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SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

1.3-DN-C0201-002

TRACKING SUBSYSTEM TEST REQUIREMENTS SURVEY

AVIONICS SYSTEM ENGINEERING

——

17 MARCH 1975

**This Design Note is Submitted to NASA Under Task Order
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1.0 SUMMARY

A survey of the test and checkout requirements of the tracking portion of the Communications and Tracking subsystem has been performed to evaluate adequacy of planned tests and test requirement documents. Emphasis is placed on identifying test completeness, duplications and omissions. Items that may save time, aid in testing and present a more complete integrated test program are also noted. Table I summarizes the results of this survey with more detailed discussion included in Section 3 and Table III. It is planned to continue the survey by covering other communications and tracking functions (command and telemetry) in subsequent reports.

TABLE I

Summary of Test Requirements Survey

DISCREPANCY	RECOMMENDATIONS
• The SAIL Integrated Test Plan, Vol. II (Ref. Q) does not specifically include testing for verification of redundancy management	• Tests should be added to accomplish verification of redundancy management.
• The SAIL and ESTL "Orbital Tracking" tests requirements are nearly the same.	• Perform a combined SAIL/ESTL test to reduce testing.
• No "Rendezvous Data Acquisition and Convergence Times" tests are called out for OFT (Flight).	• Add "Rendezvous Data Acquisition and Convergence Times" tests for OFT (Flight) test.
• OFT (Ground) testing of Rendezvous Radar/Comm A is too detailed	• Perform only self test and system functional type tests. Delete detailed performance tests such as heater temperature and RF spectrum measurements.

DISCREPANCY	RECOMMENDATIONS
• Power output measurements (out of antenna) are not made for the TACAN, Radar Altimeter, MSBLS, and S-Band transmitter subsystems during ALT ground test.	• Recommend that these measurements be taken at the output of the antenna coupler system rather than at the black box.
• Many of the ALT ground tests are too detailed.	• ALT ground testing should eliminate detailed testing such as coding rejection limits, AGC slew rates, spectrum check, pulse width, and repetition rates.
• The C-Band beacon (OV 101 only) is not referenced in either the VEI or the MVP.	• Update VEI and MVP as required to reflect use of C-Band beacon on OV 101.

2,0 INTRODUCTION

The purpose of this report is to identify the planned tracking

system tests to be performed at each major test facility and

determine if these tests and locations satisfy Orbiter Vehicle End

Item Specification (VEI) (Reference A) and the Shuttle Master

Verification Plan (MVP) (Reference B) requirements.

Program requirements that are to be controlled by the NASA Space

Shuttle Program Manager (Level II) are documented within the volumes

of JSC 07700, Space Shuttle Program Definition and Requirements.

Volume X of JSC 07700 defines the Space Shuttle Flight and Ground

system requirements to be used by all NASA and contractor organizations

involved in the design, development, production, test and operation

of the Space Shuttle flight and ground systems.   Volume X of JSC 07700

(Reference P) also defines the Space Shuttle MVP as the source of

verification program requirements to which all elements of the Space

Shuttle Program must adhere. The element and combined Test Requirement Specification Documents (TRSD) and test plans are developed from the various volumes of the MVP and VEI requirements documents. Figure 1 presents a description of document hierachy and the release status of those documents used in this survey. The documents used in this survey are also shown in the list of reference documents in Section 5.0.

3.0 DISCUSSION

3.1 General

To initiate the survey, two comparisons were made. First, the MVP (Vol. III), was compared with the VEI specification to determine if all VEI requirements were being adequately verified. It was found that the MVP specif: s test locations for each VEI tracking requirement. The second comparison made in this survey involved the tests planned for each major test facility. These tests were compared with each other and with the VEI requirements to identify test duplications, omissions, and test document discrepancies.

The major facilities addressed in this design note are as follows:

a) Avionics Development Lab (ADL) at Rockwell, Downey

b) Shuttle Avionics Integration Lab (SAIL) at JSC

c) Electronics System Test Lab (ESTL) at JSC

d) SAIL/ESTL at JSC

e) In Process Tests at Rockwell, Palmdale

f) Approach and Landing Tests (ALT), both Ground and Flight at Edwards AFB

g) Orbital Flight Tests, both Ground and Flight at KSC

There are five tracking requirement paragraphs reflected in the VEI. These requirements are: Rendezvous Tracking, Rendezvous Data Acquisition and Convergence Times, Atmospheric Flight Support Tracking, Final Approach and

Landing Tracking, and Orbital Tracking. Each have unique functional
requirements associated with them which will be discussed in detail in
this design note.

Table II is an overview showing the various test locations where testing
is to be performed versus the applicable VEI functional requirement
to be verified.

Table III is a detailed listing of the planned tests to be performed
at each test facility; the MVP designated verification program; and
the related VEI requirement. Test duplications, omissions and
comments are denoted where applicable. Test plans and test requirements
documents used in this comparison are shown in the list of reference
documents.

3.2 Rendezvous Tracking

This design note section includes discussion and comments on the
adequacy of the rendezvous tracking tests. The subcontractor test
article and OFT-OV3 are planned for the official verification programs
of the rendezvous tracking test requirements. Comments are to be found
below and in the remarks section of Table III.

3.2.1 Palmdale, OV Ground Test

In general, the Palmdale OV Ground Tests for rendezvous tracking
demonstrate system rates, accuracies and capabilities. The Requirement/
Parameter Description for the Radar Long Range Mode is listed as TBD
in Reference F. This requirement should be determined to insure adequate
testing of the Radar Long Range Mode.

3.2.2 ALT (Ground)

The ALT Ground test document (Reference G) references a test of the
Ku-Band rendezvous tracking radar. This reference should be deleted

since no rendezvous radar is included on OV-101.

3.2.3 OFT (Ground)

The KSC ground testing for the rendezvous radar system is too
detailed. Testing should be reduced to eliminate items such as
testing black box specifications. It is recommended that detailed
performance tests such as heater temperature and RF spectrum measurements
be deleted. Only self tests and system functional type tests should
be performed.

3.3 Rendezvous Data Acquisition and Convergence Times

The subcontractor test article is designated by the MVP for verification
of these requirements. Major test facility testing is quite limited
as the SAIL is the only apparent test facility to perform testing of
Rendezvous Data Acquisition and Convergence Times.

3.3.1 OFT (Flight)

It is recommended that Rendezvous Data Acquisition and Convergence
Times testing be added to the OFT Flight test program.

