	Para.	Exception	Organization
1.	3-14	3.2.5.1a & b	Continuous DRVID data cannot be obtained simultaneously with continuous range data using "discrete spectrum" ranging equipment.	JPL/MA&E
2.	3-22	3.6.2.1.b.1	A requirement is stated to "make MAWD high altitude observations once each orbit." It may be possible to accommodate this sequencing during orbits having sun occultations. Depending upon the relation between the orbit and the sun, it may be feasible to cover "all of the area surrounding the landing site for which both the incidence angle and the emission angle are less than 45 degrees." It is suggested that the requirement be delimited and more precisely stated.	JPL/MA&E
3.	3-32	3.7.1.1.e	The objective of Phobos and Deimos observations at appropriate opportunities cannot be satisfied without some optical navigation activity after MOI. Although the extent of this activity required is relatively modest, it has not been included in tne navigation planning or the software planning to date.	JPL/MA&E
4.	3-33	3.7.2.1.d	In the last sentence of the second paragraph, it is stated that low altitude swaths of MAWD data "are required on each pass." This will probably not be possible when trims are performed at periapsis. Also, since this requirement is for coverage "as high as possible" in latitude, spacecraft turns may be implied to extend the coverage as high as possible in latitude. Such turns would conflict with relay support and other VO sequences, so only that coverage which can be obtained while in celestial attitude should be required.	JPL/MA&E
5.	3-36	3.7.3.1.e	Same comments concerning Phobos and Deimos locations as for Para. 3.7.1.1.e above.	JPL/MA&E

EXCEPTIONS (Continued)

Item	Page	Para.	Exception	Organization
6.	3-38	3.7.4.1.1.a	The requirements for continuous range data for a full orbit from every third orbit may conflict with requirements for the return of orbiter science and lander relay data. The range code sufficiently suppresses high-rate link performance that the data return rate would probably be cut in half during periods when the range code is on. Full ranging on every third orbit would therefore absorb approximately one-sixth of the total high-rate data return capability of each orbiter.	JPL/MA&E
7.	3-38	3.7.4.1.1.b.1)	As with Para. 3.7.4.1.1.a above, it should be understood that meeting the requirement for continuous ranging adversely affects the return rate for other science data. During nonsynchronous orbit periods, this return rate may be at a premium.	JPL/MA&E
8.	3-38	3.7.4.1.1.b.1)	The paragraph calls for simultaneous ranging to two orbiters from one tracking station, which is not feasible with the planned DSN capabilities.	JPL/MA&E
9.	3-39	3.7.4.2.1.a.	This paragraph will require continuous ranging for about 24 out of every 36 hours from each orbiter, beginning on about September 10, 1976. Because of the suppression of high rate data resulting from the ranging signal, this requirement will absorb about one-third of the total high-rate data return capability of each orbiter after that date. It appears that this requirement will conflict with the return of required orbiter science and lander relay data.	JPL/MA&E
10.	4-4	4.2.1.b.4	Requirement has been increased by a factor of 10. Suggest rewrite as follows: Slow scan rate data at 0.25 KBPS shall be acquired during the lander mission in accordance with Table 4.2.1.1-1.	MMA/MA&D
11.	4-6	4.2.2.1.2.b		
			a) Two commands must be added to the input software command table to bypass "lamp on" step and to reenter sequence.	MMA/MA&D

EXCEPTIONS (Continued)

Item	Page	Para. Exception	Organization
11.	4-6	5.2.2.1.2.b - Continued b) Characterization of a PRS experiment conducted in the dark has not been done and is not within the scope of the present program. MMA support for data reduction or experiment characterization for an experiment conducted in the dark is unknown. c) Power prediction profiles should accommodate the change.	
12.	4-7	4.2.2.1.3.d - We have not verified via our subcontractor that a second injection can be made. The procedure should be verified, quantities of nutrient might need changing and software input must be provided for.	MMA/MA&D
13.	4-11	4.2.5.1.1.d - Eight vertical profiles are unrealistic since they cannot be done until after the second biology sample. All the other surface sample requirements cannot be met in conjunction with eight meteorology profiles.	MMA/MA&D
14.	4-12	4.2.6.1.1 - The Seismology Team takes exception to the lack of data buffer dump scheduling for Mission B.	Seismology Team
15.	4-15	4.2.7.1.a.1 - a) This paragraph is not compatible with paragraph 4.0.1. b) Sufficient data return capability is not always available to image the backhoe in all modes or imaging requirements conflict with other investigations.	MMA/MA&D
16.	4-16	4.2.7.1.a.2.a, c, and d - Same as 15 above.	MMA/MA&D
17.	4-18	4.2.8.1.a - All imaging requirements should be placed in Imaging Table 4.2.1.1-1.	MMA/MA&D
18.	4-18	4.2.8.1.c.1.c - Performed for the first and only time on sol 90.	MMA/MA&D
19.	4-19	4.2.8.1.c.1.b - Requirement has been substantially increased and should be included in the Surface Sampler Sequences table.	MMA/MA&D
20.	4-20	4.2.8.1.c.3.b - Same as 17 above.	

EXCEPTIONS (Continued)

Item	Page	Para.	Exception	Organization
21.	4-20	4.2.8.1.c.3.c	Same as 17 above.	MMA/MA&D
22.	4-20	4.2.8.1.d.3	Table 4.0.1-1 should be the only reference for surface operations and timing.	MMA/MA&D
23.	4-21	4.2.8.1.d.3.e	Same as 22 above.	MMA/MA&D
24.	4-21	4.2.8.1.d.5	Same as 22 above.	MMA/MA&D
25.	4-22	4.2.8.1.d.7	Same as 17 above and requirement has been substantially increased, especially the requirement for more boom movements.	MMA/MA&D
26.	4-23	4.2.8.1.f.1.b	New requirement is substantially higher than previous requirement and represents considerably more than just clarification.	MMA/MA&D
27.	4-23	4.2.8.1.f.2.c	It is not possible to satisfy the every 10-sol requirement with other magnetic and physical properties requirements. See Table 4.0.1-1.	MMA/MA&D
28.	4-28	4.2.10.1.b.4	The Physical Properties Team takes exception to the 70-sol waiting period before satisfying some of their requirements, considering this to be too severe a restriction on their investigation.	Physical Properties Team

CONTENTS

CONTENTS (Continued)

TABLES

FIGURES

1.0 INTRODUCTION

1.1 Purpose and Scope

This document defines

a. The detailed science requirements and constraints on mission design which must be met to satisfy the scientific objectives of the mission.

b. Mission design objectives whose satisfaction will enhance the scientific value of the mission.

The requirements, objectives, and constraints presented herein apply equally to Mission A and Mission B except as otherwise stated. In case of conflict between the mission design requirements specified herein and the system design requirements specified in approved project documents, the system design requirements shall govern.

1.2 Applicable Documents

1.2.1 General

The following applicable documents of the latest approved issue, or of the date shown, form a part of this document to the extent specified herein:

NASA Documents

None

Project Documents

M75-123	Viking Mission Definition (Appendix D to RS-3703001)
PL-3701026	Viking 75 Project Configuration Management Plan

System Level Documents

None

Military Documents

None

Other Publications

None

1.2 Applicable Documents (Continued)

1.2.2 Referenced Documents

The following document is referenced within this document for information only and is not to be considered part of this document.

M75-139 Physical Properties Investigation Requirements (Appendix A to SS 3703004)

1.3 Change Control

This document shall be maintained under VPO change control and all changes require the approval of the Change Control Board. Specifically, all requests for changes shall be submitted in writing to the Project Manager. These written requests shall include: (1) The current statement (including paragraph number) of the requirement, objective, or constraint which it is desired to change; (2) a proposed rewording of the statement; and (3) a brief paragraph summarizing the reason for the proposed change and referencing support technical data when available. The VPO will coordinate the evaluation of the proposed changes and issue revision pages for approved changes as required.

1.4 Abbreviations and Acronyms

CCS	Command Computer Subsystem
DRVID	Differenced Range Versus Integrated Doppler
DSN	Deep Space Network
DSS	Deep Space Station
EMA	emission angle
FMA	frame misalignment angle
GC	gas chromatograph
g	earth gravitational acceleration constant
INA	incidence angle
IR	infrared
IRS	infrared science (i.e., IRTM and MAWD)
IRTM	Infrared Thermal Mapper
JPL	Jet Propulsion Laboratory
km	kilometer
LCS	Lander Camera System

1.4 Abbreviations and Acronyms (Continued)

MAWD	Mars Atmosphere Water Detector
MOI	Mars Orbit Insertion
MTF	modulation transfer function
NASA	National Aeronautics and Space Administration
RF	radio frequency
RPA	Retarding Potential Analyzer
S/C	spacecraft
S/N	signal to noise ratio
sec	second
SEA	sun elevation angle
SROC	Science Requirements, Objectives, and Constraints
SSAA	surface sample acquisition assembly
SSCA	surface sampler control assembly
SSAU	Surface Sampler Acquisition Unit
TBD	to be determined
TDLR	Terminal Descent and Landing Radar
TDS	Tracking and Data System
UAMS	Upper Atmosphere Mass Spectrometer
UHF	ultra high frequency
V	velocity
VIS	Visual Imaging Subsystem
VL	Viking Lander
VLBI	Very Long Baseline Interferometry
VLC	Viking Lander Capsule
VO	Viking Orbiter
V-S/C	Viking Spacecraft

1.5 Definitions

Orbiter and Lander Observation Angles - Five interrelated angles shown in Figure 1.5-1 are used herein to specify the angular observation conditions for the orbiter or lander of a point on the planet surface:

Incidence Angle - The angle between the extended radius vector from the center of Mars through the point of interest on the surface and the vector from this point to the sun.

Emission Angle - The angle between the extended radius vector from the center of Mars through the point of interest on the surface and the vector from this point to the spacecraft.

Phase Angle - The angle between the vector from the point of interest on the surface to the sun and the vector from this point to the spacecraft.

1.5 Definitions (Continued)

Sun Elevation Angle - The angle between the horizontal plane at a specified point on the surface and the vector from this point to the sun. Unless otherwise specified, the point of interest is assumed to be the Lander or the landing site.

Convergence Angle - The included angle between the camera lines of sight to the center of the two swaths when making a stereo observation.

Sol - The period of time between consecutive VL midnights.

Day Numbering System - The day of landing is Sol Zero, and each subsequent Sol starts at local midnight, at the respective VL site. Each lander shall have its own local Sol number; for example, Sol_A18, Sol_B6.

Frame Misalignment Angle - A measure of the orientation of the field of view of any VO science instrument with respect to the apparent motion of the planet surface. For mission design purposes it is characterized adequately in Figure 1.5-2. The composite field of view of the instruments is shown, and the vector P1-P2 represents the apparent position in the field occupied by a particular surface point at two closely spaced instants. The frame misalignment angle is the clockwise angle from this vector to the line of symmetry of the fields of view.

Ground Track - The locus traced on the planet surface by the radius vector from the center of Mars to the orbiting spacecraft.

High Altitude Coverage - V-S/C and VO science measurements taken at altitudes equal to or greater than 5000 km.

Low Altitude Coverage - V-S/C and VO science measurements taken at altitudes less than 5000 km.

Maneuver - Any commanded V-S/C or VO attitude change or propulsive translation. A maneuver begins when the spacecraft leaves celestial references and ends with spacecraft reacquisition of celestial references.

Mission Design - The pre-flight design of the operational flight trajectories, orbits, and sequences of events.

Types of Landed Atmospheric Analysis -

Mode "a" (Unfiltered Analysis) - A single analysis performed without CO/CO_2 being removed from the sample.

Mode "b" (Filtered Analysis) - Two analyses performed consecutively such that: The first does not have CO/CO_2 removed from the sample; the second is performed after the CO/CO_2 is removed from the sample.

1.5 Definitions (Continued)

Types of VO Science Observations -

Photopair - A set of two pictures (image frames), one from each VIS camera, taken with the minimum time separation allowed by the VIS.

Tetrad - Two photopairs taken in succession by the VIS cameras with a scan platform slew between photopairs to provide an approximately square pattern of frames on the surface.

Pentad - A swath or strip of VIS pictures in which six frames are exposed and recorded but only five are read out so that only a single tape cell is utilized.

Swath - A continuous sequence of observations made by one or more of the VO science instruments with the scan platform in a fixed position and the spacecraft motion providing a linear coverage of the surface. If the data are being recorded, a swath is performed during one start-stop cycle of the tape recorder.

Strip - A continuous sequence of observations made by one or more of the VO science instruments with scan platform slews at appropriate intervals to provide a linear coverage of the surface. If the data are being recorded, a strip is performed during one start-stop cycle of the tape recorder.

Box Scan - A boustrophedonic sequence of observations, utilizing a continuous back-and-forth slew at low rate, with successive scans displaced to provide a rectangular pattern of coverage on the surface.

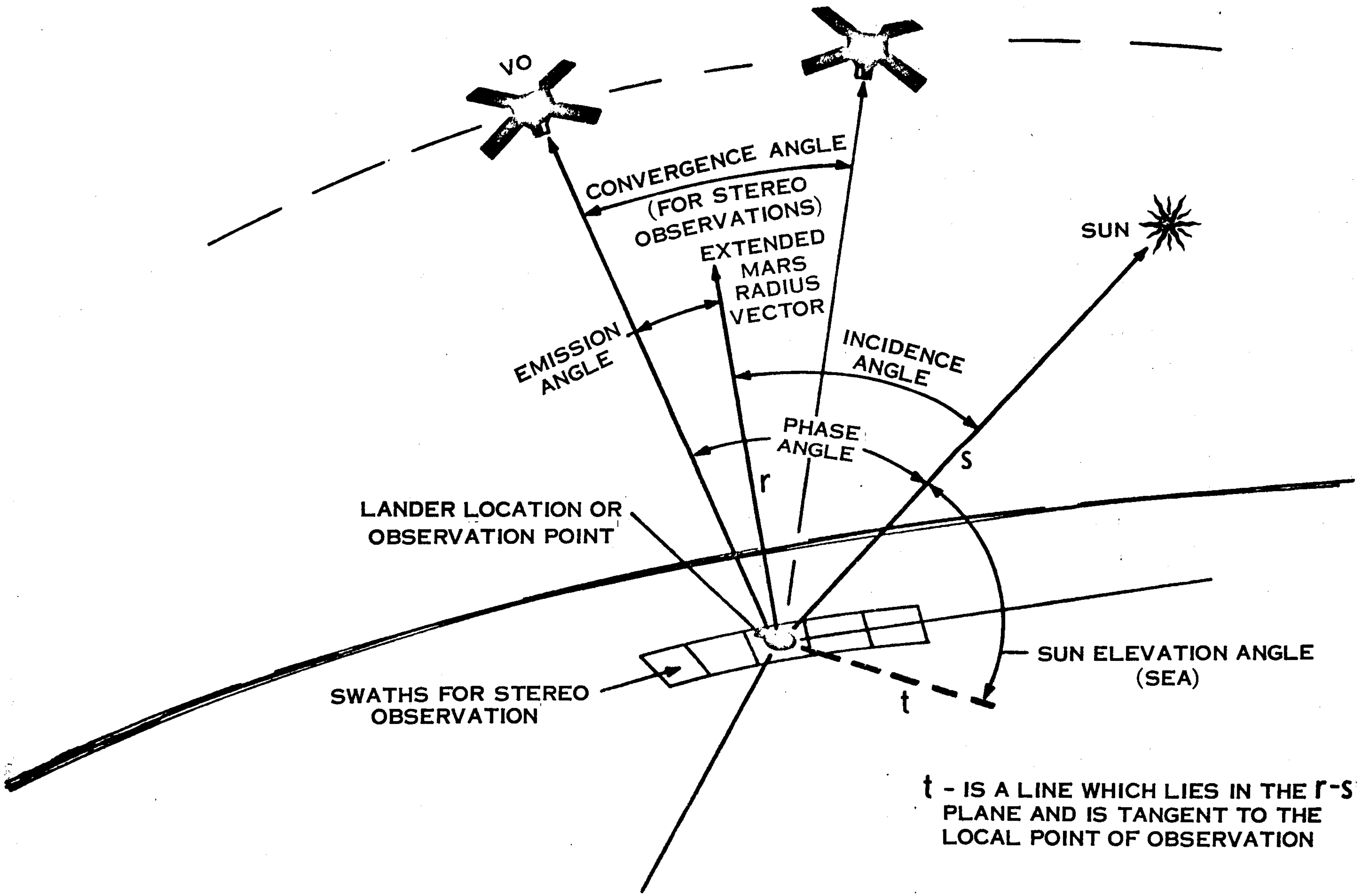

Figure 1.5-1

Orbiter and Lander observation angle relationships.

