NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

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ATTN OF: MAL

MAR 28 1972

MEMORANDUM

TO: Distribution

FROM: MA/Apollo Program Director

SUBJECT: Apollo Site Selection Board Meeting Minutes

Attached is a copy of the minutes of the February 11, 1972, Apollo Site Selection Board Meeting, including Attachments I, II and III.

Rocco A. Petrone
Rocco A. Petrone

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INDEXING DATA

DATE	OPR	#	T	PGM	SUBJECT	SIGNATOR	LOC
02-28-72	HQS		11	LEX	(Apollo)	PETRONE	075-53

date: March 23, 1972

to: Capt. W. T. O'Bryant - NASA/MAL

from: N. W. Hinners

subject: A.S.S.B. Minutes

Attached are the final minutes of the February 11, 1972 ASSB meeting, including Attachments I and II. Attachment III was brought to your office yesterday. The final minutes incorporate corrections to the draft minutes by yourself, Dr. Petrone and K. Martersteck.

The suggested distribution is the same as for the previous meeting.

N. W. Hinners

2015-NWH-ams

Attachments

Presentation Grider
not copied

MINUTES OF THE APOLLO SITE SELECTION BOARD MEETING

Held at
Apollo Action Center
955 L'Enfant Plaza North, S. W.
Washington, D. C. 20024

February 11, 1972

The Apollo Site Selection Board (ASSB) met at NASA Headquarters on February 11, 1972 to select a site for Apollo 17. The agenda is shown in Attachment I and attendees are listed in Attachment II. Copies of presentation material used are enclosed as Attachment III.

I. Summary of Science Considerations and Ad Hoc Site Evaluation Committee Deliberations

N. W. Hinners reviewed the site selection activities commencing with the June 1971 ASSB meeting at which time Descartes was selected as the Apollo 16 site and Alphonsus was denoted as a prime candidate for Apollo 17. At the June 1972 ASSB meeting it was also pointed out that the Apollo 15 photography would be screened for candidate highland landing sites and that new science data, primarily from Apollo 14 and 15, would be considered in the Apollo 17 site selection.

Screening of the Apollo 15 photography took place during October 1971. Six highland-containing candidate sites were found, spread between Mare Crisium and Mare Serenitatis. Four of those were subsequently eliminated for operational reasons (too far east, thus not allowing sufficient tracking

time between AOS and PDI). Remaining were a "pure" highland site SW of Crisium and a combination highland-volcanic site on the SE edge of Serenitatis and designated Taurus-Littrow (located ∿70 km east of the old Apollo 14 Littrow candidate site).

Consideration of previous site selection discussions and of operational constraints indicated that there were in reality five candidate sites for Apollo 17:

Alphonsus
Copernicus Central Peaks
Gassendi Central Peaks
SW of Crisium
Taurus-Littrow

In December 1971, N. W. Hinners sent a Site Evaluation Document to 32 lunar scientists, most of whom are either PI's on Apollo 17 or who have been intimately involved in lunar studies. The document included a discussion of the science objectives for Apollo 17 and a discussion of the above-named sites. Recipients of the document were requested first to respond with their personal science priorities for Apollo 17 and, second, to indicate how each candidate site might fulfill the objectives. They were cautioned against unrealistically adding new sites, were told that there could be no dependence upon Apollo 16 photography (a constraint which eliminated Davy and East Alphonsus as candidates) and were further presented with strong caveats concerning two of the candidate sites:

1. the SW of Crisium highland site is in the highland terrain unit accessible to a Russian unmanned sample return spacecraft (and which has now, after the ASSB meeting, been sampled by Luna 20). Additionally, the site is relatively homogeneous, thus would not make efficient use of the Apollo system;
2. most lunar scientists believe that samples from Copernicus were obtained from ray material acquired on the Apollo 12 mission.

The responses to the Site Evaluation Document were considered by an Ad Hoc Site Evaluation Committee in January 1972. The Committee consisted of:

P. Gast
N. Hinners, Chairman
H. Masursky
R. Phinney
L. Silver
J. Wood

A clear consensus among respondees and the Ad Hoc Site Evaluation Committee was apparent in terms of objectives for Apollo 17 (in priority order):

1. Pre-Imbrian highlands as far as possible from the Imbrium basin
2. "Young" volcanics

3. Orbital coverage
4. Traverse geophysics
5. ALSEP (high priority for the Heat Flow Experiment).

The reasoning behind the priorities is as follows. Samples acquired to date have been dominated by mare materials. We now know much about mare composition and formation but, even considering the Fra Mauro and Apennine samples, relatively little about the highlands which constitute ∿85% of the moon. Earth-based mapping, Apollo 14 and 15 sample results and Apollo 15 orbital x-ray data indicate that the highlands are complex and heterogeneous. Thus the desire to sample highlands far away from the Imbrium basin (source of Apollo 14 and 15 samples).