3.4 Atmospheric Flight Support Tracking

The subcontractor test article is designated by the MVP as the
verification program for Atmospheric Flight Support Tracking.
C-Band beacon functional verification tests (for OV 101 only) are called
out in Reference F; however, there are no references to the C-Band beacon
in either the VEI Specification (Reference A) or the MVP (Reference B).
The VEI and MVP should be updated to reflect C-Band beacon use during ALT.

3.4.1 ADL

The ADL test document (Reference M) indicates that development and trend
testing at the TACAN operational range will include power output for
the air-to-air mode. However, the air-to-air mode will not be implemented.
It is recommended that air-to-air mode testing not be performed.

3.4.2 SAIL

The SAIL test document (Reference J) currently lists no tests to be performed relating to Atmospheric Flight Support Tracking. It is recommended that SAIL perform testing to verify systems operations of a TACAN subsystem with other subsystems. Tests should be added to accomplish verification of redundancy management.

3.4.3 Palmdale, OV Ground Test

The test method for the TACAN power output T/R mode is listed as TBD in Reference F. The C-Band Beacon functional verification tests are also listed as TBD. It is recommended that test methods for each be determined in order to insure completion of TACAN and C-Band beacon testing in a timely manner.

3.4.4 ALT (Ground)

TACAN sensitivity measurements should take into account the latest test philosophy of using antenna couplers rather than a hardline directly to the hardware. Sensitivity measurement specifications as called out in Reference G must be changed because of additional power losses due to the use of antenna couplers. Many of the test requirements listed for ALT ground testing are duplicates or more detailed than those for Palmdale in process testing. It is therefore recommended that performance checks such as memory check, range and bearing limits, and adjacent channel rejection be deleted.

3.4.5 OFT (Ground)

In general the KSC ground testing is too detailed. It is recommended that testing be limited to self tests and system functional type tests.

3.5 Final Approach and Landing Tracking

The verification points for Final Approach and Landing Tracking are the SAIL and the OV-101 ALT as specified by the MVP.

3.5.1 SAIL

The SAIL should utilize flight type hardware for system verification testing of NAVAIDS rather than evaluating MSBLS and RA by using math models since SAIL is designated as a verification point. Reference K should delete references specifying using math models of landing aid RF equipment for verification of these systems. Tests should be added to accomplish verification of redundancy management.

3.5.2 ALT (Ground)

Some of the ground operations test requirements at Edwards are too detailed as called out in Reference R. For example testing parameters such as coding rejection limits, AGC slew rate, spectrum checks, pulse width, repetition rates, and interpulse spacing (of the MSBLS DME pulses) is not considered necessary. Power output measurements for the RA and MSBLS should be made out of the antenna in order to follow the latest testing philosophy of using antenna couplers rather than hardlining directly to the hardware.

3.5.3 OFT (Ground)

In general the KSC test requirements are too detailed. Tests such as DME pulse width and repetition rate, spectrum checks and AGC slew rate checks should be deleted.

3.6 Orbital Tracking

The ESTL and OV2 flight test are the MVP verification points for Orbital Tracking. The tests called out in the test documents should adequately satisfy the VEI requirements.

3.6.1 ESTL

The test requirements for ESTL are nearly the same as the test requirements for SAIL. Therefore, a combined SAIL/ESTL test program is recommended.

3.6.2 Palmdale, OV Ground Test

The Requirements/Parameter Description for the one-way doppler tracking measurement is TBD as listed in Reference F. This requirement should be specified.

3.7 Documentation Tree

Figure 1 shows the test plans and requirements documentation tree utilized for the C&T test survey.

3.8 Tests Schedule

Figure 2 presents a schedule of planned C&T system test periods for each major test location. Also shown are the major milestones which the MVP identifies as constraints against verification of VEI requirements. Test schedules appear to be compatible with major program milestones. Schedule information was obtained from the Orbiter Project, Schedule and Status Summary, 3 February 1975.

4.0 CONCLUSIONS

This survey reveals the tests planned and the division of testing among the test locations for the Tracking Subsystem. The following is a listing of the changes recommended to these test plans and test locations.

- Add a Requirement/Parameter Description for the Ku Band Rendezvous Radar Long Range Mode to eliminate a TBD in Reference F (Palmdale TRSD).

- Delete the testing of Ku-Band rendezvous radar as listed in Reference G (ALT TRSD).

- KSC ground testing for the Rendezvous Radar/Comm A as listed in Reference N is too detailed and should be limited to self tests and system functional type tests.

- Revise Reference I OFT requirements document to include testing pertaining to the Rendezvous Data Acquisition and Convergence Times.

- Add the Requirement/Parameter Description for the one-way doppler tracking measurement to eliminate a TBD in Reference F (Palmdale TRSD).

- Add testing in the SAIL to accomplish verification of redundancy management. These tests should be added to the SAIL Integrated Test Plan, Reference Q.

- Revise the Reference J SAIL test requirements to show a combined SAIL/ESTL test program for Orbital Tracking test requirements.

- Update the VEI (Reference A) and the MVP (Reference B) as required to reflect use of C-Band beacon on OV 101.

- Delete the power output measurement of the TACAN air-to-air mode as listed in the ATT test document Reference M.

- Revise the Reference J SAIL test requirements document to include testing to verify systems operations of a TACAN unit with other vehicle subsystems.

- Add a Requirement/Parameter Description for the TACAN power output T/R mode to eliminate a TBD in Reference F (Palmdale TRSD).

- Add a Requirement/Parameter Description for C-Band Beacon functional verification to eliminate a TBD in Reference F (Palmdale TRSD).

- Change NAVAID measurements listed in Reference G (ALT TRSD) to specify RF power levels measured by using antenna couplers rather than using a hardline to the equipment.

- The SAIL should use flight type hardware for system verification testing rather than math models as specified in Reference K.

- Detailed testing such as MSBLS DME pulse width and interpulse spacing, coding rejection limits, AGC slew rates, spectrum check, pulse width, and repetition rates as specified in References G and R should be eliminated.