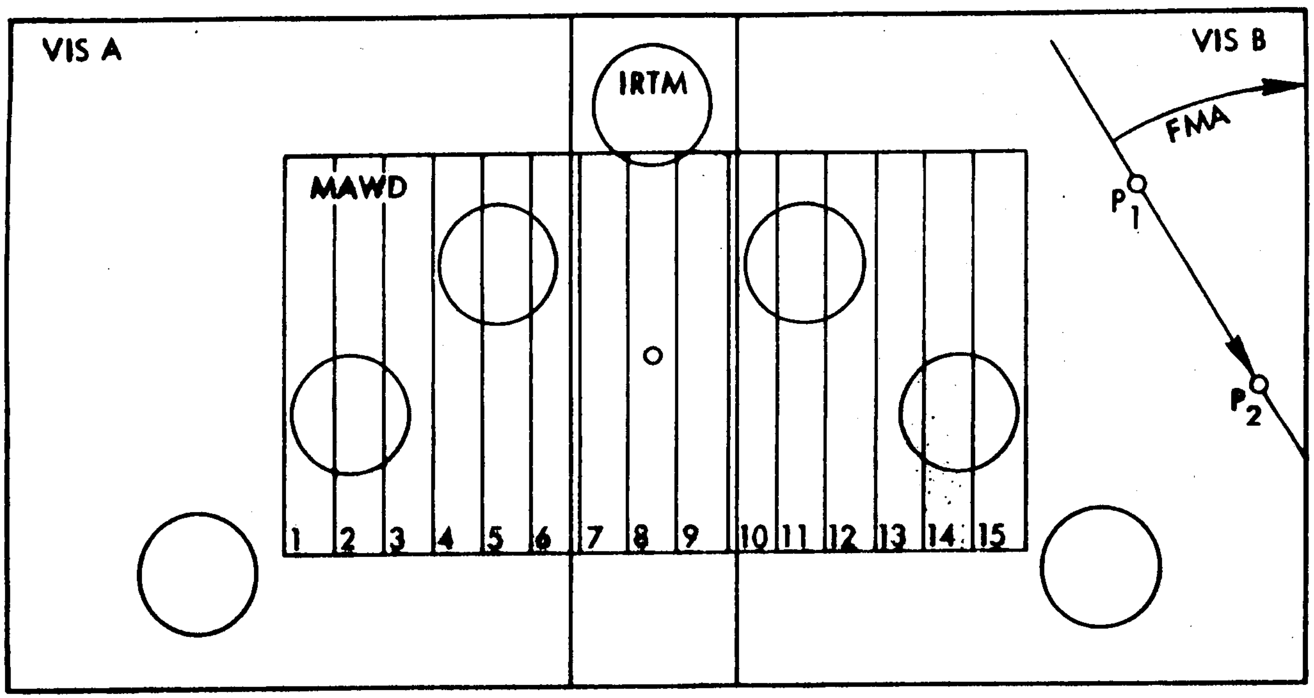

Figure 1.5-2

Diagram of composite fields of view of VO science instruments, illustrating definition of Frame Misalignment Angle (FMA). Points P_1 and P_2 represent the position of a spot on the surface of Mars at two closely spaced instants.

THIS DIAGRAM IS NOT TO SCALE.

2.0 GENERAL STRATEGY, REQUIREMENTS, AND OBJECTIVES

This section presents the science strategy, requirements, and objectives which are of general importance to the Mission Design.

2.1 Mission Design Concept

The Mission Design shall provide for a realistic dual-spacecraft mission utilizing preselected primary and secondary landing sites for each mission.

2.2 Landing Site Locations

TBD

2.3 Landing Site Certification

Both Viking Landers shall be set down in sites that have been observed by the science instruments on the Orbiters and certified as to probable safety and scientific productivity on the basis of these observations. The Mission Design related site certification requirements are included in Section 3.5 of this document.

2.4 Mission Design Strategy

2.4.1 Prelanding Strategy

Prior to the release of its VLC, each VO in orbit shall perform the following functions: correcting its orbit to that appropriate for landing, checking out and preparing the VL, and making observations with the science instruments. Its observations shall be restricted to those which provide a general view of the planet that contributes to understanding the conditions at the landing site; those which calibrate and check out the operations of science instruments, other VO subsystems, or ground systems; and those that provide information specifically about the landing site under as wide a variety of observational conditions as is feasible including the site certification observations.

2.4.1.1 Mission A Strategy

Orbiter A shall proceed expeditiously to get into its landing orbit and carry out its site certification, with particular emphasis on site safety, so as to land quickly. Following the landing it shall serve as a relay for lander data, and shall provide lander support as specified in Section 3.6. Without interfering with its primary goals, Orbiter A, prior to Mission B landing, shall provide site certification coverage of Mission B sites and additional observations of them to the extent that is feasible and justified. At an appropriate time after landing, Orbiter A shall desynchronize its orbit from the VL and observe regions on the planet not accessible from the synchronized orbit.

2.4 Mission Design Strategy (Continued)

2.4.1.2 Mission B Strategy

Orbiter B shall carry out its early observations and site certification on a more leisurely schedule to provide more thorough coverage and give greater weight to the scientific desirability of the landing site, while not downgrading safety considerations. Its post-landing strategy shall be similar to that of Orbiter A.

2.4.2 Initial VL Support

Immediately following each landing, the VO shall remain in synchronous orbit over its VL to provide data relay and observation of the landing site at least until verification of the following:

1) Reception at earth of good quality VL data via the direct telemetry link.

2) Reception of suitable quality imaging data from the initial rapid scan panorama and surface sample area survey defined in Table 4.2.1.1-1.

3) Acquisition of the second surface sample for the Biology, Organic Analysis and Inorganic Chemical Investigations, and reception of suitable quality imaging data of the sampled area both before and after sample acquisition.

4) Reception and acceptance of the data from the first two organic analyses and approval of the data by Science Analysis and Evaluation.

5) Photographic coverage of the landing site by the VO as defined in 3.6.1.1.a.

2.4.3 Subsequent VL Support

Except during periods of nonsynchronous Mars observations as specified in paragraph 2.4.4 or when prevented by orbit trim maneuvers, each VO shall provide a daily relay link for its VL in addition to making observations with all VO instruments of the landing site and its general vicinity as specified in 3.6 and other areas of the planet accessible for observation as specified in 3.7.

2.4.4 Mars Global Surveys

2.4.4.1 Global Observations

Each VO shall carry out a program of Mars observations by transferring to a nonsynchronous orbit to bring other portions of the planet under observation and resynchronizing over the VL after the periapsis has drifted once around the planet. One VO shall carry out an additional non-synchronous program, which may involve more complex orbit changes to enhance the coverage of specific areas. The scientific objectives of these three programs shall include:

2.4 Mission Design Strategy (Continued)

1) Mapping the water vapor distribution over the planet as completely as possible with the MAWD, with observation conditions as specified in paragraph 3.7.2.1.

2) Observation of the landing areas using all VO instruments as appropriate at as many different local times as possible, with the times of observation spaced no closer than hourly.

3) Mapping the predawn temperature distribution over the planet as completely as possible with the IRTM.

4) Observation with all VO instruments of selected areas of scientific interest defined in 3.7.

5) Radio Science measurements as specified in paragraph 3.7.4.1.1.b.

2.4.4.2 Timing of Global Surveys

It is desired that the first and last Mars global surveys be separated in time as far as is consistent with other constraints.

2.4.4.3 Relay Support During Global Surveys

If it is feasible, one VO shall provide data relay for both VL's when the other VO is out of range. Both VL's shall not be without relay support simultaneously.

2.4.4.4 Duration of Global Surveys

The duration of a global survey may be up to 25 sols provided that the synchronous VO is able to provide a total of 60 minutes of relay link per orbit to the two VL's. If this degree of relay support cannot be provided, then the global survey shall be limited to 15 sols.

3.0 VIKING SPACECRAFT AND ORBITER SCIENCE REQUIREMENTS, OBJECTIVES, AND CONSTRAINTS

This section defines the general V-S/C and VO science mission design requirements and objectives which apply to all phases of the V-S/C and VO science mission and the specific requirements, objectives, and constraints for various mission segments.

3.1 General

This section defines the V-S/C and VO science requirements and objectives which apply to all phases of the V-S/C and VO science mission except as specified.

3.1.1 VO Science Standard Operation Mode

3.1.1.1 Requirements and Objectives

a. Simultaneous VIS, MAWD, and IRTM Coverage

MAWD and IRTM data shall be acquired and stored whenever VIS data are acquired.

Whenever feasible in high altitude observations, additional IRS data should be acquired near the same time to provide coverage of approximately the same area that is covered by the VIS.

b. Simultaneous MAWD and IRTM Coverage

The MAWD and IRTM shall acquire data simultaneously for all observations of the sunlit portion of Mars.

c. MAWD and IRTM Calibration Sequences

IRS observations taken in conjunction with VIS observations shall include calibration sequences as defined in 3.1.2.6. IRS observations which extend longer than 2.5 minutes and are not associated with VIS observations shall contain at least two calibration sequences separated by at least 2.0 minutes.

3.1.1.2 Additional Objectives

a. Reduction of VIS Observation Overlap

As a general rule, when performing VIS observation sequences, excessive overlap of succeeding frames should be prevented without introducing gaps in the coverage. The use of small platform slews between frames may be used to accomplish this. As a goal, the scanning sequence should be chosen to provide sidelap and forelap values between zero and 1/4 degree as measured from the camera.

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3.1 General (Continued)

b. General MAWD and IRTM Coverage

1) On all periapsis passages when other operations or observations do not prevent it, it is desired that the MAWD and IRTM acquire two swaths of data near the ground track, centered on the periapsis or on the point nearest the lander, and each approximately 300 km in length. The emission angle along the entire swath should remain less than 30 degrees. When the VO is in synchronous orbit, the swaths on successive orbits should be approximately contiguous, that is, the goal should be to lay down swaths so that the slidelap for MAWD swaths is zero.

2) Whenever it is feasible, it is desired to make continuous observations with the MAWD and IRTM between ranges of approximately 2,000 and 6,000 km and intermittent observations between ranges of approximately 6,000 and 15,000 km. Slow scan platform slews should be used as appropriate to maximize the contiguous coverage of the surface.

3) At ranges beyond 15,000 km, it is desired to obtain frequent global coverage of the planet.

3.1.2 VO Science Standard Observation Types and Criteria

3.1.2.1 VIS Observation and Coverage Types

a. Low Altitude Observation Types - The five standard types of VIS observations to be used at low and intermediate altitudes are:

1) Simple - An observation consisting of the acquisition of pictures with a single filter in each camera.

2) Color - An observation consisting of two or more simple observations covering the same area with different filters.

3) Stereo - An observation consisting of the acquisition of two picture swaths (or strips) along the same path with a slew of the scan platform between swaths so that the two swaths cover as nearly as possible the same area on the planet. Between the camera lines of sight at the centers of the two swaths, the angle shall be approximately 25 degrees, and the bisector of the angle between these two lines shall make an angle of less than 12 degrees to the vertical.

4) Oblique - An observation with an emission angle greater than 60 degrees.

5) Limb - An observation consisting of the acquisition of pictures which include the edge of the planet (emission angle approximately 90 degrees).

3.1 General (Continued)

b. Low Altitude Coverage - Low altitude coverage by any of the types of observations should be acquired in a single orbiter pass if possible; otherwise, in a minimum number of consecutive passes.

c. Low Altitude Observational Criteria - The optimum observational criteria and the preferred range of these criteria listed in Table 3.1-1 shall be adhered to when performing low altitude VIS observations.

d. High Altitude Observation Types - Depending on the amount and shape of the area to be covered, a high altitude observation sequence can consist of a tetrad, a pentad, a strip, or a box scan. In each case small cone angle slews of the scan platform are required between photopairs or between frames to provide the required coverage and minimize the overlap. In special cases, a single photopair may be recorded, and, if only one frame is of interest, the other may not be read out.

e. High Altitude Coverage - Coverage for high altitude photography may be defined in terms of dimensions on the surface or in terms of phenomena to be observed. In the latter case, the coverage types are as follows:

1) White Clouds (W) - Take a pentad of an area from an altitude greater than 10,000 km in two colors at emission angles less than 60 degrees. Monitor each field approximately every TBD sols at a local time not earlier than 2 hours before noon. For each field, at three widely spaced times during the total mission, observe at several different hours of the same sol, with as broad a time span as permitted by the emission-angle limit.

2) Yellow Clouds (Y) - Take one photopair of an area from an altitude greater than 10,000 km and at emission angles less than 45 degrees. The two cameras are to have different filters, and a clock-angle slew is to be made between frames so as to maximize their overlap. Monitor each field approximately every 15 sols at the same hour of the Martian sol. For each field, at three widely spaced times during the total mission, observe at several different hours of the same sol, with as broad a time span as permitted by the emission-angle limit.

3) Variable Brightness Area (V) - Take one photopair of an area in one color (green) approximately every 15 sols. Each set of observations should sample three distributed values of air mass (secant of the emission angle) within a minimum time span on the same orbit if possible. One frame is to be read out to telemetry unless other constraints require both.

4) Surface Markings (S) - Take a photopair of an area in one color (minus blue) from a minimum altitude of 10,000 km with incidence and emission angles both less than 45 degrees. Observe each field at several widely spaced dates, reproducing the observation conditions as closely as possible.

3.1 General (Continued)

5) Low Elevation Areas (L) - Take a photopair of an area at emission angles less than 45 degrees. The two cameras are to have different filters, and a clock-angle slew is to be made between frames so as to maximize their overlap. Images very early and very late in the sol should be compared with midday images of the same sol. Observe each field on five dates distributed through the total mission.

6) Polar Regions, North (P) - Cover a narrow strip extending from latitude 80 to 90 degrees north in one color (minus blue) approximately every 15 sols. Choose the time and the longitude of observation so as to minimize the sum of the incidence angle and emission angle at +85 degrees latitude near the middle of the time period in the mission over which the observations can be made. At three widely spaced times during the total mission, obtain the same coverage in four colors. Use the two Orbiters to accomplish these objectives on two different sides of the north polar region.

7) Polar Regions, South (P) - Cover a narrow strip extending from latitude 36 to 60 degrees south in two colors (blue and red) approximately every 15 sols. Choose the time and the longitude of observation so as to minimize the sum of the incidence angle and emission angle at -50 degrees latitude near the middle of the time period in the mission over which the observations can be made. At three widely spaced times during the total mission, obtain the same coverage in four colors. Use the two Orbiters to accomplish these objectives on two different sides of the south polar region.

3.1.2.2 MAWD Observation Types

a. Low Resolution Global Coverage

The general distribution of water vapor is obtained by scanning the entire illuminated disk either at altitudes between 5,000 and 15,000 km in orbit or during the approach. The scan should be repeated over three or more equally spaced longitudes so as to cover the whole illuminated planet within a few sols.

b. Seasonal Variations

The seasonal variation of the general water vapor distribution is obtained by making the approach observations described in a. above and repeating the observations once or twice in orbit with the longest feasible time intervals between.

c. High Resolution Global Coverage

MAWD coverage of the whole planet in longitude and as large a range of latitude as possible, at the best spatial resolution consistent with near contiguity (i.e., with gaps between adjacent fields of view smaller than the width of the instantaneous FOV). The observations should be made at a fixed local time, preferably during the first two afternoon hours. (This is the most important class of MAWD observations.)

TABLE 3.1-1

Criteria for VIS Low Altitude Observations

		Optimum Angle, degrees or Range, km	Preferred Angle, degrees or Range, km
Simple (Low-sun)	Incidence angle	65	45 - 80
	Emission angle	0	<30
	Range	<1500	<3000
Simple (High-sun)	Incidence angle	0	<45
	Emission angle	0	<30
	Range	<1500	<3000
Color	Incidence angle	0	<30
	Emission angle	0	<30
	Range	<1500	<3000
Stereo	Incidence angle	65	45 - 75
	Mean emission angle	0	<12
	Convergence angle	25	20 - 30
	Range	<1500	<3000
Oblique	Incidence angle	45	20 - 70
	Emission angle	75	>60
	Range	<2800	<5000
Limb	Incidence angle	0 - 90	0 - 90
	Emission angle	90	90
	Range	any	any

3.1 General (Continued)

d. Diurnal Variations

Diurnal variations in water vapor over a selected region are determined by making observations of the region at three or more times through the sol, particularly from 4 hours before to 4 hours after local noon.

e. Latitudinal Variations

Latitudinal variations in water vapor are determined by combining observations of a selected meridian from low and intermediate altitudes within less than 30 sols. The observations should all be made close to local noon and should extend as far north and south as possible.

f. Occultation Measurements

The vertical distribution of water vapor is measured by observing the illuminated diffusing plate while entering and emerging from solar occultation.

g. Spectral Scanning

The spectral scanning mode of the MAWD is a calibration to provide verification of the correct functioning of the wavelength servo system and to aid in the initial analysis of the data in the normal mode. The spectral scanning mode can also give an indication of the equilibrium state of the water vapor and the abundances of water isotopes if a flat area of the Martian surface can be observed throughout the sequence.

3.1.2.3 MAWD Observation Criteria

a. MAWD observations shall be made with incidence and emission angles both less than 80 degrees.

b. The preferred conditions for all MAWD observations are incidence and emission angles both less than 45 degrees.

c. For low altitude MAWD observations, the preferred and optimum conditions are:

1) Emission angle: less than 45 degrees preferred, 0 degree optimum.

2) Range: less than 2,500 km preferred, as low as possible down to 1,200 km optimum.

3) Local time: from 0 to 3 hours after noon preferred, 2 hours past noon optimum (with the exception of diurnal observations).

4) Frame misalignment: less than 30 degrees preferred, 0 degrees misalignment optimum.

3.1 General (Continued)

3.1.2.4 IRTM Observation Types

a. Diurnal Coverage

Diurnal coverage is obtained by observing an area on the Martian surface at a set of the local times listed below.

The preferred local times at the point of observation are listed in order of decreasing preference. If observations at more than four local times are planned, those other than "predawn" and "peak temperature" should be spaced approximately evenly throughout the remaining accessible range of local times.

1) Predawn: After midnight local time and before sunrise. (Optimum: As late at night as possible up to within 2 degrees VO-centered angle from the morning terminator.)

2) Peak temperature: Between noon and 2 hours after noon local time. (Optimum: Between 0.5 and 1.5 hours after noon local time.)

3) Evening: Between sunset and the midpoint in time between sunset and midnight. (Optimum: Between 1 hour after sunset and 40 percent in time between sunset and midnight.)

4) Early morning: Between 1 hour after sunrise and the midpoint in time between sunrise and noon.

5) Late afternoon: Between 3/4 and 1-3/4 hours before sunset.

b. Global Coverage

IRTM global coverage consists of a nearly continuous sequence of IR observations, normally made approximately an hour or more from periapsis, made by moving the scan platform continuously in a box-scan pattern at 1/4 degree per second such that a major portion of the planet is viewed by the IRTM. When in synchronous orbit, global coverage may be divided into a few parts obtained at similar times on successive orbits.

c. Polar Latitude Strip

Coverage along approximately constant longitude between the center of the polar cap and at least 10 degrees latitude off the edge of the frosted area. Data may be obtained in multiple strips which overlap in latitude if this would achieve better viewing conditions than a single strip would provide. The highest spatial resolution is desired.

d. Polar Mapping

Coverage of the accessible portion of the region within 20 degrees latitude of the pole at the highest resolution attainable.

