Probabilistic Risk Assessment of the Space Shuttle
A Study of the Potential of Losing the Vehicle during Nominal Operation
Volume II: Integrated Loss of Vehicle Model

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LO2 SIDE FAILURES DURING VACUUM INERTING PHASE

Failure to open the inboard LO2 F&D Valve (Engine 2)

- ASMAVCOMPOF52
  - 6.62E-05
  - Lockheed PRA

- Human error to initiate the vacuum inerting phase
  - ASMNIQMSPVACCU
    - 1.00E-02
    - Hypothesis

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Failure to open the outboard LO2 F&D Valve (Engine 2)

- ASMAVCOMPOOF52
  - 6.62E-05
  - Lockheed PRA

SSME-2 LO2 PREVALVE FAILS TO OPEN

- ASMSVCOMPOF5P52
  - 4.07E-05
  - MPS R.F.D.

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LH2 SIDE FAILURES DURING PROPELLANT DUMP PHASE

GPMS15 4.0E-04

LH2 MANIFOLD REPRESSURIZATION VALVES FAIL

GPMS21 1.2E-04

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FAIL TO OPEN THE INBOARD LH2 F&D VALVE (ENGINE 3)

ASMAVFOMPHFID3 3.31E-05 MPS R.F.D.

SSME-3 LH2 PREVALVE FAILS TO OPEN

ASMSVFOMPHPRV3 4.07E-05 MPS R.F.D.

SSME-3 FUEL TOPPING VALVE FAILS TO OPEN

ASMSVFOMPHTOG3 8.99E-05 MPS R.F.D.

FAIL TO OPEN THE OUTBOARD LH2 F&D VALVE (ENGINE 3)

ASMAVFOMPHOFD3 3.31E-05 MPS R.F.D.

SSME-3 FUEL BLEED VALVE FAILS TO OPEN

ASMAVFOMPHIBLE3 8.45E-05 GALILEO RTG PRA
FAILURE OF THE OPOV ACTUATORS (ENGINE 1)

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GMECO20
3.78E-11

FAILURE TO PNEUMATICALLY ACTUATE THE OPOV (ENGINE 1)

ASMPAFOMPOPO1
1.40E-04
HYPOTHESIS

3

FAILURE OF THE OPOV HYDRAULIC ACTUATOR (ENGINE 1)

GHYACTO1
2.70E-07

HYDRAULIC ACTUATOR FAILS TO OPERATE

GHYSW2
2.70E-07

FAILURE TO CONTROL THE POSITION (INDEPENDENT FAILURES)

GHYSW3
8.67E-11

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COMMON CAUSE FAILURE TO ACTUATE SERVO-VALVES A & B (ENGINE 1)

ASMHVCPHFOAS1
2.70E-07
NPRD-3; B=0.05

3
HD BOLT 5 FRANGIBLE NUT BOOST CRTRG A FAILS TO DETONATE

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H5ANPF

4.00E-05

NSI PRESSURE / BOOST CRTRG HDS A FAILS TO DETONATE

ACRNPF/HDSASRB

3.00E-05 HYPOTHESIS-2

PIC HDS A FAILS TO FIRE

ACRPCEFHDSASRB

1.00E-05 HYPOTHESIS-3
CDF STRING L51
FAILS TO DETONATE
OR PROPAGATE

BSMCDLSL51SRB
2.00E-05

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CDF ASSY L51 FAILS
TO DETONATE OR
PROPAGATE

ACRCDFDAL51SRB
1.00E-05
USBI

CDF INIT L51 FAILS
TO DETONATE OR
PROPAGATE

ACRCDFDIL51SRB
1.00E-05
USBI
R AFT SEP BOLT 1
PIC B FAILS

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RS18PIC

2.54E-04

R SRB SEP ARM SIGNAL B

RSEPARMB

1.02E-04

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R SRB SEP FIRE 1 SIGNAL B

RSEP1B

1.02E-04

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R SRB SEP FIRE 2 SIGNAL B

RSEP2B

1.12E-04

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PIC R SEP BOLT 1B FAILS TO ARM

ACRPFCFARS1BSRB

1.00E-05

HYPOTHESIS-3

PIC R SEP BOLT 1B FAILS TO FIRE

ACRPFFSRS1SRB

1.00E-05

HYPOTHESIS-3
SPACE SHUTTLE PRA (LOSS OF VEHICLE)
R BSM 3 FAILS TO IGNITE

R BSM 3 CDFS FAIL TO DETONATE

ROCKET MOTOR RBS3 FAILS TO IGNITE (PYROTECHNIC)

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RESTART/Run
UNSUCCESSFUL; OK
STATE DURING RTL;
SEQ. 12

ECK12APU1R
3.06E-01

INDEPENDENT FAILURE TO START OR RUN; OK
EAQASRA1SOK12
1.09E-02
MD APU STUDY

LEAKAGE INDUCED FAILURE START OR RUN; OK
EAQAAFRATOSOK12
3.00E-01
MD APU STUDY

COMMON CAUSE FAILURE TO START OR RUN;
EAQASRA1COSOK12
3.43E-04
MD APU STUDY
APU AYD UNIT 3 LEAK; OK STATE DURING RTL; SEQ. 23

EOK33APU3L 2.95E-02

INDEPENDENT LEAK; OK STATE DURING RTL;
ENOAA1K3LOK23 2.95E-02 MD APU STUDY

COMMON CAUSE LEAK; OK STATE DURING RTL;
ENOAA1CLOK23 9.57E-04 MD APU STUDY
ALL THREE APU/HD UNITS FAIL; OK STATE DURING RTL; SEQ. 29