5.0 REFERENCE DOCUMENTS

(A). Orbiter Vehicle End Item Specification for Space Shuttle System, Part I, MJ070-0001-1A, Change 5, December 2, 1974

(B). Shuttle Master Verification Plan, Volume III, MJ072-0004-3, January 20, 1975 PDR Issue

(C). Avionics Development Laboratory, Communications and Tracking, Phase I, Detailed Test Plan, SD74-SH-0306, February 3, 1975

(D). Sail Test Requirements, MDC Working Paper, 1.3-WP-C0104-016, September 16, 1974

(E). Space Shuttle Program, NASA Task 501, Communications and Tracking Systems Ground Testing, Program Plan, EE7-74-003, June 1974

(F). Test Requirements Specification Document, In Process and Acceptance - Orbiter, ML0101-0001, Rev A. January 27, 1975

(G). Orbiter Approach and Landing Test Program, Test Requirements and Specifications Document (TRSD), SD74-SH-0175, December 13, 1974, Second Coordination Draft

(H). Orbiter Approach and Landing Test Requirements, JSC-08943, August 1, 1974, Baseline

(I). Shuttle Orbital Flight Test Requirements, Draft, JSC-08576, January 15, 1975

(J). SAIL Requirements Document, MDC Working Paper, 1.3-WP-C0102-022, October 29, 1974

(K). Requirement/Definition Document, Book 12, Subsystem Ground Test (SAIL) SD72-SH-0112-20, Vol. 12-20, Rockwell International, January 21, 1974

(L). SAIL Test Requirements, TRW letter 73: 7150.MF-42, November 2, 1973 (Review of Requirements/Definition Document, Avionics, Book 5, Section 4, SD-73-SH-105, July 2, 1973)

(M). Avionics Development Lab, General Test Plan, SD73-SH-0298, no date, final

(N). Launch Operations, Orbiter Tracking System, Test and Checkout Requirements, KSC, November 1, 1974, Rev. A, preliminary

(O). Checkout Plan, Orbiter and Combined Elements Ground Operations, SD73-SH-0062, May 7, 1974

(P). Space Shuttle Flight and Ground System Specification, JSC 07700 Vol X, Rev A, change 20

(Q). Sail Integrated Test Plan Vol II, SD-74-SH-0215-2, December 20, 1974 (Rough Draft)

(R). EAFB-ALT, Launch Operations, Orbiter Tracking System, Test and Checkout Requirements, KSC, December 12, 1975, Preliminary

(S). Launch Operations, Orbiter Communications System, Test and Checkout Requirements, KSC, September 25, 1974, Rev A, Preliminary

TABLE II - TEST LOCATION SUMMARY

TEST LOCATIONS FOR TRACKING TESTS

VEI PARA. NO. (TITLE)	ADL	SAIL	ESTL	SAIL/ESTL	PALM-DALE	ALT GND	ALT FLT	OFT GND	OFT FLT	COMMENTS
3.3.5.2.2.7.1 Rendezvous Tracking General Performance		X				X_1		X	(X) OV3	(X) Subcontractor Test Article (S/C TA)
3.3.5.2.2.7.1.1 Rendezvous Tracking Acquisition Time		X			X	X	X	X	X	(X) S/C TA prime test area
3.3.5.2.2.7.2.1 Atmospheric Tracking	X	(X)			X	X	(X)	X		(X) S/C TA prime test area
3.3.5.2.2.7.2.2 Approach and Landing Tracking	X	X	(X)		X	X		X		
3.3.5.2.2.7.3 Orbital Tracking		X			X	X		X	(X) OV2	

(X) Indicates prime test area, used for verification, as defined by the MVP. (Ref. B)

X Indicates additional tests performed at this location.

X_1 Test not required since there is no rendezvous radar on OV101

TABLE III
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1	Rendezvous Tracking	1. Subcontractor Test Article 2. OFT-OV3

TEST LOCATION/TEST	REMARKS
ADL No tests indicated (References C & M) **SAIL** Verify ability of Rendezvous Radar to detect, acquire and automatically track passive or cooperative targets as specified for the purpose of determining range, range rate. angle and angle rate relative to the target. (Reference K) **ESTL** No tests indicated (Reference E) **SAIL/ESTL** No documentation available. **Palmdale, OV Ground Test** Ku-Band Radar/Comm Rendezvous Track. Verif. Radar Power on ● Rendezvous Self Test ● Rend Radar - Operate ● Rend Radar - Ready ● Rend Radar - Power On ● Radar Temp ● Radar RF Power ● Radar Passive Mode Radar Search Mode ● Radar Search ● Target Tracking ● Radar Detection ● Scan Warn	

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1	Rendezvous Tracking	1. Subcontractor Test Article 2. OFT-OV3

TEST LOCATION/TEST	REMARKS
<u>Palmdale, OV Ground Test</u> (Continued) Radar Manual Mode Radar Auto Mode • Auto Mode • Wide Width Scan Radar Passive Mode • Radar Range Capability • Range Accuracy • Range Rate Capability • Range Rate Accuracy • Angle Capability • Angle Accuracy • Angle Rate Capability • Angle Rate Accuracy Co-op Mode • Range • Range Accuracy • Range Rate • Range Rate Accuracy • Angle • Angle Accuracy • Angle Rate • Angle Rate Accuracy Radar Long Range Mode (Reference F)	
<u>ALT (Ground)</u> Ku-Band Radar/Comm Rendezvous Tracking Verification (Reference G)	Delete reference to Ku-Band Rendezvous Tracking. No Rendezvous Radar on OV-101.
<u>ALT (Flight)</u> No tests indicated. (Reference H)	No Rendezvous Radar On OV-101.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1	Rendezvous Tracking	1. Subcontractor Test Article 2. OFT-OV3

TEST LOCATION/TEST	REMARKS

OFT (Ground)
 	
1. Rendezvous Radar/Comm A (OPF)
  a) Self Test
  b) Target track test
    ● Co-op range & range rate check
    ● Co-op angle & angle rate check
    ● Co-op ready, search detect and
      tracking flag check
    ● Co-op antenna scan check
    ● Non co-op range & angle check
    ● Co-op threshold
  c) Functional path delta
    ● Slew test
    ● Antenna display
    ● Distance scale check
    ● Angle scale check
    ● Comm. A data check
    ● Jettison circuit check
    ● Heater temp. measurement
    ● Standby mode check
    ● Range gate designate
  d) Performance checks
    ● Range limits co-op
    ● Range limits passive
    ● Range rate limit check
    ● Pitch & roll angle coverage
    ● Antenna drift rate
    ● Transponder check
  e) RF checks
    ● Transmit power
    ● Minimum discernable signal
    ● Pulse width, shape and rep rate
      checks
    ● Transmit frequency & spectrum
      check
    ● Receiver AGC check
	KSC ground testing is too detailed.
	Testing should be reduced to eliminate items such as testing black box specifications.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1	Rendezvous Tracking	1. Subcontractor Test Article 2. OFT-OV3

TEST LOCATION/TEST	REMARKS

OFT (Ground) (Continued)
 	
2. Comm B
  a) Self Test
  b) Target track test
    ● Lock on, angle check & Tracking
    ● Auto search & detect check
    ● Manual antenna search & detect check
    ● Threshold
  c) Function path delta
    ● Antenna deploy
    ● Slew test
    ● Comm B data check
    ● Jettison circuit check
    ● Heater temp. measurement
    ● Standby mode check
  d) Antenna performance check
    ● Pitch & roll angle
    ● Antenna drift rate
  e) RF checks
    ● Transmit power
    ● Minimum discernable signal
    ● Transmit frequency & spectrum check
    ● Receiver AGC check
(Reference N)
 	
OFT (Flight)
 	
1. Rendezvous Radar Performance Test
  Verify rendezvous radar, angle rate, range and range rate accuracy performance is within specified on-orbit performance limits required for efficient rendezvous operations.
 	