3.1 General (Continued)

e. Emission Phase Function

Observations of an area on a single pass over a range of emission angles through near zero up to at least 70 degrees on one side and preferably up to 80 degrees on both sides. The total elapsed time should be minimized.

f. Satellite Observation

Observations consisting of one or preferably several drifts across the satellite (not slewing) separated by small slews to reposition ahead of the satellite. It is highly desirable that at least one VIS picture be taken when the satellite is expected to cross the IRTM array. The IRTM should be in fixed planet or space mode with a "restore" commanded at the beginning and the end of the sequence, when the satellite is 2 to 5 degrees from the nearest IRTM detector.

g. High Temperature Coverage

Observation of surface areas having incidence angles less than 45 degrees. The highest spatial resolution is desired.

h. Sunrise Coverage

Repeated coverage of an area on the Martian surface over the period from incidence angle 91 degrees to incidence angle 80 degrees or 1 hour after sunrise, whichever occurs first. Observations should be spaced so that no gaps greater than 2 degrees incidence angle or 15 minutes local time occur.

i. Sunset Coverage

Repeated coverage of an area over the period from 85 degrees incidence angle or 30 minutes before sunset, whichever occurs last, to incidence angle 100 degrees or 1 hour after sunset, whichever occurs first. Observations should be spaced so that no gaps greater than 2 degrees incidence angle or 15 minutes local time occur.

j. High Resolution Coverage

Near-periapsis coverage of an area near the ground track using the VO orbital motion combined with platform slews to provide coverage of an approximately rectangular area.

3.1.2.5 IRTM Observation Criteria

a. Observations of an area are desired both at night and during the sol (preferably near noon).

3.1 General (Continued)

b. If repeated coverage of an area is obtained at similar local times on nearly successive sols, it is desired to obtain this coverage over a range of emission angles.

c. In the absence of other criteria it is desired to maximize IRTM resolution; i.e., to maximize the ratio of the cosine of the emission angle to the range.

d. During IRTM observations, it is desired that the planet-port look direction be at least 15 degrees from all parts of the spacecraft. When an IRTM restore is scheduled to occur, the space-port look direction should be at least 15 degrees from all parts of the planet or other bright object (Sun, Jupiter, Phobos, Deimos, or VO structure). Where practicable, small platform slews or alterations to the IRTM mode or restore commands may be used to accomplish the latter objective.

3.1.2.6 IRS Header

At the beginning of every VIS data acquisition sequence, IRS data shall be recorded for at least 2 minutes. The data shall consist of at least two calibration sequences for both MAWD and IRTM, one preceding and one following a small three-swath box scan such that an area larger than a VIS pentad is covered by both instruments. The first VIS exposure shall follow immediately after the last calibration sequence.

3.1.2.7 IRTM Zero Calibration

On approximately every third orbit, within an hour after the completion of a sequence of IRTM observations, the instrument shall acquire data for at least one minute while viewing space through the space port and again while viewing space through the planet port. In each case the line of sight shall be at least 15 degrees from the nearest limb of Mars or other bright object (Sun, Jupiter, Phobos, Deimos, or VO structure).

It is desired that this calibration sequence be performed as soon as possible after the observation to assure minimum change to the thermal environment.

3.2 Interplanetary Cruise

During interplanetary cruise, the operation of the VIS, MAWD, and IRTM shall be checked out, their calibrations and alignments shall be verified, and Radio Science Measurements shall be performed as defined in this section. These operations shall be accomplished prior to initiating the planetary approach measurements defined in Section 3.3 unless otherwise specified. None of these operations shall interfere with midcourse maneuvers.

3.2 Interplanetary Cruise (Continued)

3.2.1 Instrument Protection and Checkout

3.2.1.1 Requirements and Objectives

a. Initial MAWD Heater Operation

The heater for the MAWD radiator shall be turned on approximately 2 hours prior to launch and shall remain on continuously for a minimum of 30 earth days.

b. VIS, MAWD, and IRTM Checkout Operations

As early as the telemetry capability permits (preferably between 30 and 40 earth days after launch), the VIS, MAWD, and IRTM shall be turned on and shall acquire data in all data modes to check on the operation of the instruments and any possible interference between them. The exercise shall include at least the following operations:

1) MAWD radiator heater turn-off approximately 24 hours prior to MAWD power turn-on.

2) Power turn-on to all instruments at least 3 hours prior to data acquisition.

3) Acquisition of MAWD and IRTM data while the scan platform is moving at both slew rates over the accessible range of cone and clock angles consistent with thermal constraints.

4) Recording of one picture from each VIS camera with a high-rate platform slew during picture recording.

3.2.2 VIS Calibration and Alignment Verification

3.2.2.1 Requirements and Objectives

a. Scan Platform Alignment Calibration

1) The scan platform alignment with respect to celestial coordinates shall be calibrated during the cruise phase by taking pictures with each VIS camera of appropriate star fields with the V-S/C on celestial lock. A preliminary calibration sequence and a final calibration sequence at least 7 days later is required.

2) The targets shall be chosen so that the complete range of clock and cone angles available with the VLC in place is uniformly covered. The preliminary sequence shall consist of, at least, a tetrad at each of six star fields having at least two stars brighter than magnitude 6.0. The final sequence shall photograph at least twenty and preferably thirty star fields, including at least four around the direction of Mars during approach.

3) The preliminary calibration is required prior to attempting any of the other calibration operations specified in paragraph 3.2.2 except 3.2.2.1.b.3 (reseau photopair).

3.2 Interplanetary Cruise (Continued)

b. VIS Geometric Calibration

The geometric calibration of each VIS camera shall be verified once during the cruise phase by means of the following procedures. This calibration is required prior to any use of the VIS for approach guidance.

1) For each camera, at least 6 pictures shall be taken of a star field containing at least 7 stars brighter than magnitude 6.0 within an area between one-half and one times the field of view. An image is "usable" for analysis only if it contains at least three identifiable star images. The composite of all "usable" frames from one camera shall contain at least 30 stars with approximately uniform distribution over the field of view.

2) The sequences specified in a. above shall provide at least one photopair, taken without slewing between frames, having at least two star images in each frame.

3) One photopair with all reaseau marks visible should be taken if camera mechanization permits.

c. VIS Photometric Calibration

The data to provide a partial photometric calibration of the two cameras shall be acquired by multiple photography at constant exposure of a bright planet during the cruise phase. A sequence of 42 photopairs with each of two filters shall be taken with 1/4 degree scan-platform steps between frames so that the successive images cover the VIS composite field of view as shown in Figure 3.2-1.

It is desired that the photometric calibration be performed as late in the cruise phase as possible.

d. VIS Photometric Response Linearity

The linearity of photometric response shall be verified once for each VIS camera by acquiring 10 pictures of a bright planet at different exposures with each of three filters.

e. VIS Camera Boresight Offset

The boresight offset of the two VIS cameras shall be calibrated by analysis of at least one photopair, without slewing between frames and containing at least two star images in each frame. These data may come from the observations specified by paragraphs 3.2.2.1.a or b.

3.2.3 MAWD Calibration and Alignment Verification

3.2.3.1 Requirements and Objectives

The MAWD alignment shall be verified by one observation of Mars between MOI-25 days and MOI-15 days, simultaneous with the acquisition of a VIS photopair. The MAWD shall be in the wavelength calibration mode.

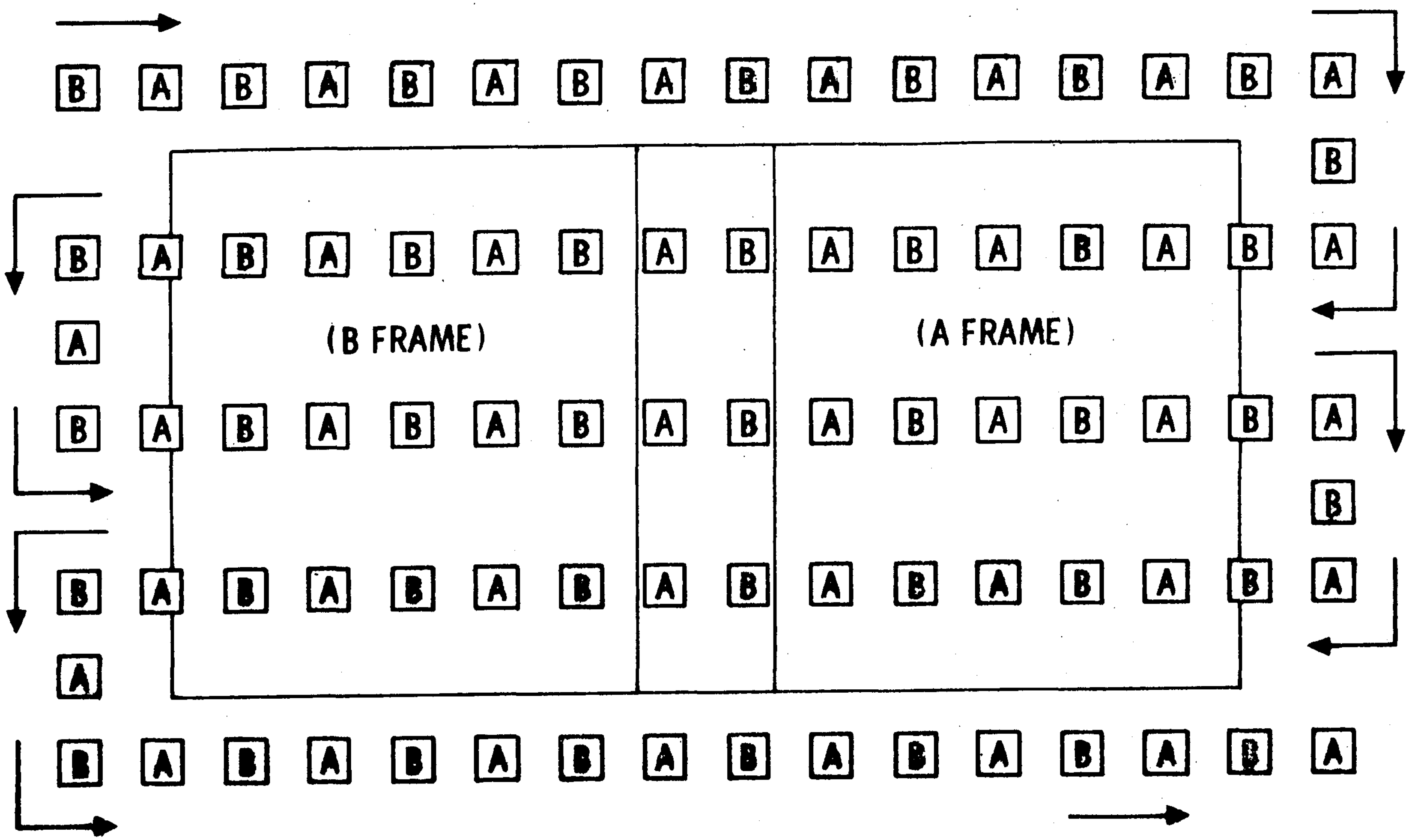

Figure 3.2-1

Scanning pattern for VIS photometric calibration.

The squares indicate the successive positions relative to the photopair field of view at which the planet should be targeted while the camera indicated by the letter is shuttered.

3.2 Interplanetary Cruise (Continued)

3.2.4 IRTM Calibration and Alignment Verification

3.2.4.1 Requirements and Objectives

a. Thermal Interference Calibration

The thermal interference of the spacecraft and the lander support structure shall be calibrated as early as feasible by operating the IRTM in its normal data mode after a 3-hour warmup while the scan platform slews at the slow rate over the range of cone and clock angles expected to be used prior to capsule separation.

It is desired to repeat this calibration within 30 days before planet encounter.

b. Alignment Verification

The IRTM alignment shall be verified by obtaining several slow slews across Mars at a time when its diameter subtends an angle between 4 and 10 milliradians. At least one VIS picture shall be taken when Mars is expected to cross the IRTM array. The IRTM should be in the fixed-planet mode. (This operation will occur during the planet approach phase.)

3.2.4.2 Additional Objectives

a. Determination of Off-Axis-Response

It is desired that the IRTM off-axis response be determined by observing Mars (1) when its diameter subtends an angle of 5 ± 1 milliradians, and (2) again when its diameter subtends an angle of 25 ± 5 milliradians. Data are to be taken on closely spaced 1/4 degree per second box scans, concentric squares, and cross patterns over square areas centered on Mars which are approximately (1) 10 and (2) 20 degrees on a side. The planet view must be at least 15 degrees from all spacecraft structure. The IRTM should be in the fixed-planet mode. (The conditions necessary to conduct these operations will occur during the interplanetary and approach phases.)

b. Operation and Warmup Time for Jupiter Observations

If photographs of Jupiter are acquired by the VIS, the IRTM should be operated in its normal mode after at least a 3-hour warmup.

c. Satellite Observation Simulation

It is desired to simulate possible observations of Phobos or Deimos by observing Mars when its apparent diameter is approximately 2 milliradians. Data should be obtained during several small, slow linear slews, separated by 1/4 degree slews, such that a region at least 2 degrees cone by 3 degrees clock angle centered on the planet is covered. The IRTM should be in the fixed-planet mode.

3.2 Interplanetary Cruise (Continued)

3.2.5 Radio Science

3.2.5.1 Requirements and Objectives

a. Doppler and Range Data

1) One full DSS pass of S- and X-band Doppler and range data shall be obtained for each V-S/C approximately every third day as soon as communications through the high-gain antenna can be established.

2) During the last 30 days before MOI, it is desired to increase the coverage in a. above to one of every two possible full DSS passes.

3) Continuous S- and X-band Doppler and range data for up to five days are desired when solar events of significant magnitude occur.

b. S-Band DRVID

Continuous S-band DRVID is desired for all Doppler tracking periods.

3.3 Planetary Approach Science Observations

During planetary approach, the VIS, MAWD, and IRTM are to make the Mars surface observations specified herein to the extent possible without interfering with optical approach guidance, MOI maneuver and related operations.

3.3.1 Imaging

3.3.1.1 Requirements and Objectives

a. Mars Observations

One image of Mars shall be taken approximately every 4 hours during the period from MOI-120 hours to MOI-20 hours.

Between MOI-120 hours and MOI-50 hours, it is desired to take an image of Mars with each of three filters approximately every 4 hours, to provide complete surface and atmospheric coverage of the planet at all longitudes.

After MOI-50 hours, it is desired to acquire one photopair or one tetrad of Mars with a single filter at intervals chosen to provide coverage of all longitudes during one planet rotation.

It is desired to read out the stored data as rapidly as practicable.

3.3 Planetary Approach Science Observations (Continued)

b. Phobos and Deimos Observations

TBD

3.3.2 Water Vapor Mapping

3.3.2.1 Requirements and Objectives

The MAWD shall acquire data in the wavelength calibration mode simultaneous with each of the VIS sequences specified in paragraph 3.3.1.

On one MAWD observation not earlier than MOI-50 hours, it is desired that the raster scan direction be parallel to the terminator of the planet and the midpoint of the MAWD scan be centered on the illuminated portion of the disk.

3.3.3 Thermal Mapping

3.3.3.1 Requirements and Objectives

The IRTM shall acquire Mars data simultaneous with each of the VIS sequences specified in paragraph 3.3.1.

It is desired that the IRTM cover the entire planetary disk at the low slew rate with the subspacecraft point near six equally spaced longitudes around Mars as near to MOI as possible.

3.4 Preliminary Landing Area Reconnaissance

It is desired that the mission design provide the maximum opportunity for preliminary reconnaissance of landing areas prior to site certification without interfering with the activities to establish the proper Martian orbit.

3.4 Preliminary Landing Area Reconnaissance (Continued)

3.4.1 Imaging

3.4.1.1 Requirements and Objectives

a. Early Surface Observation

Near periapsis on Rev 1 of Mission A the VIS shall perform stereo observation of an accessible area on the surface. The two swaths shall contain at least 5 photopairs each, and the data shall be read out as quickly as possible to provide practice in and verification of the ground data handling and analysis techniques.

b. Orientation and Alignment Verification

The scan platform alignment and the camera boresight offset shall be verified as soon as practicable after MOI.

1) Scan platform alignment verification requires photographs of at least six star fields covering the clock and cone range of the scan platform. If recalibration should be found necessary, it will be similar to the final sequence of paragraph 3.2.2.1.a.2.

2) Camera boresight offset verification or recalibration requires the same data as specified in paragraph 3.2.2.1.e.

3.4.1.2 Additional Objectives

a. Low Altitude Coverage

It is desired to build up photographic coverage of the primary and secondary landing sites by observations at low altitude with an emission angle less than 45 degrees. The number of images acquired is to be limited by the following constraints:

1) It is desired to limit the quantity of low altitude coverage to assure high altitude coverage of the primary site.

2) No imaging sequence shall fill the tape recorders so completely as to preclude daily high altitude coverage of the primary site.

3) Primary-site data shall not displace previously recorded primary-site data that have not been read out.

4) Data on secondary sites shall not displace previously recorded primary site data or approach data that have not been read out.

3.4 Preliminary Landing Area Reconnaissance (Continued)

5) The quantity of data recorded is to be matched to the expected capacity for playback prior to the orbit synchronization based upon the use of the highest telemetry rate that maintains a bit error rate no worse than 1/100. (Note, however, that a lower bit error rate is required for IRS data.)

b. High Altitude Coverage

1) On every orbit for which there is an opportunity for high altitude viewing of a sunlit primary or secondary landing site, it is desired to obtain three photopairs covering the site, each with a different filter. These pictures should be obtained when the emission angle is near its minimum value.

2) If a site remains sunlit and observable at an emission angle of less than 60 degrees, it is desired on at least one orbit to repeat the sequences at intervals of about 2 hours.

c. Oblique Observations

On every orbit for which there is an opportunity to view a sunlit primary or secondary landing site at an emission angle greater than 60 degrees, it is desired to obtain VIS coverage of the site and the atmosphere above it to determine the clarity of the atmosphere.

3.4.2 Water Vapor Mapping

3.4.2.1 Requirements and Objectives

a. Near periapsis on Rev 1 the MAWD shall observe an accessible area on the surface under the most favorable viewing conditions available in order to provide practice in and verification of the ground data handling and analysis techniques.

b. It is desired to make MAWD observations of the surface whenever it is operationally feasible and observation conditions are favorable. Areas to be observed are, in decreasing order of priority:

1) Primary and secondary landing areas covered by the VIS observations specified in 3.4.1.2.b.