The limited lunar chronology so far developed indicates that major lunar thermal and chemical evolution may have effectively ceased about three billion years ago. However, the generalized and comprehensive models of lunar origin and evolution are quite sensitive to whether or not that is indeed true. In fact, there are regions of the moon which appear to have younger volcanic materials. This is based upon observations of superposition and relative crater densities. However, at this time one does not know whether younger means, for example, 0.1 or 1-3 billion years. The volcanics must be sampled. The putative young materials are generally dark and often associated with cinder-cone or halo crater structures indicative

of explosive volcanism. The explosive nature itself is significant for two reasons:

1. it indicates a relatively high content of volatiles in the erupting magmas -- and volatiles are notoriously lacking in samples thus far seen;
2. on earth, explosive volcanism sometimes brings deep rocks to the surface in unaltered form -- we have thus far not confidently identified such a lunar sample (the Apollo 15 anorthosite may be one, however).

Orbital science coverage was discussed from two aspects. On the one hand, there is a desire to maximize the amount of new photography which in general means favoring the sites whose ground tracks least duplicate those of Apollo 15 and 16. On the other hand, certain of the new orbital experiments on Apollo 17 (IR Radiometer and Lunar Sounder) benefit by ground tracks which cover a large variety of features and a large area and may also benefit by overflying regions covered by the Apollo 15 and 16 x-ray and γ-ray sensors.

The Apollo 17 mission will include three "traverse geophysics" experiments. In general, they are all aimed at detecting layering, so one might think of selecting a site with a high probability of having layering. The general

consensus of the Ad Hoc Site Evaluation Committee was, however, that the traverse geophysics should not be a determinant in the site selection; rather, after the site is selected, for other reasons, one should determine how best to use the traverse experiments.

Lastly, of all the ALSEP experiments, it was felt that only the Heat Flow Experiment should carry much weight in site selection deliberations. It was further noted that the desires regarding the location of the Heat Flow Experiment correlate with those for sampling since the heat flow is a direct function of rock composition.

The specific site evaluation was addressed next. The candidate sites Copernicus and SW of Crisium generated no enthusiasm among respondees to the Site Evaluation Document for the reasons noted previously. Of the three remaining sites, Alphonsus, Gassendi, and Taurus-Littrow all contain highlands material but the Ad Hoc Site Evaluation Committee saw no obvious way to discriminate strongly the highlands of one site from another regarding age or composition. Gassendi is farthest from the edge of the Imbrium Basin (∿1000 km) but the nearest, Taurus-Littrow, is still ∿800 km distant. The difference of ∿200 km was not deemed significant. There remains a question about whether or not the wall of Alphonsus, expected source of highlands sample, is mantled by Cayley volcanics. The highland blocks at Taurus-Littrow and the

central peaks of Gassendi both appear to be good, "clean" exposures. Between Gassendi and Taurus-Littrow one can make an argument favoring Gassendi in that we have not had a central peak-type mission while Taurus-Littrow is a front-type as was Hadley-Apennine.

"Young" volcanics do not occur at Gassendi. A strong argument cannot be made as to whether the dark halo craters at Alphonsus are any better or worse than the dark mantling blanket at Taurus-Littrow for accomplishing the stated objectives.

The orbital science coverage arguments tend to favor Gassendi. A Gassendi mission would result in the least duplication of Apollo 15 and 16 photography and has the positive attribute of flying over the Orientale Basin in sunlight. The IR Radiometer and Lunar Sounder might benefit more by the Taurus-Littrow ground tracks on account of the greater variety of overflown targets. Alphonsus clearly is least desirable because of close duplication of Apollo 16 ground tracks and less variety in overflown targets.

The Ad Hoc Site Evaluation Committee concluded that the Taurus-Littrow site is the best of the candidates, followed by Gassendi. Alphonsus is a distant third. The overall result is based primarily upon the fact that Taurus-Littrow is a two-objective site (highlands, young volcanics) while Gassendi is a single-objective site (highlands). The better photographic coverage for a Gassendi mission was not deemed

both primary objectives could be reached on the nominal walking traverse.

In summary, good potential LRV traverses exist at all three candidate sites. The contingency walking traverses, however, result in a decreasing priority ordering of Taurus-Littrow, Alphonsus, and Gassendi.