2. Orbital Rendezvous
  Objective: To demonstrate closed loop performance of GN&C system in performing orbital rendezvous using both the star tracker and rendezvous radar.
(Reference I)
	
	Add angle accuracy test.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1.1	Rendezvous Data Acquisition and Convergence Time	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS
ADL No tests indicated (References C&M)	
SAIL Verify ability to acquire/reacquire a rendezvous target via radar within the time limits specified. (Reference K)	
ESTL No tests indicated (Reference E)	
SAIL/ESTL No documentation available	
Palmdale, OV Ground Test No tests indicated (Reference F)	
ALT (Ground) No tests indicated (Reference G)	
ALT (Flight) No tests indicated. (Reference H)	
OFT (Ground) No tests indicated. (Reference N)	Include Acquisition & Convergence Time testing as performed in SAIL.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.1.1	Rendezvous Data Acquisition and Convergence times	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS
OFT (Flight) No test indicated. (Reference I)	Add Rendezvous Data Acquisition and Convergence Times testing to OFT flight test program. This test could be part of the rendezvous radar general performance test.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article
TEST LOCATION/TEST		REMARKS

ADL

TACAN

1. Initial testing of the TACAN subsystem will verify the accuracy, validity, and drift trends of all functional outputs with the use of ground station simulators, special test equipment, and general laboratory test equipment. Development and trend testing of the operational range will include power output of transmit/receive (T/R) and air-to-air (A/A) modes, and receiver sensitivity. Other parameters to be verified, and trends developed are: bearing accuracy, distance accuracy, selectivity and select time, response speed (distance and bearing), tracking rate, and memory capability. Digital output compatibility with special MDM input/output circuitry will also be developed.
(Reference M)

Remarks: A/A mode will not be implemented.

2. Serial Digital

   - Distance and Bearing Data Output
   Verify the T/R TACAN transmits to the MDM, 32 bit ternary serial digital words which shall contain distance and bearing information, derived from the STE. This data output will be correlated with the software.

   - Serial Digital Data Channel

   - Signal Characteristics

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS
ADL (continued) 3. Transmission Method • Data Code • Data Rate • Clock • Word Sync • Word Size and Format 4. Analog Signals • Beacon Identify Tone 5. Input/Output Singals • Blanking Pulse • Radio Frequency (Reference C) SAIL No tests indicated. (Reference J) ESTL No tests indicated. (Reference E) SAIL/ESTL No documentation available.	Should perform a test utilizing a TACAN unit to verify system operations including redundancy management.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS
Palmdale, OV Ground Test	

Palmdale, OV Ground Test

TACAN Functional Verification
TACAN Activation & Warmup Test
TACAN 1, 2, 3 Power On
TACAN Verification
   TACAN 1, 2, 3 Tests
      o Range
      o Bearing

Operational Range
   TACAN 1, 2, 3 Range & Range Flag

Operational Bearing
   TACAN 1, 2, 3 Bearing & Bearing Flag

Accuracy, 15 Hz Digital Bearing
   TACAN 1, 2, 3

Distance Tracking Rate Verif
   TACAN 1, 2, 3

Bearing Tracking Rate Verif
   TACAN 1, 2, 3

Response Speed Verification
   TACAN 1, 2, 3 DME Mode & Bearing Mode

TACAN X-Y Mode Select Test
   TACAN 1, 2, 3

Channel Select Time Test
   TACAN 1, 2, 3 (Auto Mode)

Receive Only Mode Test
   TACAN 1, 2, 3 No RF output.

TACAN Memory Verif.
   TACAN 1, 2, 3 Distance Memory
   & Bearing Memory

TACAN Transmitter Frequency
   Freq. 1, 2, 3 X & Y Mode Verif

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article
TEST LOCATION/TEST		REMARKS

TEST LOCATION/TEST	REMARKS

Palmdale, OV Ground Test (Continued)
 	
Blanking Test
  TACAN 1, 2, 3
 	
Antenna Switching
  Auto mode with no signal input
  TACAN 1, 2, 3 Ant switching rate
  Manual Mode - Verif RF signal from
  selected antenna
 	
TACAN power output, T/R mode
  TACAN 1, 2, 3
 	
C-Band Beacon
  Functional Verification
(Reference F)
 	
ALT (Ground)
 	
1. TACAN
  a) Self Test
  b) Functional path delta
    • Channel select X and Y mode
    • Threshold
    • Receive only mode
    • Antenna switching
    • Blanking Test
    • Power measurement
  c) Performance Check
    • Memory Check
    • Range limits
    • Bearing limits
    • Adjacent channel rejection
    • Dynamic tracking
    • Ground station check
  d) RF Checks
    • Minimum discernable signal
    • Transmit frequency & spectrum
      check
    • Transmit pulse width & rep rate
	The test method for TACAN power output, T/R mode is TBD. See para. 3.4.3 of this report.
	
	C-Band Beacon Functional Verification tests need to be determined (use tests suggested by FRC/EAFB).
	
	Many of these test requirements are duplicates or more detailed than those for Palmdale. It is recommended that performance checks such as memory check, range and bearing limits, and adjacent channel rejection be deleted.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS
ALT (Ground (Continued)	

ALT (Ground (Continued)

2. C-Band Beacon
   a) Interrogation Test
      ● Coding rejection limits
      ● Antenna switching test
      ● Sensitivity
      ● Center frequency & bandwidth
   b) Reply measurements
      ● Transmit frequency
      ● Power out
   c) FPS 16 test
(Reference R)

3. TACAN Functional Verification
   a. TACAN Activation & Warmup Test
      TACAN 1, 2 & 3 Power On
   b. TACAN Verification
      TACAN 1, 2 & 3 Test, Range &
         Bearing Range
   c. Operational Range
      TACAN 1, 2, & 3 Range &
      Range Flag
   d. Operational Bearing
      TACAN 1, 2 & 3 Bearing & Bearing
         Flag
   e. Accuracy 15 Hz Digital bearing
      TACAN 1, 2 & 3 Bearing
   f. Distance Tracking Rate Verif.
      TACAN 1, 2 & 3
   g. Bearing Tracking Rate Verif
      TACAN 1, 2 & 3
   h. Response Speed Verif.
      TACAN 1, 2 & 3 DME Mode & Bearing
         Mode
   i. TACAN X-Y Mode Select Test
      TACAN 1, 2 & 3
   j. Channel Select Time Test
      TACAN 1, 2 & 3 Auto Mode
   k. Receive Only Mode Test
      TACAN 1, 2 & 3
   l. TACAN Memory Verif.
      TACAN 1, 2 & 3 Distance & Bearing
         Memory

REMARKS:

Power output measurements (out of antenna) should be performed for the TACAN. See para. 3.4.4 of this report.