2) Areas of scientific interest listed in Table 3.7-3 that may become accessible.

3) The subspacecraft track, if illuminated.

4) A portion of the lighted disk having an emission angle near the minimum available.

3.4 Preliminary Landing Area Reconnaissance (Continued)

3.4.3 Thermal Mapping

3.4.3.1 Requirements and Objectives

a. Near periapsis on Rev 1 the IRTM shall observe an accessible area on the surface under the most favorable viewing conditions available in order to provide practice in and verification of the ground data handling and analysis techniques.

b. If the preliminary orbits permit, the IRTM shall obtain coverage of the entire 3σ landing dispersion ellipse at the primary site over as wide a range of local times as practicable (diurnal coverage). Pre-dawn observations shall have the highest priority.

c. Landing Area Coverage

It is desired that the IRTM make observations of the primary landing area and of other potential landing areas at several local times as specified in 3.1.2.4.a.

d. Other Coverage

It is desired that the IRTM make observations of Mars whenever the planet is accessible at altitudes less than 15,000 km. Areas to be observed are, in decreasing order of priority:

1) Potential landing areas, with regard to the criteria in paragraph 3.1.2.5.

2) Areas of IRTM interest listed in Table 3.7-4 that may become accessible.

3) Other areas chosen with regard to the criteria of paragraph 3.1.2.5.

3.5 Site Certification and Reconnaissance

This section defines the detailed V-S/C science requirements and objectives necessary to satisfy the overall Mission A and B site certification requirements and objectives. (See paragraph 2.3.)

TBD

3.5 Site Certification and Reconnaissance (Continued)

3.5 Site Certification and Reconnaissance (Continued)

3.6 Post-Landing Observations of the Landing Areas

This section defines the VO science requirements and objectives for post-landing observations of the landing sites and their vicinity by either VO whether in a VL-synchronous orbit or not. All time intervals specified are to be considered approximate.

3.6.1 Imaging

3.6.1.1 Requirements and Objectives

a. Low Altitude Coverage

1) Observation of the area within 150 km of the VL that was not covered prior to landing shall be completed before the initial desynchronization of the orbit. This coverage shall consist of simple observations with a single filter.

2) It is desired that colorimetric coverage with two filters over the area within 100 km of each VL be obtained at 30-sol intervals.

3) Stereo coverage of that area within 30 km of the VL that was not covered prior to landing is required to be completed before the initial desynchronization of the orbit.

b. Oblique Observations

Within the geometric constraints of the orbit, an oblique observation of area around each VL shall be made at 3-sol intervals, preferably at high altitude.

c. High Altitude Observations

1) Within the geometric constraints of the orbit, the area around each VL shall be photographed at a time between the occurrence of minimum incidence angle and minimum emission angle at 3-sol intervals.

2) Diurnal Variation Monitoring

It is desired to obtain one pentad centered on the lander approximately every 2 hours throughout the period of its visibility at 30-sol intervals.

3) Extended Landing Area Monitoring

It is desired to obtain up to 30 images spaced to cover as much area around the landers as can be usefully obtained at 30-sol intervals.

4) Cloud Layer Monitoring

At 15-sol intervals it is desired to obtain four pictures with each of two filters depicting the lighted limb and the atmosphere over each VL, with the pictures spaced over the length of the limb.

3.6 Post-Landing Observations of the Landing Areas (Continued)

3.6.2 Water Vapor Mapping

3.6.2.1 Requirements and Objectives

a. Low Altitude Coverage

1) Observation of all the area within 150 km of the VL shall be made prior to the initial desynchronization of the orbit. Preferably all these observations should be accomplished within a 5-sol period or less.

2) When in synchronous orbit over the VL, it is desired to obtain nearly contiguous coverage of as large an area around the VL as possible in the minimum number of orbits. This coverage should be obtained at emission angles no greater than 30 degrees, and should be repeated at approximately 20-sol intervals.

b. High Altitude Coverage

1) The MAWD shall make high altitude observations once each orbit of all the area surrounding the landing site for which both the incidence angle and the emission angle are less than 45 degrees.

2) Greatest emphasis should be placed on the determination of diurnal variations by observations of the landing area throughout the period of visibility. The observation should be repeated at intervals not greater than 2 hours on as many orbits as possible.

c. Variable Emission Angle Coverage

MAWD data should be acquired during the IRTM emission phase function sequence defined in 3.6.3.1.b.

d. MAWD Calibrations with Diffuser Plate

MAWD data acquisition with the field of view centered on the diffuser plate for a full 4.8-minute normal scan are required at approximately 15-sol intervals on each VO. Two widely spaced sequences with each VO should be for the full 24-minute wavelength scan.

3.6.3 Thermal Mapping

3.6.3.1 Requirements and Objectives

a. Landing Site Coverage

1) The IRTM shall obtain high-resolution coverage of an area approximately 100 km in radius around each landing site at least once during the mission when in synchronous orbit. It is desired that this coverage extend to 400 km in radius.

3.6 Post-Landing Observations of the Landing Areas (Continued)

2) It is desired that the IRTM obtain diurnal variation coverage of each landing site, including at least the five local times listed in 3.1.2.4.a, both early and late in the mission.

3) At approximately 10-sol intervals when in synchronous orbit, the IRTM shall obtain at least one high-resolution strip or swath approximately 200 km long aimed to cross the landing site. It is desired that an area approximately 200 km radius around the lander be covered by as many additional equally spaced (not necessarily contiguous) swaths or strips as is practicable on a single pass.

b. Variable Emission Angle Coverage

Once during the mission the emission phase function should be determined as specified in 3.1.2.4.e, using a landing site as the target.

c. Thermal Emission Calibration

1) It is required that the IRTM measure the background of thermal emission from the VO following VLC separation by making observations of space over all cone/clock angles planned for use during the rest of the mission. This requirement can be satisfied by scans at either slew rate around the limits of accessible cone/clock angles with the mirror in the planet position and in the space position. Throughout the data acquisition sequence, both the space view and the planet view of the instrument shall be at least 15 degrees from the planet. These data shall be obtained as soon after VLC separation as is feasible (within a few orbits).

2) It is desired to perform these calibration sequences as soon after periapsis passage as practicable.

d. Diffuser Plate Observations

It is desired that the IRTM view the MAWD diffuser plate with the albedo telescope at approximately 15-sol intervals on each VO. Data acquisition duration should be at least 80 seconds with calibration sequences preceding and following.

3.7 Post-Landing Mars Observations

This section defines the VO science requirements and objectives for post-landing observations by either orbiter not specifically intended to include the landing site.

3.7.1 Imaging

3.7.1.1 Requirements and Objectives

a. Low Altitude Observations

1) Observational Areas of Interest

Prime targets for low altitude photography are listed in Table 3.7-1, and their precise positions and shapes are shown

TABLE 3.7-1

PRIME TARGETS FOR VIS LOW ALTITUDE PHOTOGRAPHY

No.	Long.	Lat.	Name	Priority	Stereo	Color
1	177	10S	Plains/cratered terrain, Mesogaea	1		
2	173	23N	Knobby terrain, Amazonis	1		
3	165	3N	Dissected plains	2		
4	166	21S	Cratered terrain	2		
5	163	52S	Patterned cratered terrain	2		
6	151	5S	Channel, Mesogaea	1		
7	151	21S	Fractured cratered terrain	2		
8	145	23N	Grooved terrain	1		
9	143	33N	Grooved terrain/fractured terrain	1		
10	139	34S	Upland plains	2		
11	136	39N	Fractured terrain	1		
12	134	28N	Nix Olympica	1	X	
13	125	11N	Fractured terrain	2		
14	120	63N	Patterned cratered terrain	1		
15	120	9S	South Spot	1	X	
16	113	1N	Mid Spot	2		
17	113	45N	Arcadia ring	1	X	
18	106	25S	Phoenicus Lacus fracture system	1	X	
19	104	11N	North Spot	1	X	
20	96	25N	Domes	1		X
21	95	5S	Labyrinth	1	X	
22	81	52S	Multi-ring basin	2	X	
23	80	48N	Fractured terrain	1	X	
24	60	13S	Coprates canyon	1	X	X
25	65	25N	Channeled plateau	1	X	X
26	56	8N	Cratered plateau	2		
27	57	56S	Argyre rim	2		X
28	40	29S	Channel	1	X	
29	33	43S	Argyre rim	1	X	

TABLE 3.7-1 (Continued)

No.	Long.	Lat.	Name	Priority	Stereo	Color
30	25	58N	Mottled cratered plains	1		X
31	342	57S	Patterned cratered plains	2	X	
32	342	2S	Smooth floored crater	1		
33	330	40N	Fretted terrain	1	X	
34	325	25S	Cratered terrain	2		
35	312	63N	Anomalous ozone region	1		
36	315	42S	Hellas rim	1		
37	280	12N	Syrtis Major	1		
38	275	47N	Patterned plains	2		
39	270	63N	Mottled cratered plains	1		
40	265	31S	Old volcano	1	X	
41	250	43S	Hilly terrain	2		
42	253	22S	Dandelion	1	X	X
43	248	11N	Plains/cratered terrain contact	1	X	
44	240	63S	Patterned cratered terrain	2		X
45	236	19N	Channeled plains	2		
46	222	27N	Faulted plains	2		
47	214	3S	Plains/cratered terrain contact	1	X	
48	212	23N	Elysium shields	1	X	
49	209	32N	Elysium dome	1	X	
50	205	53S	Cratered terrain	2		
51	197	18S	Channels	1		
52	195	42N	Knobby terrain	2	X	
53	185	8S	Old volcanic shield	2		
54	182	20S	Channels	1		
55	182	15N	Irregular crater	2		
56	All	75-90N	North polar region	1	X	
57	0-20	65-75N	Mottled cratered plains	1	X	
58	90-110	65-76N	Mottled cratered plains	1		
59	All	75-90N	North Pole	1		

5

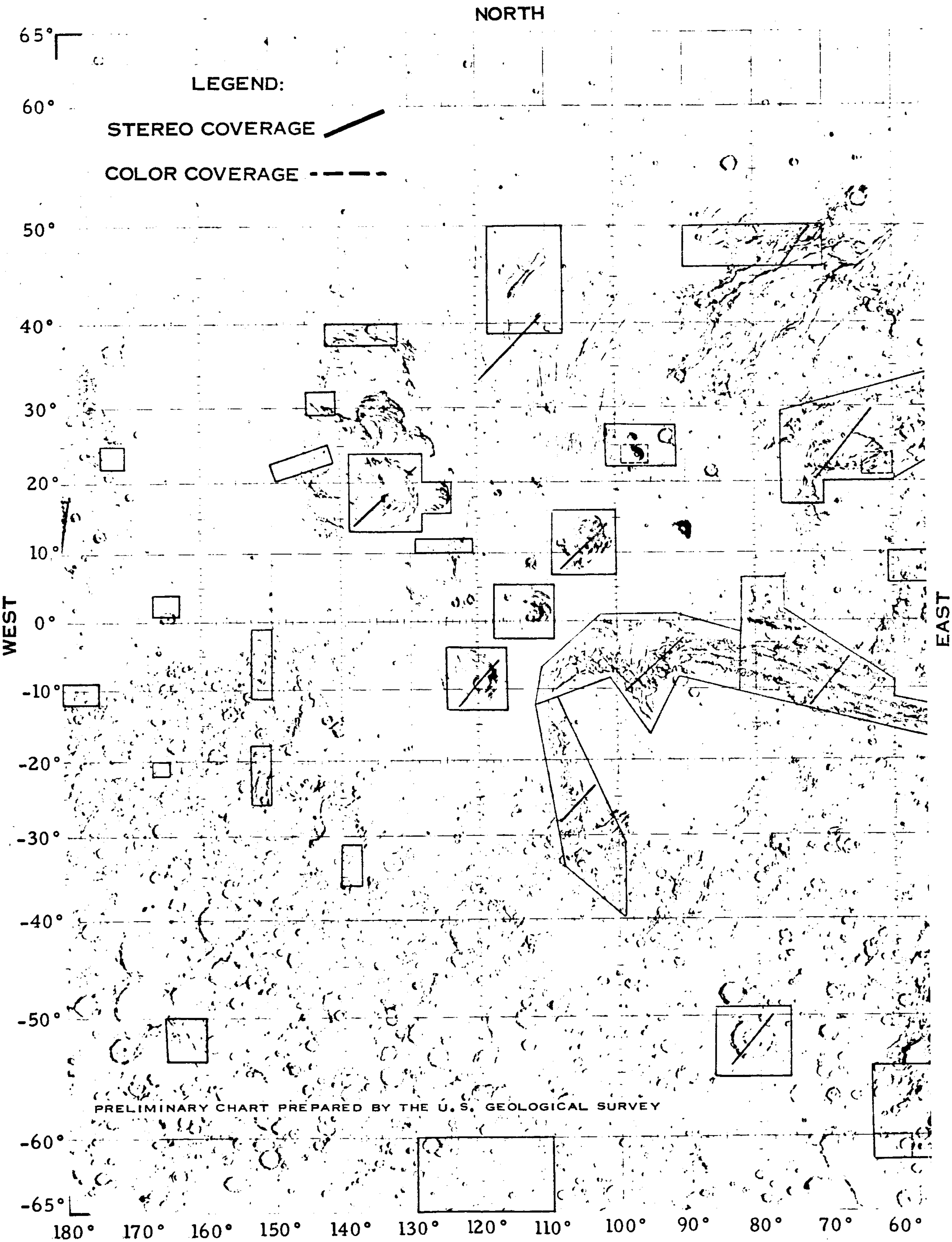
NORTH
LEGEND:
STEREO COVERAGE
COLOR COVERAGE
65°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
-30°
-40°
-50°
-60°
-65°
WEST
EAST
PRELIMINARY CHART PREPARED BY THE U. S. GEOLOGICAL SURVEY
180°
170°
160°
150°
140°
130°
120°
110°
100°
90°
80°
70°
60°

Figure 3.7-1

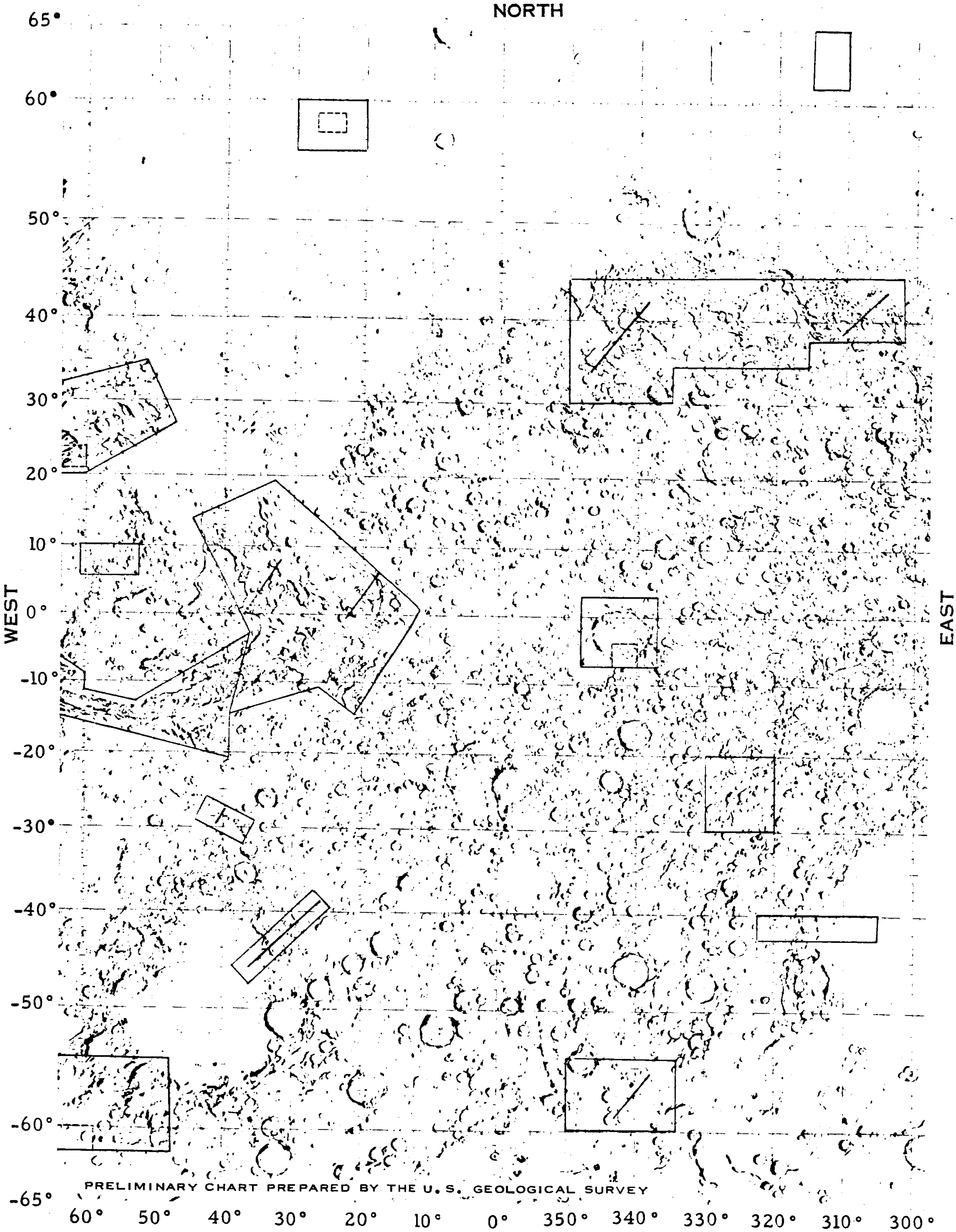

Figure 3.7-1 Continued.