III. Apollo 17 Candidate Site Accessibility and Operational Considerations

At this, the potentially last ASSB meeting, J. Sevier commenced with a short soliloquy on the history of the Apollo site selection process. He noted in particular that there has been a continuing evolution which has seen both the scientists and engineers become increasingly aware of and sensitive to the respective desires and constraints.

Sevier presented the "n-numbers" for each site. For the 1 km radius circle they are 0.74 for Alphonsus, 0.70 for Gassendi, and 0.68 for Taurus-Littrow. The differences are not significant. In terms of map products, however, the Taurus-Littrow site has an edge on account of the availability of the Apollo 15 panoramic and mapping camera photography as contrasted with Orbiter IV and V photography for Alphonsus and Gassendi.

Anticipating the next two speakers, Sevier noted that there are several new things involved if one were to go to Gassendi or Taurus-Littrow, namely, a night launch and Atlantic injection. Additionally, there might be a hover

penalty of 2 sec. at Taurus-Littrow on account of moving perilune west of the landing site to protect bailout capability in event of a DOI overburn. The expected hover-time margin above the descent budget at Taurus-Littrow is expected to be 10 sec. This should be compared with 11 sec. at Hadley-Apennine and 19 sec. at Descartes.

G. Ricks presented the accessibility conclusions. The requirement for 12 minutes of time between AOS and PDI (15 desired) results in a 43°E limit (34°E desired) for landing site location. It is this constraint that eliminated four of the six candidate science sites found in the screening of the Apollo 15 photography.

Regarding SPS ΔV reserves for LM rescue and weather avoidance, Alphonsus looks good for all launch opportunities (2-3-3). For Gassendi, the first month T-0 opportunity available LM rescue ΔV is at the minimum required. It was noted that the sun elevation angle at landing (i.e., time of landing) can be altered slightly to keep the reserve above the desired 600 feet per second. The Gassendi T-24 and T-0 opportunities in the second month present a problem in that one must add 3 revs prior to landing in order to have 210 ft antenna coverage. Alternatively, one can keep the current timeline but relax the translunar abort requirement to DPS + APS. At Taurus-Littrow adequate ΔV reserves are available for all opportunities if one accepts sun elevation angles at landing up to 26° (resulting from the requirement for a minimum of

7.5° to avoid excessive site shadowing). Additionally, the T-0 opportunity in the second month may require relaxing to DPS + APS for abort or adding one additional pre-PDI rev.

F. Bennett discussed landing capability at the three candidate sites. At Alphonsus there is nothing new to add over what was discussed at the previous ASSB meeting. The Alphonsus approach and landing area remain highly acceptable.

The approach to Gassendi is acceptable but the landing area presents problems. Outside the nominal 3σ landing ellipse (1 × 1.4 km), which one obtains with both good landmark tracking and a good noun-69 update, the terrain is either heavily cratered, or rolling, or contains rilles. If one were to land downrange of the nominal ellipse, it is likely that even if the landing were successful, the astronauts would not be able to traverse to the prime objective, the central peaks. The possibility of landing northwest of the central peaks, in apparently more favorable terrain, was discarded because that area is not covered by high resolution photography. There is no confidence that at Gassendi one can extrapolate from the medium resolution photography as was done at Hadley-Apennine, which was a mare landing point. The net result is that MSC deems Gassendi to be operationally unacceptable.

Taurus-Littrow has undergone a changing history. The initial qualitative look led to the belief that there were no serious problems associated with the site. However, when the approach path constraint (-90°) was combined with the pre-

Apollo 15 3σ no-landmark-tracking ellipse (3.4 × 3.7 km), it was not possible to fit the no-landmark-tracking and no noun-69 3σ ellipse into the site without including significant portions of topography unacceptable for landing. That topography included either the escarpment at the west end of the site or the mountains to the east, both of which might also cause problems with the landing radar. Further analysis indicated, however, that pre-Apollo 15 ellipses were too pessimistic. Assuming that the map errors would be the same as those for Apollo 16 (using Apollo 15 mapping camera products) and that unbalanced thruster effects would be no worse than on Apollo 15 results in a no-landmark-tracking ellipse decreased in size to 1.5 × 2.7 km. This allows the no-landmark-tracking plus no noun-69 ellipse to be placed such that there is no landing problem due to topography. The western-most part of the ellipse does include a small portion of the debris flow but it is well within the capability of the crew to redesignate out of that area should they be heading towards it. The summary conclusion was that Taurus-Littrow is an operationally acceptable site.

Discussion

Discussion occurring throughout the operational presentation indicated an acceptance of the evaluation that Gassendi is operationally unacceptable. The discussion thus focused on Alphonsus versus Taurus-Littrow.