Suggest deleting Y mode testing if Y mode is not used for Edwards testing.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS

<u>ALT (Ground) (Continued)</u>
 	
   m. TACAN Transmitter Freq.
      TACAN 1, 2 & 3 X & Y Mode Verif.
   n. Blanking Test
      TACAN 1, 2 & 3
   o. Antenna Switching
     ● Auto Mode
      TACAN 1, 2 & 3 Antenna Switching Rate
     ● Manual Mode
 	
 4. C-Band Beacon (OV 101 only) Functional Verification
<u>(Reference G)</u>
 	
<u>ALT (Flight)</u>
 	
TACAN
Objectives:
1. Verify TACAN range and bearing accuracy performance.
2. Verify adequacy of display manual approaches.
<u>(Reference H)</u>
 	
<u>CFT (Ground)</u>
 	
1. TACAN (at OPF)
   a) Self Test
   b) Functional path delta
     ● Channel select X & Y mode
     ● Threshold
     ● Receive only mode
     ● Antenna switching
     ● Blanking test
     ● Power measurement
   c) Performance check
     ● Memory check
     ● Range limits
     ● Bearing limits
     ● Adjacent channel rejection
	CFT Ground tests appear too detailed. See paragraphs 3.4.5.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.1	Atmospheric Flight Support Tracking	Subcontractor Test Article

TEST LOCATION/TEST	REMARKS

OFT (Ground (Continued)
 	
     ● Dynamic Tracking
     ● Ground station check
    d) RF checks
     ● Minimum discernable signal
     ● Transmit frequency & spectrum check
     ● Transmit pulse width & rep rate
 2. TACAN (at PAD)
    a) Self test
    b) Functional path delta
     ● TACAN beacon check
     ● Channel select
     ● Threshold
     ● Receive only mode
     ● Blanking test
     ● Power measurement
 	
 OFT (Flight)
 	
 High Altitude TACAN Performance
 Objectives:
 Verify the acquisition constraints and TACAN performance after the Orbiter exits blackout. Determine L-Band blackout constraints.
 (Reference I)	

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Tracking	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS

ADL

1. Microwave Scan Beam Landing System

The DME transmitter power, center frequency, and stability trends will be investigated. Receiver sensitivity and center frequency will be used to verify adjacent channel rejection, channelization, and compatibility of the digital information output to the MDM. Ground station simulators will provide a cooperative station for landing system mode verification

2. Radar Altimeter

The radar altimeter compatibility with the special MDM input/output module will be analyzed. Altitude accuracy, tracking rate, maximum acquisition range, and accuracy at all bank angles of an orbiter landing situation will be verified.
(Reference M)

3. MSBLS

- Power on tests
- Signal characteristics
- Transmission tests
- Output tests
- Operation
- Accuracy
- Frequency-channel tests
- Guidance tests
- Dynamic Range and coverage tests
- Sensitivity
- Built-in test

4. Radar Altimeter

- Prerequisite measurements
- Power up tests

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Tracking	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS
ADL (Continued) ● Verify timing, waveform, and voltage amplitude of MDM ● Verify analog altitude from RA ● Verify analog and digital altitude outputs identical within allowable tolerance. ● Perform bit comparison test of digital altitude data outputs (from RA, from MDM) ● Determine RA altitude accuracy using fixed program pulse delays corresponding to altitude between 0-2500 ft. ● Verify that RA will maintain reliable track at altitude rate of +/-2000 ft/sec ● Determine the degradation of BER resulting from the injection of TBD specified magnitudes of noise at specific points. (Reference C) SAIL Verify ability to obtain position information relative to the runway during approach and landing to support autoland with range, coverage and accuracy specified in VEI table 3.3.5.2.2.7.2. Evaluate using math models of the landing aid RF equipment (Reference K) ESTL No tests indicated. (Reference E) SAIL/ESTL No documentation available.	 Should verify system by utilizing NAVAID hardware (MSBLS & RA) rather than using math models.

TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.7.2.7.2.2	Final Approach and Landing Tracking	SAIL

TEST LOCATION/TEST	REMARKS

Palmdale, OV Ground Test

1. Radar Altimeter Functional Verification
   Activation

   Radar ALT No. 1, 2-on
   Radar ALT No. 1, 2-Flag

   Altimeter Verification

   Radar ALT. No. 1, 2-Test (Stimuli on)
   Radar ALT. No. 1, 2 Altitude
   Radar ALT. No. 1, 2 Operating Freq.
   Radar ALT. No. 1, 2 Power Output
   Radar ALT. No. 1, 2 Pulse Width
   Radar ALT. No. 1, 2 Sensitivity
   Radar ALT. System delay (each system)
   Radar ALT. No. 1, 2 Range
   ALT. No. 1, 2 PRF
   ALT. No. 1, 2 Altitude Above Floor

2. MSBLS Functional Verification

MSBLS Activation

   MSBLS 1, 2, 3 Power

   MSBLS Self Test
   MSBLS 1, 2, 3:
   - Azimuth flag
   - Range flag
   - Elevation flag
   - Azimuth
   - Range
   - Elevation

   Elevation Guidance Test
      MSBLS 1, 2, 3 Elev Flag & Output

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Tracking	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS

<u>Palmdale, OV Ground Test (Continued)</u>
 	
Azimuth Guidance Test
  MSBLS 1, 2, 3, Az Flag & Output
 	
Range Information (DME) test
  MSBLS 1, 2, 3 Range Flag & Output
 	
MSBLS 1,2,3 RCVR/XMTR Channel Verif
  RCVR Channels 1 through 10
  XMTR center frequency (DME)
 	
Adjacent Channel Rejection
  MSBLS 1, 2, 3
 	
Digital Interface-MSBLS 1, 2, 3
  Parity
  Velocity
 	
DME Pulse Parameter Test-MSBLS 1, 2, 3
  Pulse width
  Interpulse spacing
 	
MSBLS RF Power Output-DME
  MSBLS 1, 2 & 3
(Reference F)
 	
<u>ALT (Ground)</u>
 	
1. MSBLS
  a) Self test
  b) Functional path delta
    • Channel select
    • Threshold
    • DME power
  c) Performance check
    • Elevation limits
    • Azimuth limits
    • Range limits
    • Coding rejection limits *
    • Angle rate limits *
	ALT Ground tests appear too detailed. Tests such as coding rejection limits, AGC slew rate, spectrum checks, pulse width, and rep rates need not be tested for ALT. Consideration should be made for tests of a self test nature only; especially for turnaround testing.