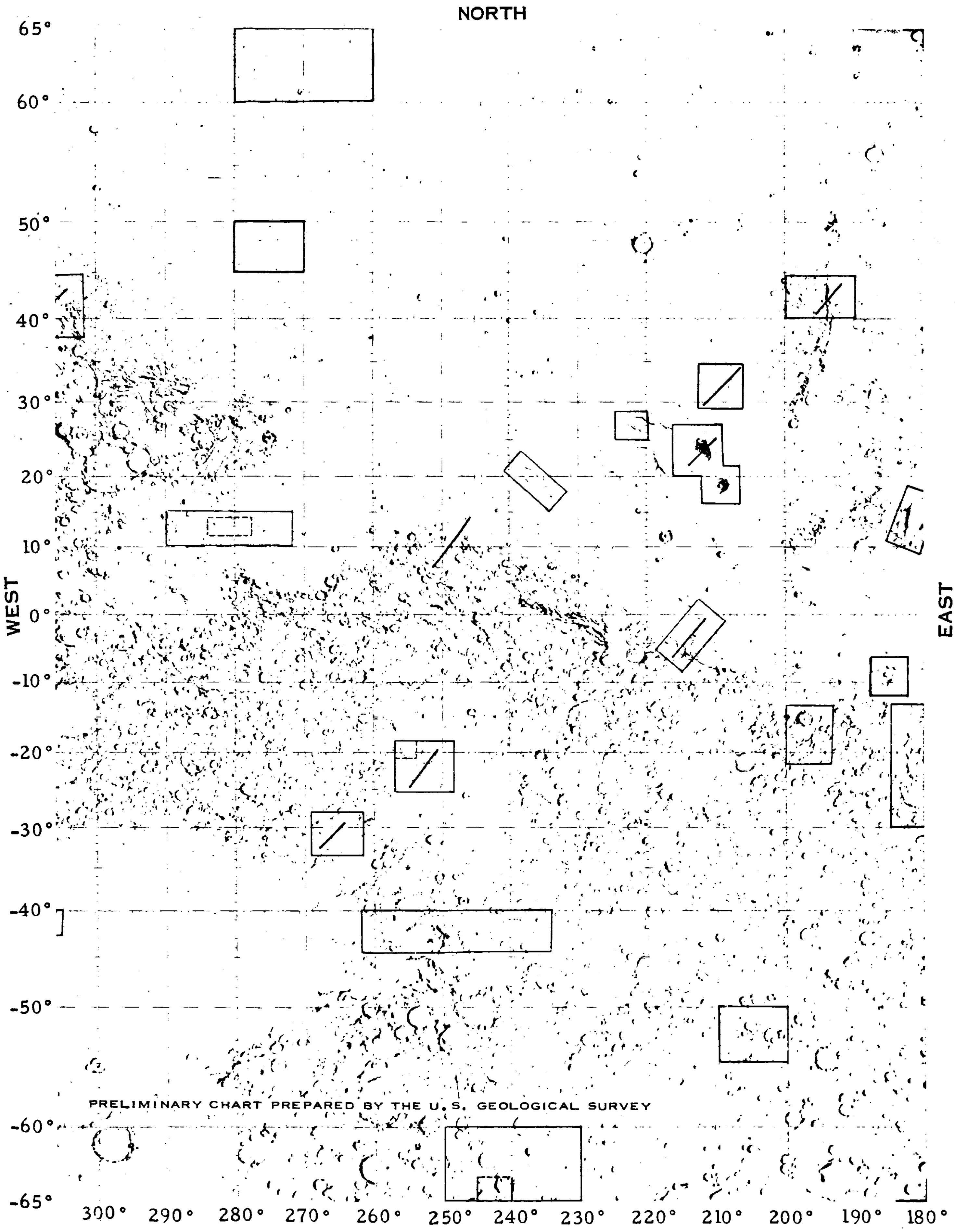

Figure 3.7-1-Concluded

3.7 Post-Landing Mars Observations (Continued)

in the map, Figure 3.7-1. For each area a priority and a class are assigned, and an indication is given as to whether color or stereo coverage in addition to simple coverage is to be obtained.

2) Area Coverage

a. Simple coverage by either VO with observational conditions within the preferred range specified in Table 3.1-1 shall be obtained for at least one-half of the Priority 1 areas listed in Table 3.7-1. The areas shall be chosen for their accessibility. Color or stereo coverage shall also be obtained for a chosen site if specified in the table. Single or multiple swaths or strips shall be employed, depending upon the shape and size of the area as given on the map, Figure 3.7-1.

Simple or color coverage shall be considered to be complete when:

(1) 100% of the area is covered for a class A area.

(2) 80% of the area is covered for a class B area.

(3) 40% of the area is covered for a class C area.

(4) 10 clusters of at least 10 pictures each have been spread fairly uniformly over a class D area.

For stereo coverage a single stereo observation covering at least 50 x 300 km at each spot indicated on the map is required.

b. It is desired to cover more than one-half of the Priority 1 areas and as many as possible of both the Priority 1 and Priority 2 areas. The same observational conditions apply to these areas, but the amount of simple or color coverage which is considered complete coverage is one-half that specified in paragraph 3.7.1.1.a.2.a.

c. When the VO is in synchronous orbit over the VL and on orbits when other specific data acquisition sequences do not interfere or utilize the storage and telemetry capability, it is desired to acquire low altitude swaths or strips of pictures located such that the area within 500 km of the VL is mapped as completely as possible in the course of the mission.

b. High Altitude Observations

1) Observational Areas of Interest

Prime targets for high altitude photography are listed in Table 3.7-2. The targets are divided into classes according to the type of phenomena which it is desired to observe. Position, elevation, and relevant characteristics are also listed in the table. The coverage that is appropriate for each class of target is specified in 3.1.2.1.e.

M75-143-0

TABLE 3.7-2 CANDIDATES FOR HIGH ALTITUDE IMAGING WITH VIKING ORBITER

No.	Feature or Region	Class*	Long.	Lat.	Elev.	Relevant Characteristics
1	South Spot	W	123	-8	+7	Very repetitious white clouds
2	Arcadia	W	114	+43	?	Spawning area for moving clouds
3	Nix Olympica (NW)	W	135	+20	+4	High frequency of white clouds in Martian July
4	North Spot (NW)	W	110	+15	+7.3	High frequency of white clouds in Martian July
5	Elysium	W	213	+23	+5	High frequency of white clouds
6	Albor	W				
7	Libya	WY	266	+5	-1	High regional frequency of white clouds
8	North Hellas	WY	300	-37	-10	Transient yellow brightenings
9	Mare Serpentis	Y	320	-30	-0.5	Chronic origin of yellow storms
10	West Hellas	Y	305	-45		Region of seasonal brightening
11	Utopia	Y				
12	Xanthe	V	44	+23	-3	Active light area for comparing with Nilokeras; also low
13	Aeria	V	305	+13	+3.8	Active light area for comparing with Syrtis
14	Nilokeras Canyon	V	54	+27	-1.2	Dark region of peculiar contrast statistics
15	Claritas	V	100	-30		Active light area
16	Solis Lacus	VS	85	-24	+1	Craters with light streamers; region of known secular changes
17	Syrtis Major	VS	284	+12	+1.3	Light and dark streaks
18	Zephyria	S	191	+8	-2.3	Crater with very dark streamer 3° long
19	Hesperia	S	241	-22	-1	Craters with light streamers
20	Marsissippi Delta	L	37	-10	-3.5	Channel at low elevation; H_2O candidate
21	Red River	L	39	-29	-2.5	Meandering channel; H_2O candidate
22	Pyrrhae Regio	L	27	-17	-6	Ultra-low spot; H_2O candidate
23	Chryse Canyon	L	34	+15	-2.5	Channel at low elevation and north; H_2O candidate
24	North Cap boundary	P	ANY	+82	?	Boundary changes slowly
25	South Polar Clouds	P	ANY	-45	?	Polar hood boundary varies (strip 35°S-60°S)

***See paragraph 3.1.2.1e for class definitions.**

3.7 Post-Landing Mars Observations (Continued)

2) Area Coverage

a. Coverage as specified in 3.1.2.1.e shall be obtained for at least half of the areas listed in Table 3.7-2, including at least one from each of the six classes.

b. It is desired to obtain coverage as specified in 3.1.2.1.e for as many of the areas listed in Table 3.7-2 as is feasible.

c. Limb Observations

1) Two-color (red and blue) coverage of three sample latitudes is required every 10 sols and desired every 4 sols.

2) Coverage with the blue filter of a specified sample latitude at three different times of sol on a single revolution is required every 10 sols and desired every 4 sols.

3) It is desired to obtain complete coverage of the illuminated limb on a single revolution from maximum altitude using the blue filter every 30 sols.

3.7 Post-Landing Mars Observations (Continued)

d. Lowered Periapsis Observations

It is desired to lower the periapsis altitude of one VO for at least 15 orbits to 700 km, or as low as allowable within planetary quarantine constraints, and to observe the following sites in order of decreasing priority:

1) The VL sites

2) Areas listed in Table 3.7-1

e. Phobos and Deimos Observations

It is desired that Phobos and Deimos be photographed with at least two filters every time the diameter of either subtends at least 0.2 degree. Observations with MAWD and IRTM are also desired at these times.

f. Photometric Calibration Verification

It is desired that on three widely spaced occasions after landing, the photometric calibration be checked by taking a sequence of four to eight pictures with each camera at varying exposures of either (1) a flat featureless region of Mars (e.g., Hellas), or (2) a bright planet (Jupiter or Saturn), with the first alternative preferred. In the first case, read out of only a single track of picture data will suffice.

g. Scan Platform Alignment Calibration

TBD

3.7 Post-Landing Mars Observations (Continued)

3.7.2 Water Vapor Mapping

3.7.2.1 Requirements and Objectives

a. Global Surveys

Two global surveys of total vertical water vapor abundance, one by VO-A as early as possible and one by either VO as late as possible, shall be obtained with the MAWD while in a nonsynchronous orbit. The observation conditions to provide optimum coverage and value are described in 3.1.2.2.c and 3.1.2.3.

b. High Altitude Observations

High altitude MAWD observations shall be made in the area scanning mode, with scan dimensions sufficient to provide complete coverage of the illuminated portions of the planetary disk. During synchronous phases the high altitude area scans shall be made at a minimum frequency of every fifth orbit. It is desired that these observations be made on as many orbits as possible consistent with noninterference with other orbiter science activities. During nonsynchronous phases the high altitude area scans shall be made on every orbit.

c. Medium and Low Altitude Area Scans

The medium and low altitude observations made in the area scanning mode are designed primarily to provide data related to diurnal variations and migration mechanisms. The regions of interest for these purposes are listed in Table 3.7-3. The observations should be made at times spaced roughly equally about and including local noon (see 3.1.2.2.d); a minimum of three observations within any 20-orbit period should be made of each region. The priorities associated with the choice of selected areas of interest for the medium and low altitude MAWD area scans are indicated in Table 3.7-3.

d. Low Altitude Swaths

Low altitude swaths consist of continuous MAWD raster scans made with the midpoint of the MAWD scan oriented close to the sub-S/C direction; observations in this mode should be made during synchronous orbits and should extend as high as possible in latitude consistent with acceptable illumination geometry as specified in 3.1.2.3.a.

For the mission having the lower orbital inclination, observations in the low altitude swath mode should be taken on every 10th orbit, with adjacent swaths being covered on alternate sides of the sub-VO point at periapsis during the intervening passes when possible. For the mission having the higher orbital inclination, low altitude swath observations are required on each pass with the scan platform oriented in a direction such that the incidence and emission angles at latitudes > 60° are minimal.

Table 3.7-3

MAWD REGIONS OF INTEREST FOR MEDIUM AND LOW ALTITUDE AREA SCANS

Region	Priority	Central Coordinates Lat.	Central Coordinates Long.	Approx. Area to be Covered Lat.	Approx. Area to be Covered Long.
N. Polar Cap Edge	1	+55	Any	±10	±4
Amazonis	1	+32	160	±8	±5
Nix Olympica	1	+30	140	±5	±5
Nix Olympica	1	+18	134	±6	±6
Nix Olympica	1	+20	121	±3	±3
Chryse	1	+36	32	±8	±5
Elysium	2	+24	216	±8	±8
Aetheria	2	+41	232	±3	±3
Nepenthes Thoth	2	+25	250	±5	±5
Memnonia	2	-20	150	±5	±5
Zephyria	2	-5	195	±4	±4
Margaritifer Sinus	2	0	20	±3	±10
Deucalionis Regio	3	-15	10	±3	±6
Hellas	3	-35	298	±4	±4
Hellas	3	-44	265	±5	±5
Aurorae Sinus	3	-10	60	±8	±20

3.7 Post-Landing Mars Observations (Continued)

e. Solar Occultation

MAWD observations, made with the scan platform oriented such that the midpoint of the MAWD scan intersects the center of the MAWD diffusion plate during the period ± 5 minutes of solar limb crossing, are required on both ingress and egress of any five solar occultations. It is desirable that the orbits (occultations) chosen for these observations should be those for which the tangent point intersects the surface in a low elevation region.

3.7.3 Thermal Mapping

3.7.3.1 Requirements and Objectives

a. Off-Axis Response Calibration

1) In the event the IRTM off-axis response calibration is not performed during interplanetary cruise as defined in 3.2.4.2, it shall be performed as soon after landing as practicable. This calibration shall be performed twice with frame misalignment angles differing by about 90 degrees. Each sequence consists of the acquisition of bright limb crossing data under the following conditions:

a) Continuous data acquisition extending at least 10, preferably 20, degrees on either side of limb.

b) Image motion as near perpendicular to the limb as practicable (within 10 degrees).

c) Large planet angular diameter (at least 60 degrees is desirable).

2) It is desired that acquisition of these data be accompanied by acquisition of at least one VIS picture centered on each limb crossing.

3) It is desired to perform this calibration sequence even if the interplanetary cruise calibration defined in paragraph 3.2.4.2 is performed.

b. Global Coverage

1) During nonsynchronous orbital periods, it is required to obtain predawn global coverage approximately 2 hours before periapsis on at least every other orbit, preferably each orbit. (This is potentially the most valuable IRTM data that will be obtained.)

2) When in lander synchronous orbit it is desired to obtain:

a) Predawn global coverage of at least the entire dark side at approximately 3-1/2 hours before periapsis at approximately 10-sol intervals.

3.7 Post-Landing Mars Observations (Continued)

b) Predawn global coverage of at least the entire dark side at approximately 1-1/2 hours before periapsis at approximately 10-sol intervals.

c) Global coverage of at least the entire lighted side at approximately 1 hour from periapsis at approximately 10-sol intervals.

c. Polar Cap Edge Coverage

It is desired that the IRTM on either VO obtain polar latitude strips as defined in 3.1.2.4.c at mid-sol and at night across the edges of both polar caps at approximately 10-sol intervals.

d. Dark Side Planet Coverage

It is desired that the IRTM obtain as complete coverage as practicable of the dark side of the planet during as many as 10 solar occultations of either VO and that some of these observations be near midnight local time at small emission angles.

e. Phobos and Deimos Observations

It is desired that the IRTM make observations of each Martian satellite as defined in 3.1.2.4.f whenever its diameter subtends an angle greater than 0.2 degree. As a minimum, it is desired to make such observations at least three times when the diameter exceed 0.1 degree. It is desired that observations be obtained over as wide a range of phase angles as possible. Observations covering a satellite entrance or exit from solar eclipse are particularly valuable.

f. Observations of Special Areas

It is desired to obtain diurnal coverage of as many of the areas specified in Table 3.7-4 as become accessible.

g. Maximum Diurnal Variation Coverage

1) This coverage is obtained under the following conditions:

a) As many of the five local times defined in 3.1.2.4.a as possible.

b) Additional local times including sunrise and sunset are desirable.

c) Latitude between -30 and +40 degrees.

d) Emission angle less than 70 degrees.

TABLE 3.7-4

IRTM SPECIAL INTEREST AREAS

	Name	Latitude	Longitude
1.	Landing Site A	--	--
2.	Landing Site B	--	--
3.	Hellas Center	-40	300
4.	Canyonlands delta, Niliacus Lacus	25	40
5.	Nix Olympica, South flank	26	133
6.	North Polar Cap	85+	--
7.	West Nix Olympia flat lands	28	160
8.	South Tharsis	-30	120
9.	Syrtis Major Center	10	290
10.	Iapygia	-13	305
11.	South spot Caldera	-9	120
12.	Plateau bordering meander, Elysium	19	235
13.	South Polar Cap	-70	90
14.	Cap, dark valley	-85	10
15.	Cerberus Caldera	20	210
16.	Parallel fractures, Ascraeus	25	107
17.	Elysium plain	23	213
18.	Roughened area, Amazonis	10	127
19.	River junction, Lunae Palus	24	61
20.	Rough area, Chryse	2	37
21.	Crater tails, Syrtis Major	13	283
22.	Crater tails, Mesogaea	8	192
23.	Canyonlands, Coprates	-12	66
24.	Jumble, Chryse	-8	33
25.	Mound, Mare Tyrrhenum	-23	254
26.	IRR hot areas, Solis Lacus	-27	76
27.	IRR hot areas, Trinacria	-27	263
28.	IRR hot areas, Aonius Sinus	-46	115
29.	IRR hot areas, Titonius Lacus	-8	86
30.	IRR hot areas, north edge of Hellas	-30	290
31.	IRR cold areas, Eridania	-44	213
32.	IRR cold areas, Tharsis	0	110
33.	IRR cold areas, Thaumasia	-32	75

3.7 Post-Landing Mars Observations (Continued)

e) All observations obtained in about 5 sols or less.

f) Both VO's may be used.

2) This coverage is desired for a 5-degree wide latitude band at two widely separated dates in the mission. Differing longitudes may be used.

3) This coverage is desired for at least one low-elevation (below -3 km) and one high-elevation (above +3 km) areas about 100 km in diameter at two widely separated dates in the mission.

3.7.4 Radio Science

3.7.4.1 Celestial Mechanics and Charged Particles

3.7.4.1.1 Requirements and Objectives

a. Regular Doppler and Range Data

Continuous S- and X-band Doppler and range data coverage of one full orbit shall be obtained for each VO approximately every third orbit, within operational constraints. These data shall have a nominal one-minute sample period, start 30 minutes prior to one periapsis passage and end 30 minutes after the second periapsis passage.

b. Daily Data Coverage

1) During the nonsynchronous orbit Mars observation periods, continuous S- and X-band Doppler and range data shall be taken as 1-minute samples for a 4-hour period which includes periapsis. Simultaneous S-band Doppler and range from the other VO shall be obtained over the same time period and from the same tracking station, preferably DSS 14.