J. McDivitt noted that while both Alphonsus and Taurus-Littrow are operationally acceptable, Alphonsus presents

fewer risks. He went on to say that Dr. Kraft requested that everyone be made aware that there are greater risks at Taurus-Littrow. The risks are not risks of safety, but of mission success. The differences in probability of success are not quantifiable, the situation being one of shades of gray rather than of blacks and whites. There are no strong discriminators.

Looking at the new features of a Taurus-Littrow mission, it was reiterated by Dr. Petrone that the bullet had already been bitten on the night launch. The additional time in orbit before the second TLI opportunity does not present a problem due to S-IVB propellant boil-off. It was further reported by D. Scott (via D. Slayton) that the potential problem of spacecraft orientation during an abort from a night launch, where there is no visible horizon, does not exist. The program has been rewritten to preclude gimbal-lock thus ensuring that gyro-orientation will be available.

The discussion returned to the science attributes of the sites. N. Hinners and H. Masursky noted that the science evaluation clearly favors Taurus-Littrow over Alphonsus, the decisive factor being the certainty of acquiring highlands material at Taurus-Littrow (remembering the possible mantling of highlands at Alphonsus). J. Lovell pointed out that Taurus-Littrow is preferable in the sense that there is a significantly greater chance of achieving the objectives in the event of an off-nominal landing.

Dr. Petrone canvassed the ASSB for individual comments and recommendations. The unanimous response was that Taurus-Littrow offers a significantly greater science return and should be recommended as the Apollo 17 site to the Associate Administrator for Manned Space Flight.

ATTACHMENT I

APOLLO SITE SELECTION BOARD MEETING

Apollo Action Center, Room 5032
L'Enfant Plaza North
Washington, D. C.

February 11, 1972

AGENDA

1.	Introduction R. A. Petrone - Headquarters	9:00 a.m.
2.	Summary of Science Considerations and Ad Hoc Site Evaluation Committee Deliberations N. W. Hinners - Bellcomm	9:05 a.m.
3.	Apollo 17 Candidate Site Example Traverses J. W. Head - Bellcomm	10:45 a.m.
4.	Apollo 17 Candidate Site Accessibility and Operational Considerations J. R. Sevier, G. Ricks, F. Bennett - MSC	11:15 a.m.
5.	Discussions and Recommendation Apollo Site Selection Board	12:00 noon

ATTACHMENT II

Attendance, ASSB Meeting
February 11, 1972

Board Members Present

C. M. Lee - NASA/MA
W. T. O'Bryant - NASA/MAL
R. A. Petrone - NASA/MA
W. E. Stoney - NASA/MAE

J. A. McDivitt - MSC/PA
D. K. Slayton - MSC/CA

Board Members Absent

A. J. Calio - MSC/TA
S. A. Sjoberg - MSC/FA

H. F. Kurtz - MSFC/PM-MO-MGR
R. G. Smith - MSFC/PM-SAT-MGR

R. C. Hock - KSC/AA

Other Participants

R. J. Allenby - NASA/MAL
P. J. Bayer - NASA/MAO
D. A. Beattie - NASA/MAL
R. P. Bryson - NASA/MAL
R. L. Campbell - NASA/MAB
J. B. Hanley - NASA/MAL
J. K. Holcomb - NASA/MAO
C. H. King - NASA/MAL
R. G. Luedke - NASA/MAL
P. V. Mason - NASA/MAL

Other Participants (cont'd.)

B. Milwitzky - NASA/MAE
U. H. Polking - NASA/MAO
J. H. Pomeroy - NASA/MAL
D. W. Rankin - NASA/MAL
F. I. Roberson - NASA/MAL
R. B. Sheridan - NASA/MAO
T. H. Smith - NASA/MAB
R. A. Weeks - NASA/MAL

R. E. Moser - KSC/LO-PLN

R. E. Evans - MSC/CB
J. A. Lovell - MSC/TA
D. R. Scott - MSC/CB

L. B. Bell - MSFC/PM-SAT-E

F. J. Doyle - USGS
H. Masursky - USGS
W. R. Muehlberger - USGS

R. A. Bass - Bellcomm
F. El-Baz - Bellcomm
W. W. Ennis - Bellcomm
K. P. Klaasen - Bellcomm
K. E. Martersteck - Bellcomm
A. J. Michael - Bellcomm
W. L. Piotrowski - Bellcomm
P. E. Reynolds - Bellcomm
G. S. Taylor - Bellcomm
R. A. Troester - Bellcomm
R. L. Wagner - Bellcomm
S. B. Watson - Bellcomm