* Planned to be deleted

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Tracking	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS

ALT (Ground) (Continued)
 	
d) RF checks
  ● Minimum discernible signal
  ● DME pulse width & rep rate
  ● DME frequency & spectrum check
  ● AGC slew rate check *
 	
2. Radar Altimeter
  a) Self Test
  b) Altitude above ground
  c) Functional path delta
    ● Threshold
    ● Power
  d) Performance check
    ● Altitude limits
    ● System delay
  e) RF checks
    ● Minimum discernable signal
    ● Transmit pulse width & rep rate
    ● Transmit frequency & spectrum check
(Reference R)	

3. Radar Altimeter Functional Verif.
  a. Activation
    RA 1, 2 - on & flag
  b. Altitude verif.
    RA 1, 2 - Test & alt.
    RA 1, 2 - Alt. above floor
	Power output measurements (out of antenna) should be made for the Radar Altimeter. See para. 3.5.2 of this paper

4. MSBLS Functional Verif.
  a. MSBLS Activation
    MSBLS 1, 2 & 3 - power on
  b. MSBLS Self test
    MSBLS 1, 2 & 3 - Test, azimuth flag, range flag & elevation flag
  c. Elevation Guidance Test
    MSBLS 1, 2, 3 - Output & Elev flag
  d. Azimuth Guidance Test
    MSBLS 1, 2 & 3 - Output & azimuth flag
	Power output measurements (out of antenna) should be made for the MSBLS. See para 3.5.2 of this paper.

* Planned to be deleted.

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Tracking	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS

ALT (Ground) (Continued)
 	
e. Range info (DME) test
   MSBLS 1, 2 & 3 - Output & range flag
f. MSBLS 1, 2 & 3 RCVR/XMTR
   Channel verif.
   RCVR channels 1 through 10
   XMTR center frequency (DME)
g. MSBLS 1, 2 & 3 Antenna isolation
h. MSBLS 1, 2 & 3 - AGC dynamic range
i. MSBLS 1, 2 & 3 Digital interface
   ● parity
   ● validity
j. MSBLS 1, 2 & 3 DME Pulse parameter test
   ● Pulse width
   ● Interpulse spacing
(Reference G)
 	
ALT (Flight)
 	
1. MLS Performance
OBJECTIVE:
 	
Verify the performance of the Microwave Scanning Beam Landing System during the final approach and landing phase. The capability to provide display data required for manual instrument landing and the capability for autoland through rollout shall be verified.
 	
2. Radar Altimeter Performance
OBJECTIVE:
 	
Verify the altitude capability and accuracy of the radar altimeter.
(Reference H)
	These tests (g through j) are too detailed for ground operations testing. See para. 3.5.2 of this paper.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Test	1. SAIL 2. OV-101

TEST LOCATION/TEST	REMARKS

OFT (Ground)
 	
1. MSBLS (at OPF)
  a) Self test
  b) Functional path delta
    ● Channel select
    ● Threshold
    ● DME power
  c) Performance check
    ● Elevation limits
    ● Azimuth limits
    ● Range limits
    ● Coding rejection limits
    ● Range rate limits
    o Angle rate limits
  d) RF checks
    ● Minimum discernible signal
    ● DME pulse width & rep rate
    ● DME frequency & spectrum check
    ● AGC slew rate check
 	
2. MSBLS (at PAD)
  a) Self test
  b) Functional path delta
    ● Channel select
    ● DME power
    ● Threshold
 	
3. Radar Altimeter (at OPF)
  a) Self test
  b) Altitude above ground
  c) Functional path delta
    ● Threshold
    ● Power
  d) Performance check
    ● Altitude limits
    ● System delay
  e) RF checks
    ● Minimum discernible signal
    ● Transmit pulse width & rep rate
    ● Transmit frequency & spectrum check
	KSC ground testing is too detailed. Tests such as DME pulse width and rep rate, spectrum checks and AGC slew rate should be deleted.

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.2.2	Final Approach and Landing Test	1. SAIL 2. OV-101
TEST LOCATION/TEST		REMARKS

OFT (Ground) (Continued)
 	
4. Radar Altimeter (at PAD)
   a) Self test
   b) Altitude ranging off ET
(Reference N)
 	
OFT (Flight)
 	
No tests indicated.
(Reference I)		

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.3	Orbital Tracking	1. ESTL 2. OFT-OV2

TEST LOCATION/TEST	REMARKS
ADL No tests indicated. <u>(References C & M)</u> **SAIL** 1. Verify ability to provide coherent turnaround of the S-Band carrier to permit tracking by STDN, TDRS and AFSCF and to extract one-way doppler from STDN, TDRS or AFSCF S-Band signals. Accuracy and stability shall be specified. <u>(Reference K)</u> 2. Verify orbiter STDN tracking provisions are provided in accordance with the STDN link. Conduct laboratory test of C&T STDN tracking provisions to establish compliance with performance requirements. 3. Verify ability to support STDN-Direct tracking by turnaround of carrier phase to permit range rate determination by STDN ground stations Verify using simulated STDN tracking link. 4. Verify orbiter ability to support AFCSF tracking by turnaround of carrier phase to permit range rate determination by the ground stations. Verify using simulated STDN tracking links. 5. Verify AFSCF tracking provisions (on-board) are provided in accordance with the AFSCF link. Conduct laboratory tests of C&T AFSCF tracking provisions to verify compliance with performance requirements. <u>(Reference L)</u>	

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.3	Orbital Tracking	1. ESTL 2. OFT-OV2

TEST LOCATION/TEST	REMARKS

ESTL
 	
1. Verify STDN tracking provisions are provided in accordance with STDN link.
 	
2. Verify TDRS tracking provisions are provided in accordance with the TDRS link
 	
3. Verify orbiter ability to support AFSCF tracking by turnaround of carrier phase to permit range rate determination by the ground station
 	
4. Verify ability to support STDN-Direct tracking by turnaround of carrier phase to permit range rate determination by STDN ground station.
 	