2) It is desired to obtain continuous S- and X-band Doppler, range, and DRVID data for each VO for a period of 4 hours centered about periapsis each sol.

3) It is desired to obtain continuous range and DRVID data when Doppler data are being acquired.

c. Orbit Period and Inclination Variation

1) Nonsynchronous orbits shall be provided for obtaining at least 360-degree variations in longitude of the subperiapsis point in increments no larger than 30 degrees.

2) It is desired to have inclinations of the two VO's separated by at least 30 degrees with the minimum inclination being 25 degrees.

3.7 Post-Landing Mars Observations (Continued)

d. Orbit Trim or Adjustment Maneuver

Continuous S-band Doppler data are required for a 2-hour period before and for a 2-hour period after any orbit trim or adjustment.

3.7.4.1.2 Additional Objectives

a. Latitude of Subperiapsis Point

It is desired to have one subperiapsis point at the maximum practicable northern latitude and the other at the maximum practicable southern latitude.

b. Periapsis Altitude Reductions

A reduction in each VO periapsis altitude to the minimum consistent with planetary quarantine constraints is desired with an orbit period variation as defined in paragraph 3.7.4.1.1.c.

c. Simultaneous VO Tracking

During the nonsynchronous Mars observation periods, it is desired to have simultaneous X-band Doppler and range from both orbiters in addition to the requirements in 3.7.4.1.1.b.

d. Solar Activity

Continuous S- and X-band Doppler and range coverage for up to 5 sols is desired when solar events of significant magnitude occur.

e. X-Band Observations

It is desired to obtain X-band data whenever a station equipped to receive it is tracking a VO.

3.7.4.2 Solar Corona and Relativity

3.7.4.2.1 Requirements and Objectives

a. When the sun-earth-VO angle is less than 15 degrees and signals are detectable, the implementation of paragraph 3.7.4.1.1.a shall be accomplished such that full orbit coverage of each orbiter is alternately accomplished with approximately 36 hours between the start of data acquisition periods.

b. It is desired to obtain continuous S- and X-band Doppler and range coverage of one VO whenever the sun-earth-VO angle is less than 15 degrees.

3.7 Post-Landing Mars Observations (Continued)

3.7.4.3 Atmospheric, Ionospheric, and Surface Properties

3.7.4.3.1 Requirements and Objectives

a. Near Occultation Doppler Data Coverage

Continuous, simultaneous S- and X-band VO Doppler data, with a nominal one-second sample interval, shall be obtained for a period of at least 15 minutes before and after all occultations of the RF signals by Mars or during any period in which the radio signal ray path passes within 1,000 km of the Martian surface, whichever period is greater. Sampling rates as high as ten per second may be required. All data taken during entrance into occultation shall be two-way. Exit data shall be one-way or two-way as defined in 3.7.4.3.1.d.

b. Near Occultation Signal Amplitude Data Coverage

Continuous, digitized, calibrated signal amplitude data with a nominal 100 samples per second rate shall be obtained for at least 5 minutes before and after all occultations of the RF signals by Mars or during any period in which the radio signal ray path passes within 100 km of the surface.

It is desired that only engineering modulation be applied during occultation data acquisition. On exit, the signal should be reacquired as soon as possible.

c. Occultation Period Doppler Data Coverage

S-band Doppler data of the non-occulted VO are required during the near occultation period of the other VO, described in a. above. This coverage shall be from the same station used to satisfy requirement a. above.

d. Initiation of Post-Occultation Doppler Data Coverage

One-way Doppler data are required upon emergence from occultation for the first 9 of every 10 occultations. In this case, reestablishment of two-way Doppler lock shall be delayed until atmospheric effects occuring at this time have disappeared. For each tenth occultation, reestablishment of the two-way Doppler lock shall be attempted immediately upon emergence.

e. UHF VL-VO Relay Signal Amplitude and S/N Measurements

Measurements of the UHF VL-VO relay signal amplitude and S/N as a function of time are required for low radio

3.7 Post-Landing Mars Observations (Continued)

ray grazing angles at least every fifth orbit. S/N and signal strength measurements are to be made at the orbiter over the relay operating period for the region of operation of the S/N estimator (nominally -2.7 to +2.5 db above noise). In selecting the relay window for this measurement, the beginning or end of the relay session should favor the horizon providing the best grazing conditions. In the event that the relay link performance is not adequate to provide measurements at less than 20 degrees above either horizon, the experiment may be terminated. The central angles (to center of Mars) between the VL and the VO of particular interest are from 27 degrees to 43 degrees.

3.7.4.3.2 Additional Objectives

a. Occultation Coverage

It is desired to obtain the maximum number of occultations with maximum variability in longitude and latitude of the point of tangency of the occultation rays. It is desired that occultations start early in the mission and with large sun-earth-VO angles.

b. Occultation at the VL Site

It is desired to obtain occultation of the vertical column near each VL site.

c. Meteorology Measurement Support

For occultations which occur within 20 degrees central angle of a VL site, it is desired that near simultaneous meteorology temperature and pressure measurements be obtained.

d. Periapsis Altitude Reductions

It is desired to obtain reductions in periapsis altitude to the minimum consistent with planetary quarantine requirements.

e. Dual Spacecraft Tracking

It is desired to track both the occulting and nonocculting VO's simultaneously at both S- and X-band with the same DSS.

4.0 VIKING LANDER SCIENCE REQUIREMENTS, OBJECTIVES, AND CONSTRAINTS

This section defines the detailed VL science mission design requirements, objectives, and constraints for the Mission A and Mission B VL investigations.

4.0.1 General Requirements

a. Surface Sampler Use and Sample Strategy

The following strategy has been developed to assure minimum risk for the accomplishment of the landed science requirements and objectives:

1. The surface sampler will only be used to acquire samples for the Biology, Molecular Analysis, and Inorganic Chemical Investigations until the second sample for these investigations has been obtained.

2. The first sample shall be for Biology and Molecular Analysis Investigations (common sample), followed by the first sample for the Inorganic Chemical Investigation.

3. The second sample for the Inorganic Chemical Investigation shall not be acquired until after the second sample for Biology and Molecular Analysis.

For purposes of preflight mission design, table 4.0.1-1 (TBD) lists the sequence for the various uses of the surface sampler during Mission A and Mission B.

b. Preseparation Instrument Calibration

During preseparation checkout, a calibration shall be provided for the following instruments: Entry Pressure, RPA, UAMS, LCS's, and the meteorology sensors.

c. Data Transmission

All nonimaging science data and any imaging data necessary for the conduct of mission operations shall be returned at bit error rates less than 3×10^{-3} (based on the sum of adverse tolerances).

4.1 Entry

4.1.1 Atmospheric Composition

4.1.1.1 Requirements and Objectives

a. Operating Range

The UAMS shall obtain data from an altitude corresponding to an ambient pressure equal to or less than 10^{-10} millibar to an altitude corresponding to an ambient pressure as close to 10^{-4} millibar as is consistent with aerodynamic constraints.

SURFACE SAMPLER SEQUENCES

TBD

4.1 Entry (Continued)

b. Attitude Control

The VL attitude shall be controlled such that the longitudinal axis of the UAMS is maintained within 20° of the VL velocity vector over the measurement range specified in paragraph 4.1.1.1a.

4.1.1.2 Additional Objectives

It is desired to extend the UAMS warm-up period from Entry-40 minutes to Entry-70 minutes.

4.1.2 Ionospheric Properties

4.1.2.1 Requirements and Objectives

a. Operating Range

The RPA shall obtain data from completion of the deorbit burn to an altitude corresponding to an ambient pressure as close to 10^{-4} millibar as is consistent with aerodynamic constraints.

b. Sampling Rate

The RPA shall perform analyses for at least a 24-second period corresponding to a 10 percent change in altitude over the period from completion of deorbit propulsion burn to an altitude corresponding to an ambient pressure of approximately 10^{-10} millibar. The RPA shall operate continuously over the altitude range corresponding to the ambient pressure range of 10^{-10} to 10^{-4} millibar.

It is desired that the RPA perform analyses continuously over the period from completion of the deorbit propulsion burn to an altitude corresponding to an ambient pressure of 10^{-4} millibar.

c. Attitude Control

1) During instrument operation, the VL attitude shall be controlled such that the sun is prevented from shining into the RPA port, that is, within 90° of the instrument longitudinal axis, until an altitude corresponding to a pressure equal to or greater than 10^{-10} millibar is reached.

During instrument operation, it is desired that the sun be prevented from shining into the RPA port from an altitude corresponding to a pressure equal to or less than 10^{-10} millibar to an altitude corresponding to a pressure equal to or greater than 10^{-4} millibar.

2) The VL attitude shall be controlled such that the longitudinal axis of the RPA is maintained within 20° of the VL relative velocity vector from an altitude corresponding to a pressure equal to or less than 10^{-10} millibar to an altitude corresponding to a pressure equal to or greater than 10^{-4} millibar.

4.1 Entry (Continued)

4.1.3 Atmospheric Structure

4.1.3.1 Requirements and Objectives

a. Entry Data

The requirements are as defined in section 4.2.3 of the Viking Mission Definition, M75-123.

b. Landed Data

The three-axis accelerometer readings shall be obtained for at least 5 minutes after landing on the surface of Mars to define the local acceleration due to gravity, the planetary radius at the landing site, and the angular orientation of the landed spacecraft.

4.2 Landed

4.2.1 Imaging

a. General Requirements and Objectives

The Imaging Investigation shall obtain images such that:

1) The entire sample area is photographed with multiple lighting conditions using all imaging modes (i.e., high resolution black-white, color, IR, Stereo).

2) Targets of opportunity are photographed with multiple lighting conditions using all imaging modes.

3) Areas of potential change (variable features) are photographed repeatedly under identical lighting conditions using all imaging modes.

4) Selected areas are observed during operation of meteorological instruments. Special observations will be made after high winds and eolian depositional events.

5) Footpads are repeatedly photographed with all imaging modes to determine character of surficial materials and possible progressive changes.

6) Trenches dug with the Surface Sampler Subsystem are repeatedly photographed with all imaging modes to determine character of surficial materials and possible progressive changes.

7) Rocks and sediment samples manipulated with the Surface Sampler Subsystem are repeatedly photographed using all imaging modes to determine character and change.

8) Possible dust coatings on the spacecraft are repeatedly photographed with all imaging modes to determine presence and evolution.

4.2 Landed (Continued)

9) Possible motion in the field of view is monitored by single line scan (high resolution, color, IR).

10) Surveys of Phobos, Deimos, and stars are accomplished by conventional frame photographing and by single line scan. Some images will be obtained during the Martian night.

11) Selected areas of the surface are photographed using mirrors mounted on the Surface Sampler Subsystem.

12) Surface materials in the collector head jaw are photographed utilizing the magnifying mirror.

13) The three external targets are photographed repeatedly with multiple lighting conditions utilizing all imaging modes.

For purposes of preflight Mission Design, the Imaging Investigation requirements are listed in Table 4.2.1.1-1, along with imaging sequences to support other science investigations. The table items shall be accomplished sequentially, that is, in the order given, where possible. The mission design shall provide the capability for daily updating of at least ten images per sol.

b. Detailed Requirements and Objectives

1) Initial Operation

The LCS shall acquire and transmit the maximum data practicable in the initial relay link. Use of the second VL camera shall not be scheduled before VL sol two.

2) Relay Data Transmission Requirements

For the purpose of preflight mission design, imaging data shall utilize the capability of the relay link to transmit with bit error rates as high as 2×10^{-2} within power, thermal, or other system constraints. When scheduling data transmission, nominal link performance shall be used for imaging science data.

3) Surface Sampler Position for Near-Field Imaging

The Surface Sampler parking positions shall be planned such that minimum visual interference occurs for near-field imaging sequences. These positions shall be consistent with surface sampler safety requirements.

4) Slow Scan Rate Data

A minimum of 1.0×10^8 bits of the imaging data acquired during the landed mission shall be taken at the slow scan rate, 0.25 Kbps. Otherwise, data shall be obtained at the high scan rate, 16 Kbps.

TABLE 4.2.1.1-1 LANDER IMAGING INVESTIGATION REQUIREMENTS

TBD

4.2 Landed (Continued)

4.2.1.2 Additional Objectives

4.2.1.2.1 General

It is desired to obtain 4.0×10^7 bits of imaging and other lander science data each sol that the UHF link is established.

It is desired that the maximum transmission rate with acceptable error bit rate be utilized for the S-band link to increase the amount of recorded imaging which can be transmitted to earth.

4.2.1.2.2 Optimization of Lighting Over the Surface Sampler Area

a. Landed Orientation

It is desired that the lighting over the surface sample area be optimized by orienting the lander position in azimuth. The landed VL orientation should be such that leg #1 is pointed north.

4.2.2 Biology

4.2.2.1 Requirements and Objectives

4.2.2.1.1 General

a. Sample Acquisition

1) Four different surface samples shall be acquired for analysis.

2) The biology sample for the first analysis shall be acquired on the first safe operation of the sampler.

3) Commonality of soil samples for biology, organic, and inorganic investigations is a requirement for the first two samples acquired for biology and is an objective for the last two samples. Two samples are common when they have been acquired from approximately the same location and depth, and at approximately the same time.

b. Initialization and Analysis Scheduling

1. The instrument initialization sequence shall be completed a minimum of 5 hours prior to the first Biology Analysis Sequence initiation.

2. Four 15-sol analysis segments shall be scheduled; the first segment commencing no later than sol 6. It is desired that the analysis segments be separated by 5-sol intervals.

4.2 Landed (Continued)

c. Supporting Data from Other Investigations

1) VL imaging data shall be obtained for each sampling operation as follows:

a) First sample - Imaging data shall be obtained and analyzed to assure the safe operation of the sampler. If imaging data permit a choice of several safe sample sites, the site selected should be that which appears to be most desirable from the biological point of view.

b) Imaging data shall be used to select, where possible, the most desirable samples for biology for the second, third, and fourth samples.

c) It is required that these imaging data be acquired before and after each sample acquisition. It is desired to have the pictures taken immediately before and after the operation, depending upon other constraints.

2) Atmospheric Analysis data from the GCMS experiments shall be obtained and used to verify the dissipation of the landing exhaust gases prior to the sampling for biology on sol 6.

3) It is desired to have meteorology data available in a timely fashion to support update of commands to the SSCA for the sol 6 sample acquisition.

4) It is desired that meteorology temperature data be obtained and used to verify that the sample temperature will not exceed that prescribed in paragraph 4.2.2.1.5.

d. Control Analysis

For each of the three Biology experiments, the option shall exist to run a control analysis during any of the last three analysis segments. For the purpose of preflight mission design, the control analyses for Pyrolytic Release and Labeled Release occur during the third analysis segment; for Gas Exchange, during the fourth analysis segment.

4.2.2.1.2 Pyrolytic Release

a. The soil sample shall be incubated for a period of up to 5 sols followed immediately by a measurement phase.

b. The option shall exist to turn off the lamp upon command during any incubation period. For the purpose of mission design, the lamp shall be on continuously during incubation for the first three analysis segments (including control specified in d. above) and off for the fourth analysis segment.

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4.2 Landed (Continued)

c. The option shall exist to command the addition of water vapor to the soil sample. For the purpose of mission design, the third and fourth segments should have added water vapor, and the first and second segments should not.

d. The option shall exist to select which of the three incubation chambers shall be used for any given incubation and analysis cycle. For the purposes of mission design, the first sample shall be placed in Chamber #1, the second sample shall be placed in Chamber #2, the third sample shall be placed in Chamber #3, and the fourth incubation shall be run in Chamber #1.

4.2.2.1.3 Labeled Release Experiment

a. The starting sequence of each incubation shall be adjusted with respect to time such that the predicted nutrient temperature at time of injection is essentially constant from one incubation cycle to another, and that the predicted diurnal incubation temperature variations are synchronous from one incubation cycle to the next. This requirement is particularly important with respect to the control incubation.

b. Sample Radioactivity Measurement

The cumulative release of radioactivity shall be measured with a frequency not less than once every hour for approximately 13 sols for each analysis.

c. Background Radioactivity Measurement

The radioactivity background shall be counted for two 24-hour periods within the 15-sol experiment period for each segment.

d. Commandable Nutrient Injection

The mission design shall have the capability to command injection of a second aliquot of nutrient during incubation if desired.

4.2.2.1.4 Gas Exchange Experiment

a. Analysis Scheduling

1) During each 15-sol period, the chamber gas shall be analyzed twice on sol 1, and once on sols 2, 4, 8, and 15.

2) Before termination of the first, second, and third incubation segments (prior to draining the incubation chamber), an additional gas analysis shall be performed. Then, after draining, purging, and introduction of fresh nutrient and incubation atmosphere, the chamber gas shall be analyzed as in 4.2.2.1.4.a.1.

4.2 Landed (Continued)

3) Should the option for nutrient injection (c. below) be commanded, an additional analysis shall be run on sol 7, after nutrient injection.

b. Medium and Gas Addition and Experiment Reinitiation

1) For the first incubation period, the amount of medium added to the chamber shall be sufficient to humidify the soil without direct contact with the soil sample.

2) Immediately prior to initiating the remaining incubation periods, the medium shall be drained and replaced with fresh medium, and gas shall be flushed and replaced with fresh gas.

c. Commandable Nutrient Injection

The option shall exist to complete the addition, on sol 7, of nutrient medium to the sample during the first incubation cycle so as to wet the soil. Should this option be exercised, the additional analysis specified above in a. 3) shall be run. The reconstructed data from the gas sampling on sol 4 is required for decision on this option.

d. Time and Thermal Considerations

Gas chromatograms shall be taken during periods of maximum stability of the detector as determined by thermal analysis and tests. The mission design shall have the capability to adjust these periods to the favorable thermal windows for each incubation cycle after receipt of lander temperature data. Once a window is selected, these analyses shall be performed at the same local time throughout the incubation cycle.

4.2.2.1.5 Sample Temperature

The maximum temperature of the sample, from acquisition until delivery to the test cells, shall not exceed the maximum incubation temperature or the maximum diurnal temperature by more than 10° C.

4.2.2.1.6 Mission B

The start of sampling and incubation for Biology on Mission B may be earlier than specified above for Mission A depending upon data available from Mission A (such as atmospheric analysis). Time dependent events, optimized for thermal considerations, may be different for Mission B.

4.2 Landed (Continued)

c. The option shall exist to command the addition of water vapor to the soil sample. For the purpose of mission design, the third and fourth segments should have added water vapor, and the first and second segments should not.

d. The option shall exist to select which of the three incubation chambers shall be used for any given incubation and analysis cycle. For the purposes of mission design, the first sample shall be placed in Chamber #1, the second sample shall be placed in Chamber #2, the third sample shall be placed in Chamber #3, and the fourth incubation shall be run in Chamber #1.

4.2.2.1.3 Labeled Release Experiment

a. The starting sequence of each incubation shall be adjusted with respect to time such that the predicted nutrient temperature at time of injection is essentially constant from one incubation cycle to another, and that the predicted diurnal incubation temperature variations are synchronous from one incubation cycle to the next. This requirement is particularly important with respect to the control incubation.

b. Sample Radioactivity Measurement

The cumulative release of radioactivity shall be measured with a frequency not less than once every hour for approximately 13 sols for each analysis.

c. Background Radioactivity Measurement

The radioactivity background shall be counted for two 24-hour periods within the 15-sol experiment period for each segment.

d. Commandable Nutrient Injection

The mission design shall have the capability to command injection of a second aliquot of nutrient during incubation if desired.

4.2.2.1.4 Gas Exchange Experiment

a. Analysis Scheduling

1) During each 15-sol period, the chamber gas shall be analyzed twice on sol 1, and once on sols 2, 4, 8, and 15.

2) Before termination of the first, second, and third incubation segments (prior to draining the incubation chamber), an additional gas analysis shall be performed. Then, after draining, purging, and introduction of fresh nutrient and incubation atmosphere, the chamber gas shall be analyzed as in 4.2.2.1.4.a.1.

4.2 Landed (Continued)

3) Should the option for nutrient injection (c. below) be commanded, an additional analysis shall be run on sol 7, after nutrient injection.

b. Medium and Gas Addition and Experiment Reinitiation

1) For the first incubation period, the amount of medium added to the chamber shall be sufficient to humidify the soil without direct contact with the soil sample.

2) Immediately prior to initiating the remaining incubation periods, the medium shall be drained and replaced with fresh medium, and gas shall be flushed and replaced with fresh gas.

c. Commandable Nutrient Injection

The option shall exist to complete the addition, on sol 7, of nutrient medium to the sample during the first incubation cycle so as to wet the soil. Should this option be exercised, the additional analysis specified above in a. 3) shall be run. The reconstructed data from the gas sampling on sol 4 is required for decision on this option.

d. Time and Thermal Considerations

Gas chromatograms shall be taken during periods of maximum stability of the detector as determined by thermal analysis and tests. The mission design shall have the capability to adjust these periods to the favorable thermal windows for each incubation cycle after receipt of lander temperature data. Once a window is selected, these analyses shall be performed at the same local time throughout the incubation cycle.

4.2.2.1.5 Sample Temperature

The maximum temperature of the sample, from acquisition until delivery to the test cells, shall not exceed the maximum incubation temperature or the maximum diurnal temperature by more than 10° C.

4.2.2.1.6 Mission B

The start of sampling and incubation for Biology on Mission B may be earlier than specified above for Mission A depending upon data available from Mission A (such as atmospheric analysis). Time dependent events, optimized for thermal considerations, may be different for Mission B.

4.2 Landed (Continued)

4.2.3 Organic Analysis

4.2.3.1 Requirements and Objectives

a. Sample Acquisition

1) Three different surface samples shall be obtained for organic analysis. The capability shall exist to provide a sample to the GCMS which is common with the biology sample. For purposes of preflight mission design, the first two samples shall be common with the first two biology samples. The third sample shall be a subsurface sample.

2) VL imaging data of the sample area shall be acquired as soon as possible before and after sampling to support sample selection as specified in Table 4.2.1.1-1.

3) The temperature of the sample shall not be raised to more than 10° C above the ambient acquisition temperature or 50° C, whichever is lower, until the beginning of the experiment. After sample acquisition there shall be no delay in filling and sealing the oven. The first analysis of each sample shall be accomplished within 24 hours of its acquisition.

b. Analysis Scheduling

1) Each of the three samples shall first be analyzed by heating to either 200° C or 350° C (selectable by ground command). Following data analysis, the second analysis shall be performed approximately 3 sols later by heating the sample to 500° C.

2) The three sets of two organic analyses shall be conducted at approximately equal time intervals throughout the landed phase of the mission.

3) One GC column conditioning sequence shall be performed prior to the first sample analysis.

4) The 36-minute hold duration at maximum GC column temperature shall be utilized.

It is desired to utilize the 54-minute hold duration at maximum GC column temperature.

5) The mission sequence of events shall be planned so that the experiment sequence of events for organic analysis shall be capable of being updated before the second analysis (500° C) of each set of analyses.

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4.2 Landed (Continued)

4.2.4 Atmospheric Composition

4.2.4.1 Requirements and Objectives

a. Initial Analysis

Four atmospheric analyses shall be performed daily commencing at approximately 22 hours after lander midnight on lander sol 2, and continuing each sol for a 3-sol period. The four daily analyses shall then be repeated approximately every 6 sols thereafter.

For the purpose of preflight mission design, the four analyses shall be two mode "a" and two mode "b," which shall be alternated and equally spaced throughout the day within system constraints.

4.2.4.2 Additional Objectives

a. Analysis Scheduling

1) It is desired that as many atmospheric analyses as practicable be accomplished prior to biology instrument venting.

2) It is desired that no atmospheric analyses be conducted within 48 hours after completion of an organic analysis.

3) One filtered atmospheric analysis shall utilize the maximum recycling capability (10 filtering cycles) of the system.

4.2.5 Meteorology

4.2.5.1 Requirements and Objectives

4.2.5.1.1 General

a. Operational Cycle

1) The basic operational cycle shall be to measure temperature, wind direction, and wind speed, with samples every 4 seconds for 6 minutes of each hour during the diurnal cycle. Pressure and temperature data shall be acquired from the parachute phase pressure and temperature sensors during the meteorology data acquisitions, consisting of four determinations of pressure per sequence. In addition, it is desired that the platinum resistor within the aeroshell phase temperature sensor be monitored to supply data in the event that the thermocouples do not survive landing.

2) For purposes of preflight mission design the following table shall govern meteorology scheduling:

4.1.2 Landed (Continued)

Data acquisition	Sampling rate	Module duration
Maximum	1 per second	1.5 minutes
Normal	1 per 4 seconds	6 minutes
Minimum	1 per 120 seconds	180 minutes

The meteorology cycle shall be capable of being updated by ground command. The updating shall consist of sampling rate changes from once per second to once per one hundred twenty seconds, sampling duration from one and one-half to one hundred eighty minutes, and sampling sequence frequency from zero to twenty four times per cycle.

It is desired that longer modules containing more data bits be obtained during the mission design when feasible.

b. Duration of Operation

The Meteorology Investigation shall operate throughout the nominal 90-sol landed mission.

c. Interrupts of Operation

Interrupts in the basic operational cycle due to S-band transmissions shall not cover the same time period or parts thereof in successive sols, where possible.

d. Temperature Profile Data

The SSAU shall be programed to obtain vertical temperature profiles at least eight times during the mission, following acquisition of the third sample for the Biology, Organic Analysis, and Inorganic Chemical Investigations.

4.2.5.1.2 Initial Operations

a. Boom Deployment

The meteorology boom deployment shall be delayed to as close as possible to landing plus 10 minutes within systems constraints, so that the deployment operation may aid in removal of dust from the sensors.

b. Imaging Support

1) Low resolution imaging of the entire surface capable of being viewed shall be obtained no later than sol 4.

2) High resolution stereo imaging of three selected near-field spots in the vicinity of the meteorology instrument shall be obtained no later than sol 8. This sequence shall be repeated eight different times during the mission.

4.2 Landed (Continued)

3) High resolution stereo imaging of the entire surface capable of being viewed shall be obtained as soon as practical.

4.2.5.2 Additional Objectives

a. It is desired to increase the total bit allotment for meteorology as the mission progresses.

b. It is desired to maximize the simultaneous operation of the meteorology instruments on both the VL's.

c. It is desired to increase the number of sequences around sunrise and sunset since these are the times at which the greatest atmospheric changes can be expected.

4.2.6 Seismology

4.2.6.1 Requirements and Objectives

4.2.6.1.1 General

a. Operational Cycle

The seismometer shall monitor ground motion for an average of at least 20 hours per sol throughout the landed mission. Threshold, gain and filter settings and the operational cycle shall be capable of being updated by ground command.

The seismometer shall operate in the Normal Mode (Low Data Rate Mode) with automatic triggering into and out of the Event Mode (Moderate Data Rate Mode) and with preprogramed and commandable cycles of calibration, High Data Rate and Moderate Data Rate operation.

The seismometer shall be turned off when the number of data buffers transferred to the DAPU reaches the allowed number of transfers. For purposes of mission design, 600 data buffer transfers per sol shall be scheduled when compatible with other science requirements. For a minimum of 45 sols during Mission A, at least 600 data buffer dumps per sol shall be scheduled for seismology. It is desired that no less than 158 data buffer transfers per sol be scheduled.

The mission design shall provide the capability to update the operational sequence, seismometer settings and number of buffer transfers by ground command.

The seismology investigations shall operate throughout the normal 90-sol landed mission.

4.2.6.1.2 Detailed Requirements and Operational Modes

a. Initiation Sequence

The following initiation sequence is for the purpose of verifying the operation and performance of the seismometer and

4.2 Landed (Continued)

for obtaining information on background noise which is required for later operation. The initiation sequence shall begin as soon as possible after landing.

1) Power on

2) Normal mode, high gain, trigger inhibit with filter stepping - duration, 1 hour

3) Event Mode - 10 minutes

4) High Data Rate Mode - 1 minute

5) High Data Rate Mode, Test Signal Start - 16 seconds

6) High Data Rate Mode, Low Gain

7) Uncage sequence

8) Command into day-to-day operating sequence

b. Normal Mode Operation

The seismometer shall operate in its nominal sequence (Normal Mode plus triggered event mode plus commanded high data rate and calibration modes) until the number of data buffer storage transfers reach the scheduled number. When this number is reached, the seismometer will be powered off.

c. Event Mode Operation

The mode is also called the Moderate Data Rate Mode or the Triggered Mode.

The seismometer shall operate in the Event Mode by automatic triggering from the Normal Mode or by command. This mode can be inhibited by GCSC or ground command.

It is desired to extend the period of Event Mode Operation in accordance with the following priority:

1) It is desired to operate the seismometer in the moderate data rate mode by automatic triggering for more than 600 data buffer transfers per sol.

2) During the lifetime of the investigation and preferably early in the landed mission, it is desired that the seismometer be operated continuously in the moderate data rate mode (command rather than trigger control) for a 20-hour period.

4.2 Landed (Continued)

3) It is desired to operate the seismometer continuously in the moderate data rate mode (command rather than trigger control) for a period of one hour per sol.

4) It is desired to dedicate the equivalent of two full sols late in the mission to primarily seismology and meteorology data in moderate and high data modes in order to obtain continuous and unambiguous coverage of seismic and meteorological events. This coverage will require the assignment of most of the available VL storage and transmission capability to these experiments during this period of time.

5) It is desired that as other experiments complete their tasks or go off the air for other reasons that the seismology bit allocation be increased in order to increase the amount of time that the seismometer can operate in the triggered mode. This will increase the number of seismic events that can be processed and will permit a decrease in the threshold level of detection, thereby increasing the sensitivity of the seismometer.

d. High Data Rate Mode Operation

1) The seismometer shall operate in the high data rate mode at least one minute every sol.

It is desired to operate the seismometer in the high data rate mode for as long as possible each sol consistent with the minimum average operating time of 20 hours per sol and data storage and transmission capabilities.

2) The high data rate mode of operation shall be scheduled, for seismological purposes, for periods of minimum VL-originated disturbance.

3) Other experiments may wish to monitor activities such as sample collection, boom movements, venting, sample preparation, soil properties, etc., with the high Data Rate Mode. The number of buffer transfers shall be increased for these purposes.

4) The high data rate mode of operation will be scheduled to monitor such events as rock dropping and release of sampler protective cover.

e. Calibration

The seismometer shall be calibrated during one of the high data rate mode operations specified in paragraph 4.2.6.1.2.d.

f. Simultaneous Operations

The seismometers on the two VL's shall operate simultaneously as much as possible.

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4.2 Landed (Continued)

It is desired to operate the seismometers on the two VL's at the same time in both the commanded moderate and high data rate modes.

It is desired that "noise making" activities at the two landers be planned to occur simultaneously.

g. Surface Sampler and S-Band Antenna Parking

1. The Surface Sampler parking positions shall be planned such that minimum interference occurs with the seismic experiment, such as would be caused by wind or seismic induced oscillations of the sampler. The Surface Sampler position shall be optimized to minimize the cross-section area of the lander and to damp out induced vibrations. These positions shall be consistent with Surface Sampler safety requirements.

2. It is desired that the S-band antenna be parked in a position to minimize wind resistance when not engaged in data transmission.

h. Sequencing

It is desired that the initiation sequence and at least two hours of seismic data be collected before the Surface Sampler is deployed. It is desired to operate the seismometer in the high data rate mode for one minute and in the moderate data rate mode for 10 minutes before and after deployment of the Surface Sampler. This will require an increase in buffer transfers for this period of time.

i. Support by Meteorology

Wind speed data shall be acquired immediately before and during the times the seismometer operates in the high data rate mode. The seismometer shall be on during the meteorology measurement sequences as much as possible.

It is desired that meteorology measurements be made during all seismometer operations in the moderate and high data rate modes.

4.2.7 Magnetic Properties

4.2.7.1 Requirements and Objectives

a. Magnetic Surface Sample Properties

1. During the acquisition of the surface samples for Biology, Inorganic, and Organic Analysis, the collection head backhoe magnet array will automatically acquire a magnetic properties sample from the surface. The LCS's shall be used to image* the back surface of the backhoe after the

*The use of the word image throughout the Magnetic Properties Section means use of all modes, i.e., high resolution, color, IR, and stereo if feasible.

4.2 Landed (Continued)

samples have been delivered, except for the first sample. It is desired to image the back surface of the backhoe for this first sample.

2. For three other surface samples, one of which is acquired by digging a trench, the following sequence shall be followed:

a) Prior to the sample acquisition, the front surface of the Collector Head backhoe shall be cleaned using the magnet cleaning brush assembly and then imaged to determine the degree of cleanliness.

b) Collector Head temperature measurement shall be made during the sample acquisition and immediately prior to the imaging.

c) The LCS shall be used to image directly the backside of the backhoe.

d) The LCS shall be used to image the front side of the backhoe via the magnification mirror.

3. Twice during the mission period, when convenient and as early as possible, the SSCA shall be commanded to acquire a magnetic peculiar sample. The procedure shall be that specified in 2. above except that imaging of the front side of the backhoe via the magnification mirror shall occur before and after vibration of the Collector Head.

4. It is desired to infer the low temperature dependence of the magnetic properties of the sample by acquisition of additional samples in the following sequence:

a) From a designated location on the surface during the hottest part of the sol.

b) From the same location as "a" during the coldest part of the sol.

c) If more material is seen to have accumulated in "b" than in "a," then "b" should be repeated and the backhoe should be allowed to heat slowly from solar radiation. During the heating cycle the SSAU should be periodically vibrated, its temperature measured, and the backhoe imaged after each vibration cycle.

For preflight mission design, assume six such vibration/imaging/temperature measuring cycles at half-hour intervals.

It is desired for all samples a, b, and c, that the Collector Head should rest on the surface for 30 minutes, during which three Collector Head temperature measurements are made at 10-minute intervals; that imaging should commence within 10 minutes of removing the Collector Head from the surface, that imaging be performed via the magnifying mirror.

4.2 Landed (Continued)

5. It is desired to infer the high temperature dependence of the magnetic properties of a sample by the following sequence:

a) Acquire a magnetic sample at a time and a location determined from previous data. The backhoe should remain on the surface for 30 minutes while acquiring the magnetic sample.

b) During the 30 minutes of acquiring a sample, the SSCA should be commanded to make three Collector Head temperature measurements approximately 10 minutes apart.

c) The backhoe should be imaged directly by the LCS and indirectly via the magnification mirror.

d) Collector Head temperature measurement should be made immediately prior to and immediately after viewing.

e) The surface sampler boom should be commanded to locate the Collector Head in a position close to the RTG so that the Collector Head backhoe will be heated. The location is to be determined from analysis and surface sampler subsystem testing.

f) The LCS should image the backhoe while in position (e) above every 5 minutes.

g) Collector Head temperature measurement should be made immediately prior to and immediately after imaging.

h) After 30 minutes, the backhoe should be commanded to a position to allow the LCS to image the backhoe via the magnification mirror.

i) The LCS should image the backhoe via the magnification mirror. Collector Head temperature measurements should be made prior to and after viewing imaging.

It is desired to perform the sequence of 4.2.7.1.a.2 whenever the SSAU is used to acquire a sample, dig and trench, or in any other way come in contact with the surface.

b. Magnetic Wind Blown Sample Properties

1. The magnet on the photometric target shall be imaged each time the photometric target is imaged for LCS calibration.

2. During the period between sol 20 and sol 30, the LCS shall image the magnet on the photometric target once during both the coldest and hottest parts of the sol when illumination is suitable.

4.2 Landed (Continued)

4.2.8 Physical Properties

4.2.8.1 Requirements and Objectives

a. General

The detailed requirements listed below are derived from the general requirements as stated in the Physical Properties Investigation Requirements Document M75-139-0, Appendix A to SS 3703004.