5. Perform acquisition test on all subsystems involved in frequency acquisition (with and without doppler):
• Transponder frequency tracking capability
• Receiver frequency tracking capability
• Acquisition times
• Probability of first sweep acquisition.
(Reference E)
 	
SAIL/ESTL
 	
No documentation available.
 	
Palmdale, OV Ground Test
 	
S-Band Verification - STDN, SGLS
  FM Xponder Carrier Doppler Tracking
    Acquisition modes
      Acquisition - with doppler
    2 Way Doppler tracking MSMT No. 1
      Orbiter frequency no. 1
	These test requirements are nearly the same as the Orbital Tracking test requirements for SAIL listed above. Therefore, a combined ESTL/SAIL test program is recommended. (See para. 3.6 of this paper.)

TABLE III (CONT'D)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVP VERIFICATION PROGRAM
3.3.5.2.2.7.3	Orbital Tracking	ESTL OV2

TEST LOCATION/TEST	REMARKS
Palmdale, OV Ground Test (Continued)	

Orbiter frequency No. 2
    Receiver AGC
    Receiver static phase error	

'2 Way Doppler tracking MSMT No. 2	

Orbiter frequency No. 1
    Orbiter frequency No. 2
    Receiver AGC
    Receiver static phase error	

2 Way doppler tracking MSMT No. 3	

Orbiter frequency No. 1
    Orbiter frequency No. 2
    Receiver AGC
    Receiver static phase error	

One-Way doppler tracking MSMT (Reference F)	One-way doppler tracking MSMT's Requirements/Parameter Description are TBD.
ALT (Ground)	System not installed on OV101
No tests indicated (Reference G)	
ALT (Flight)	
No tests indicated (Reference H)	
DFT (Ground)	
1. S-Band Xponder System Threshold ● Doppler ranging	

TABLE III (COMPLETED)
TEST REQUIREMENT SUMMARY

VEI PARA. NO.	REQUIREMENT SUMMARY	MVF VERIFICATION PROGRAM
3.3.5.2.2.7.3	Orbital Tracking	1. ESTL 2. OFT-OV2

| TEST LOCATION/TEST	REMARKS

OFT (Ground) (Continued)
 	
2. S-Band Xponder System Delay (Orbiter system turnaround delay)
  ● Doppler ranging
    STDN
    SGLS
    TDRS
 	
3. S-Band Xponder RCV Only
  (STDN, SGLS, TDRS)
Verify operation of RCV only made with coherent signal and verify uplink data and one-way doppler extraction capability.
(Reference S)
 	
OFT (Flight)
 	
1. On Orbit Navigation Performance Objective: Verify capability to determine and maintain orbiter position within specified accuracies during all on-orbit' operating modes utilizing on-orbit one way (onboard) and two way (ground system) doppler navigation
(Reference I)	

FIGURE 1

APPLICABLE ORBITER TRACKING TEST
PLANS AND REQUIREMENTS DOCUMENTATION

INDICATES DOCUMENT IS NOT
REFERENCED IN THIS REPORT

COORDINATION DRAFT

RELEASED

FINAL

PRELIMINARY
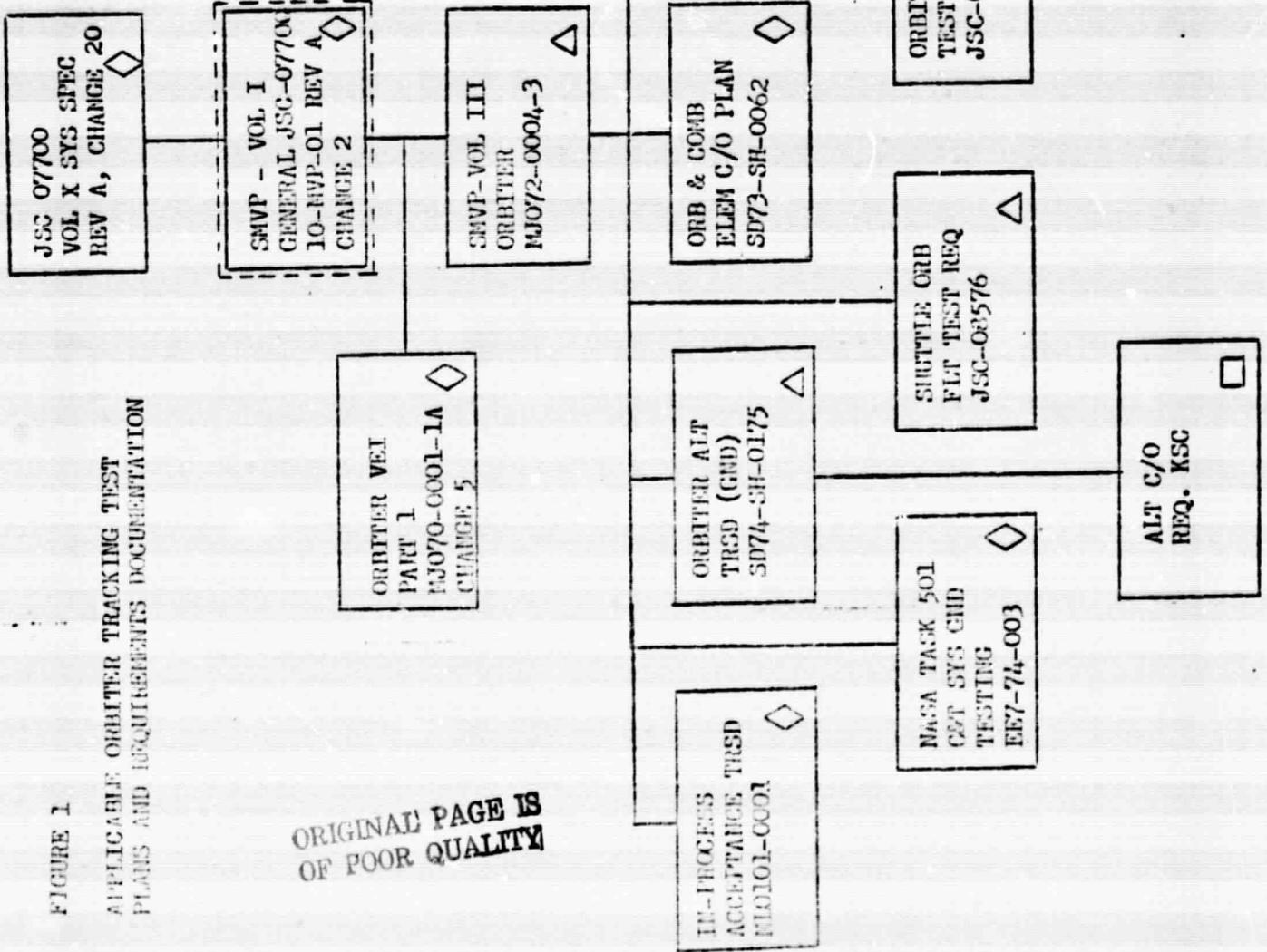
ORIGINAL PAGE IS
OF POOR QUALITY