Whenever possible, Physical Properties experiments shall be obtained as a result of the intial preprogramed sequence of events of the VL. Subsequent Physical Properties experiments shall be accomplished by either the preprogramed sequence of events or as a direct result of Earth update of the Mission Sequence of Events. Earth update of the sequence of events shall be used to accomplish the Physical Properties experiments that cannot, or were not obtained by means of the preprogramed sequence of events.

The following experiments have been identified to be accomplished during Missions A and B. Additional experiments will be identified during mission operations within the constraints that exist at that time.

During all LCS imaging sequences in support of the Physical Properties Investigation, it is desired that as many of the imaging modes as practicable be used. The imaging requirements and objectives for the Physical Properties Investigation shall be integrated with other imaging requirements to the maximum extent possible to minimize the number of images. Images of the surface sampler acquisition area and natural and lander-made features shall be acquired whenever possible via the boom-mounted mirrors to provide additional (and otherwise unobtainable) views of these targets.

b. Surface Material Bulk Density

1. During the acquisition of surface samples, as described in "a" or "b" below, the Surface Sampler Boom elevation/depression motor current will be obtained when the SSAA is empty and after it is loaded with surface material. The operation of the Boom shall be planned such that motor current readings when the SSAA is loaded are obtained when the Boom is within 10° of the azimuth and elevation angle position that existed when the motor current readings were obtained with the SSAA empty. The motor currents shall be measured for the loaded and empty conditions, for both elevation and depression motions of the Boom. The empty and loaded motor measurements shall be taken within one hour of each other.

The measurements shall be obtained at least four times as follows:

4.2 Landed (Continued)

a) The third time a surface sample is acquired for Biology and for GCMS.

b) Two times, during the mission period following acquisition of the second sample and prior to sol 60, by acquiring samples at the maximum Boom extension at azimuth locations 100° ± 20° apart.

2. The LCS's, aided by positioning the Surface Sampler Boom-mounted mirrors, shall be used to view the surface below engine #2. The viewing required shall be as follows:

a) The retracted Surface Sampler Boom shall be positioned such that LCS #2 can view, through the Boom-mounted mirrors, the surface below engine #2. Five pictures are required at different boom azimuths bracketing this position.

b) It is desired that these operations be performed at a time of sol that the Lander does not shadow the area being viewed. Further, it is desired that three sequences be taken for each of the five positions with widely separated sun incidence angles.

c. Surface Material Bearing Strength

1. The SSAU shall apply loads to the surface while the motor current of the motor providing the load power is measured. The loads shall be applied using the extend and the depression motor of the boom. The following sequence shall be performed following the acquisition of all surface samples.

a) The SSAU shall be pressed into the surface by the extension motion of the boom at a surface location as close to the lander as possible. After stopping at the surface, the SSAU shall be extended into the surface for at least 8 seconds, while pressing into the surface.

b) For positions different from "a" above, after stopping at the surface, the SSAU shall be pressed into the surface using the depress motion of the boom for at least 8 seconds.

c) "a" and "b" shall be performed twice during the last 30 sols of the mission.

d) Stereo LCS images shall be acquired after "a" and "b" are performed. An additional stereo image at a different SEA is desired. A stereo image just prior to "a" and "b" is also desired.

2. The LCS's shall be used to view the landing leg stroke gauges. The gauge on each of the three lander legs shall be viewed at appropriate times during the Martian sol such that there is optimum illumination on the gauge being viewed. The following criteria for viewing sequence shall be met:

4.2 Landed (Continued)

a) Viewing of each of the gauges (a set) shall be accomplished as soon as possible during the first 20 sols of the mission.

b) Additional sets of viewing are desired during mission sols 25-40 and 40-80 as determined by analysis of data.

c) It is desired to view the landing leg stroke gauges immediately after landing.

3. The LCS's shall be used to view the impressions made on the surface by footpads #2 and #3.

a) The cameras shall be used to determine the positions of the footpads as early in the mission as feasible. It is desired to accomplish this in the first three sols. Camera #1 shall view footpad #2 and camera #2 shall view footpad #3.

b) Following acquisition of the first two samples for Biology, GCMS, and Inorganic Chemical, and using the data obtained from "a" above, a more detailed view sequence shall be performed. It is desired that two pictures of each footpad be taken at different times during the Martian sol. It is also desired that some of the imaging be in color.

c) It is required that sequence "b" above be repeated during the mission period of sol 30 to 60, and again from sol 60 through 90.

4. The LCS's shall be used to view the impressions of a rock dropped from the SSAU. This experiment shall be performed after all samples have been acquired.

a) The Surface Material Bulk Density Sequence 4.2.8.1.b.1 shall be performed.

b) The LCS's shall take post-drop high resolution stereo sequences of the rock on the surface.

c) In addition to e), it is desired that two sereo sequences be conducted during the following sol with two widely separated sun incidence angles.

d) It is desired that the seismometer operate continuously during the rock drop sequence.

e) It is desired to repeat experiment sequences "a" through "d" of paragraph 4.2.8.1.c.4 during the last 45 sols of the mission.

4.2 Landed (Continued)

d. Surface Material Particle Characteristics

The LCS's and the Surface Sampler Subsystem shall be used to evaluate the particle characteristics such as size distribution, strength, friction angle, and eolian transportability. The sequences shall be as follows:

1. After delivery of the surface sample to Biology, GCMS, and Inorganic Chemical, the material remaining in the SSAU which is emptied onto the Mars surface shall be stereoscopically viewed by the camera. This activity shall be imaged as follows:

a) After the SSAU is moved away from the pile, the LCS's shall then stereoscopically view the pile formed during the emptying process. It is desired to image the pile in color and via the boom-mounted mirrors.

b) In addition to a), it is desired that the LCS's view the pile during the morning and afternoon of the following sol at SEA's of approximately 30° and 45°.

2. After the acquisition of the surface sample, the sampling site shall be stereoscopically viewed as soon as possible and at a second time within 10 sols. It is desired to image each 10 sols afterward. It is desired that some of the images be in color.

3. During the mission period between sol 20 and sol 40, the SSAU shall acquire a sample from a location determined from the analysis of previous data. The sample acquired shall be as large a volume as it is possible to obtain. The experiment sequence shall be performed as follows:

a) During the acquisition of the above sample the Bulk Density sequence of 4.2.8.1.b.1 shall be performed.

b) The SSCA (Surface Sampler Control Assembly) shall position the SSAU such that LCS #2 can view the surface material via the magnification mirror. The illumination of the sample shall be the optimum attainable.

c) At a location within stereo view of the LCS's (TBD), and as close to the Mars surface as is practical, the SSAU shall: Dump material through the SSAU screen into a pile on the Mars surface, and empty the remaining material in the SSAU, through its jaw, into another pile separate from the previous pile of sieved material.

d) The Camera System shall take a stereoscopic view of the area of deposition no later than 15 minutes after the operation in "c," at a second time within 4 hours, and at a third time within 19 sols.

4.2 Landed (Continued)

e) Sequences "a" through "d" shall be repeated during the mission sols 45 through 90. The location of the sample and the viewing conditions shall be specified based on the analysis of the data from the previous experiment sequence.

f) Between mission sols 30 and 40, it is desired that the sequences of 4.2.8.1.d.3.a through d be performed, with the exception that the sample be made into two piles on a Lander surface, in focal view through the magnification mirror, rather than on the Mars surface as required in 4.2.8.1.d.3.c.

4. During the comminution of the GCMS samples two and three the seismometer shall be operated for a period beginning no later than 5 minutes before and ending no earlier than 5 minutes after the period of comminutor motor operation.

5. During the mission period of sol 45 through sol 60 the Surface Sampler Subsystem shall be used to backhoe two trenches that have an included angle, between their longest axes, of 90° ± 10°. The trenches shall be at least TBD cm long. The two trenches shall be dug in stereoscopic view of the LCS's and the second trench shall be dug on the same sol as the first trench. One trench may be that dug for the acquisition of a subsurface sample for the GCMS or inorganic analysis. The trenches shall be stereoscopically imaged repeatedly, the first time as soon as possible after generation, and at least three additional times separated by at least 10 sols each. The imaging shall be taken during the morning and afternoon at SEA's of approximately 30° to 45°. It is desired that some of the images be in color and via the boom-mounted mirrors if practicable.

a) Within 4 sols after the data from 4.2.8.1.d.5 are received, it is desired that the sequence be repeated with the time of sol and the camera settings determined from that data analysis.

b) It is desired that the experiment of paragraph 4.2.8.1.d.5 be repeated in the mission period of sol 60 through sol 90 with the parameters of the trenching and viewing specified from the analysis of the data obtained from the initial sequence.

6. During the mission period between sol 1 and sol 10 and every 30 sols thereafter, the grid pattern on top of the Lander shall be viewed with LCS #2.

7. During a period of predicted moderate wind velocity, the SSAU shall sieve material through the SSAU screen into one pile and empty the remaining material into a second pile on the Martian surface. These operations shall be accomplished while the SSAU is positioned approximately 0.1 m above the surface.

Within five minutes after completion of the above sequence, the resulting piles shall be stereoscopically imaged and viewed via the boom-mounted mirrors if practicable. It is desired that the images be in color. This viewing sequence shall be repeated within five sols and thereafter at 10-sol intervals throughout the mission.

4.2 Landed (Continued)

e. Solar Flux Levels

The LCS shall be used to evaluate the condition of the ultraviolet degradable materials on the Photometric Targets. The UV degradable materials shall be viewed through each filter during each of the LCS calibration viewing sequences of the photometric targets and at least every three sols during the first 20 sols of the mission and once every five sols thereafter through sol 60.

f. Diurnal Temperature

1. Lander Temperature and Parachute Phase Temperature Transducer

a) The engineering data format (Format 4) shall be sampled once in conjunction with each meteorology module.

b) The engineering data format (Format 4) shall be sampled at least 12 times in the hour before sunrise and sunset and 12 times in the hour after sunrise and sunset, six times during the mission.

c) "b" shall be performed on two sols in the period between sol 20 and sol 30; on three sols in the period between sol 31 and sol 60; and on four sols in the period between sol 61 and sol 90.

2. The SSAU temperature sensor shall be used to infer the diurnal temperature of the surface. The sequences shall be as follows:

a) The SSAU shall be commanded to a position such that the bottom of the SSAU jaw is resting on the surface.

b) The SSAU shall remain on the surface for at least (TBD) minutes and then the SSCA shall be commanded to take two temperature measurements.

c) Sequences "a" and "b" shall be performed after all samples have been acquired and repeated approximately every 10 sols to the end of the mission.

It is desired that sequence "2" above be performed by allowing the SSAU to remain on the surface for 24 hours and making temperature measurement every hour during that period except as specified in paragraph 1.b above.

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4.2 Landed (Continued)

4.2.8.2 Additional Objectives

a. Imaging Support

1. It is desired that high resolution stereo images be obtained for all sample trenches at least four times during the mission, and once more for all other surface sample acquisitions.

2. High resolution imaging is desired on the VL body following the deposition of surface material on the VL by the surface sampler. This imaging is desired immediately after deposition and four additional times at equally spaced intervals.

b. Topographic Mapping

The Surface Sampler Subsystem and the LCS's may be used to map the Mars surface in the vicinity of the VL. The mapping should be determined from the analysis of the initial pictures of the sample area and should be performed after all samples have been acquired. The topographic sequence should be as follows:

1. During selected Surface Sampler Subsystem operations, the SSAU area of contact with the Mars surface should be stereoscopically viewed by the LCS's in stereo. The viewed area should be determined from data and the field of view large enough to make a unique determination of the surface location seen in previous photographs.

2. From earlier data, six locations will be specified which are in stereoscopic view of the LCS's and divided equally between the right and left portions of the sample acquisition field. The SSAU should make contact with the surface using the depression motion of the boom.

3. It is desired to stereoscopically image the area of contact at the location from "2" above, immediately after contact. The imaged area should be large enough so that unique landmarks can be identified from earlier photographs. The time of sol to conduct this experiment should be such as to provide optimum illumination.

4. It is desired to repeat the experiment during the last 10 sols of the mission, based on the analysis of the first sequence.

c. Wind Environment

It is desired that the seismometer be operated continually in order to infer wind turbulence induced motions of the lander.

4.2 Landed (Continued)

4.2.9 Radio Science

4.2.9.1 Requirements and Objectives

a. Early Post-Landed VL Tracking

Until the VL landed position is known to within 30 km (three sigma) or until sol 10, whichever is sooner, Doppler data from each VL shall be obtained for one continuous 30-minute tracking period each sol. One good range point shall be obtained for each VL at least every 5 sols. One full orbit of continuous S- and X-band Doppler and range data from the orbiting VO is required, centered around each VL range point.

b. Landed VL Tracking

After the VL landed position is known to within 30 km (three sigma) or after sol 10, whichever is sooner, Doppler data from each VL shall be obtained for at least one continuous 30-minute tracking period every 5 sols. One good range point approximately every 5 sols for each lander is required. One full orbit of continuous S- and X-band Doppler and range data from an orbiting VO is required, centered around each VL range point.

It is desired that Doppler data from each VL be obtained on a regular basis for one hour or more per sol over the maximum range of earth elevation angles that are operationally possible. One good range point at least every 3 sols for each lander is desired in the post-landed phase.

c. Near Limb VL Tracking

Doppler tracking of the individual landers no farther than 45° from the planet limb is required at least five times uniformly distributed during landed operation.

d. Very Long Baseline Interferometry

1. Doppler tracking of a VO and a VL simultaneously, at two ground stations is required for 30 minutes at least four times throughout the mission.

2. Doppler tracking of two VL's simultaneously at two ground stations is required when lander locations permit. This measurement will be required for approximately six periods of 5 minutes each, spread over one common lander view period. These data are required at least five times uniformly distributed throughout the landed operation. If operational constraints do not permit the six 5-minute periods, one 30-minute period may be substituted.

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4.2 Landed (Continued)

3. Alternate VLBI tracking of a quasar and an Orbiter is required for one full pass of the common visibility of the participating tracking stations, several times during the mission.

4. Alternate VLBI tracking of a quasar and a lander is required for one full pass of the common visibility of the participating tracking stations at least once during the mission.

5. For Jodrell Bank, Haystack, or Arecibo VLBI participation with a DSN station, mutual view time is required for the above four experiments to be as large as possible compatible with geometric and operational considerations.

e. UHF VL-VO Relay Signal Amplitude and S/N Measurements

See section 3.7.4.3.1.e.

4.2.9.2 Additional Objectives

a. Solor Corona and Relativity

When the Sun-Earth-Mars angle is less than 15° and signals are detectable, Doppler and ranging are desired from at least one VL each sol. These observations should be made simultaneously with the corresponding VO observations (3.7.4.2.1).

b. Meteorology Measurement Support

See section 3.7.4.3.2.c.

4.2.10 Inorganic Analysis

4.2.10.1 Requirements and Objectives

a. Sample Acquisition

1. A minimum of six different surface/subsurface samples shall be acquired for analysis. The first and second sample shall be obtained from the same location and at the same time as the GCMS sample. For planning purposes, the third sample shall be a subsurface sample. Subsequent surface and subsurface sample locations shall be determined from analysis of the data obtained from the other Lander experiments.

It is desired that the following additional categories of surface material be delivered for analysis:

a) Material remaining in the SSAU that does not pass through the 2000-micron sieve.

4.2 Landed (Continued)

b) Material that is wind blown, e.g., material that is blown into a previously made trench.

c) Magnetic and/or nonmagnetic fractions of surface material resulting from operation of the magnetic properties experiment.

It is desired to attempt to collect wind blown particles directly into the X-ray instrument. This could be accomplished very late in the mission by using previous data on wind direction and placing the SSAU in a position to act as a partial fence to deflect material into the funnel.

It is desired that samples be acquired for analysis from depths greater than 10 cm.

2. The LCS shall view the sample area within a 3-hour interval both prior to and after acquiring a sample. It is desired that the sample imaging be obtained in the high resolution, the multi-spectral (including color) and the stereoscopic (when sample is in view of both cameras) modes.

3. The Meteorology Investigation shall obtain wind speed and direction measurements during the time the surface sampler is delivering a sample to the X-ray fluorescence instrument funnel.

4. No sample analyzed shall be commanded to be dumped from the sample analysis chamber of the X-ray fluorescence instrument until just prior to commanding the next subsequent analysis.

5. The sample shall be acquired and delivered in such a way as to minimize the thermal shock experienced in the sample analysis chamber.

b. Analysis Scheduling

1. As soon after landing as possible and prior to the first S-band link, an instrument initialization sequence shall be conducted to determine the high voltage bias settings and to verify the presence or absence of materials that might have been inadvertently introduced. This sequence shall be scheduled to permit any required adjustment of the high voltage bias settings by ground update prior to the first analysis. A minimum of four hours shall be allowed for evaluation of the reduced data.

2. Analysis scheduling shall be compatible with the sample strategy given in paragraph 4.0.1.

4.2 Landed (Continued)

3. It is desired that sample 3 be acquired prior to the orbiter MAWD walk.

4. The remaining samples shall be acquired prior to sol 70.

5. It is desired that as many samples as possible be scheduled for analysis by the X-ray fluorescence spectrometer consistent with the sample dump capacity of 650 cm^3.

c. Analysis Conditions

1. A complete analysis shall consist of a calibration sequence and a surface sample sequence.

2. For mission planning purposes, a nominal sequence shall be used. This is approximately 5 hours for a calibration sequence and 5 hours for the surface sample sequence.

3. The calibration sequence shall be performed at a time of sol chosen to minimize the temperature difference of the instrument between the calibration sequence and the surface sample sequence. For mission planning, the calibration sequence shall be performed exactly one sol previous to the surface sample sequence.

4. The surface sample analysis sequence shall be performed during the hours of minimum change in the Lander internal temperatures. The preferred time to start the sequence is 0300 local Mars time.

5. The surface sample shall be in the measuring cavity for at least TBD hours prior to initiating the surface sample sequence.

4.2.10.2 Additional Objectives

For purposes of mission planning, the site selection of the sample to be acquired for the magnified viewing experiment of the Physical Properties Team should be determined by both the Physical Properties and Inorganic Chemical Investigation Teams. After imaging is complete, this sample is to be delivered to the X-ray fluorescence spectrometer for analysis.