JSC 07700
VOL X SYS SPEC
REV A, CHANGE 20

SMVP - VOL I
GENERAL JSC-07700
10-MVP-01 REV A
CHANGE 2

SMVP-VOL III
ORBITER
MJO72-0004-3

ORBITER VEI
PART 1
MJO70-0001-1A
CHANGE 5

ORB & COMB
ELEM C/O PLAN
SD73-SH-0062

ORBITER ALT
TEST REQ (FLT)
JSC-08943

AVIONICS
DEVL TEST &
SIM PLAN
SD73-SH-0133

KSC GROUND
TEST REQ
REV A

ADL GEN TEST
PLAN
SD73-SH-0298

C&T PHASE I
DETAILED TEST
PLAN
SD74-SH-0306

SAIL RDD BOOK 12
SD72-SH-0112-20
VOL 12-20

SAIL INTR
TEST PLAN
SD74-SH-0215-2
-2

SHUTTLE ORB
FLT TEST REQ
JSC-08576

ORBITER ALT
TRSD (GND)
SD74-SH-0175

ALT C/O
REQ. KSC

NASA TASK 501
C&T SYS GND
TESTING
EE7-74-003

IN-PROCESS
ACCEPTANCE TRSD
MJ0101-0001

FIGURE 2 C&T TEST SCHEDULE

TASK	1975	1976	1977	1978	1979	1980	1981

MAJOR MILESTONES

ODCDR FAL FAL FMOF IOC

TEST

ATL

SAIL PHASES
I ACTIVATION
II ALT
III OFT
IV MISSION SUPPORT

ALT FLT SUPPORT

KTL PHASES
I SYS DEV
II PERF VERIF

(101) (102) (102) (102)

*SAIL/KTL
PALMDALE
ALT (GRD)
ALT (FLT)
OFT (GRD)
OFT (FLT)
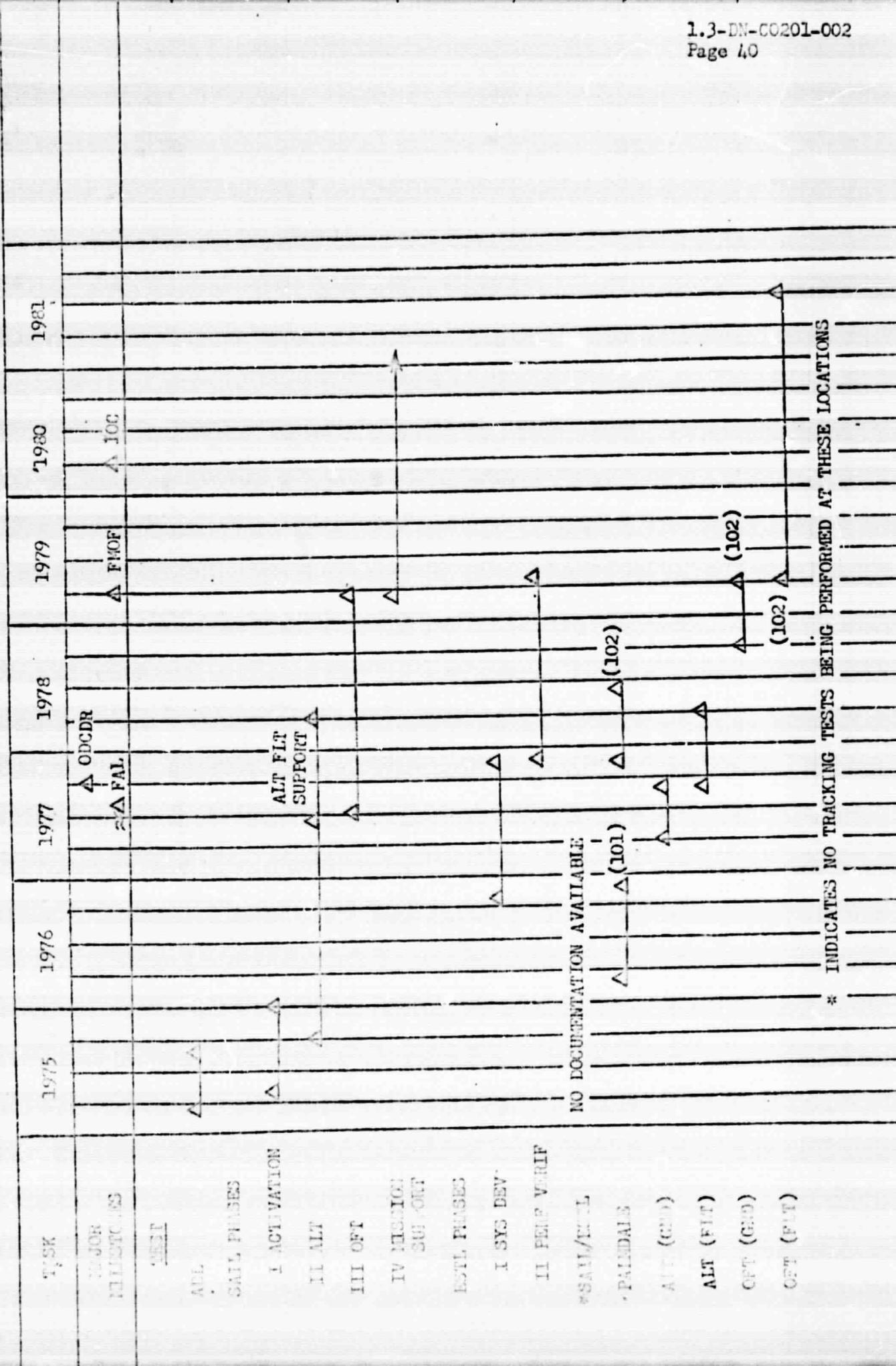
NO DOCUMENTATION AVAILABLE

* INDICATES NO TRACKING TESTS BEING PERFORMED AT THESE LOCATIONS