APU/HD UNIT 1 FAILURE; OK STATE DURING RTL; SEQ. 29

APU/HD UNIT 2 FAILURE; OK STATE DURING RTL; SEQ. 29

APU/HD UNIT 3 FAILURE; OK STATE DURING RTL; SEQ. 29

INDEPENDENT FAILURE TO START OR RUN; OK

OWN LEAK INDUCED FAILURE TO START OR RUN;

COMMON CAUSE FAILURE TO START OR RUN;

OTHER UNIT LEAK INDUCED FAILURE TO START

INTEGRATED MODEL REV. 2
LOV DURING RE-ENTRY DESCENT DUE TO ONE LATENT HYDRAZINE LEAKAGE

SEQUENCE 4 LOV;
INITIAL LEAK IN 1
APU; SEQ. 4

SEQUENCE 6 LOV;
INITIAL LEAK IN 1
APU; SEQ. 6

SEQUENCE 7 LOV;
INITIAL LEAK IN 1
APU; SEQ. 7

SEQUENCE 11 LOV;
INITIAL LEAK IN 1
APU; SEQ. 11

SEQUENCE 12 LOV;
INITIAL LEAK IN 1
APU; SEQ. 12

SEQUENCE 16 LOV;
INITIAL LEAK IN 1
APU; SEQ. 16

SEQUENCE 18 LOV;
INITIAL LEAK IN 1
APU; SEQ. 18

SEQUENCE 19 LOV;
INITIAL LEAK IN 1
APU; SEQ. 19

SEQUENCE 23 LOV;
INITIAL LEAK IN 1
APU; SEQ. 23

SEQUENCE 24 LOV;
INITIAL LEAK IN 1
APU; SEQ. 24

LOV APU: ELO-1
1.64E-06
APU/HYD UNIT 2
FAILURE; INITIAL
LEAK IN 1 APU, SEQ.
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E1004APU2
8.10E-02

INDEPENDENT FAILURE
TO START OR RUN;

EAQAASRA2SL004
1.09E-02
MD APU STUDY

LEAKAGE INDUCED
FAILURE TO START OR
RUN;

EAQAASRA2SL004
7.00E-02
MD APU STUDY

COMMON CAUSE
FAILURE TO START OR
RUN;

EAQAASRA1CSL004
8.87E-04
MD APU STUDY

SPACE SHUTTLE PRA (LOSS OF VEHICLE) INTEGRATED MODEL REV. 2 Page 482
APU HYD UNIT 3
FAILURE; INITIAL
LEAK IN 1 APU; SEQ.
4

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INDEPENDENT FAILURE
TO START OR RUN;

LEAKAGE INDUCED
FAILURE TO START OR
RUN;

COMMON CAUSE
FAILURE TO START OR
RUN;

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8.10E-02

1.09E-02

7.00E-02

8.87E-04

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MD APU STUDY

MD APU STUDY

MD APU STUDY

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TWO APU/HYD UNITS FAIL; INITIAL LEAK IN 1 APU; SEQ. 23

APU/HYD UNITS 1 AND 2 FAIL; INITIAL LEAK IN 1 APU; SEQ. 23

APU/HYD UNIT 1 FAILURE; INITIAL LEAK IN 1 APU; SEQ. 23

APU/HYD UNIT 2 FAILURE; INITIAL LEAK IN 1 APU; SEQ. 23

EL023APU12F 1.28E-01

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EL023APU12F 1.28E-01

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EL023APU23F 1.28E-01

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EL023APU12F 3.57E-01

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EL023APU22F1 3.57E-01

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APU HYD UNIT 2
FAILURE: INITIAL
LEAK IN 23

APU HYD UNIT 2
FAILURE: INITIAL
LEAK IN 23

INDEPENDENT FAILURE TO START OR RUN:

OWN LEAK INDUCED FAILURE TO START OR RUN:

OTHER UNIT LEAK INDUCED FAILURE TO START OR RUN:

COMMON CAUSE FAILURE TO START OR RUN:

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1.0E-02 MD APU STUDY
3.0E-01 MD APU STUDY
7.0E-02 MD APU STUDY
1.3E-03 MD APU STUDY
3.57E-01
LOV DURING RE-ENTRY/DESCENT DUE TO THREE LATENT HYDRAZINE LEAKAGES

SEQUENCE 4 LOV; INITIAL LEAK IN 3 APUS; SEQ. 4

ELT04LOV 5.94E-09
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SEQUENCE 6 LOV; INITIAL LEAK IN 3 APUS; SEQ. 6

ELT06LOV 3.59E-09
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SEQUENCE 7 LOV; INITIAL LEAK IN 3 APUS; SEQ. 7

ELT07LOV 1.29E-08
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SEQUENCE 11 LOV; INITIAL LEAK IN 3 APUS; SEQ. 11

ELT11LOV 4.12E-08
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SEQUENCE 12 LOV; INITIAL LEAK IN 3 APUS; SEQ. 12

ELT12LOV 6.44E-08
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LOV DUE TO FAILURE OF THE RIGHT BODY TPS

TPS RIGHT BODY

7.16E-04

CATASTROPHIC FAILURE OF RIGHT SIDE TPS; UNDER CREW; 158 TILES

ANOTPST1/ID1111

1.23E-04

TPS STUDY

CATASTROPHIC FAILURE OF RIGHT SIDE TPS; NOSE; 277 TILES

ANOTPST1/ID2321

3.00E-06

TPS STUDY

CATASTROPHIC FAILURE OF RIGHT SIDE NEAR MAIN LDG GEAR (FWD) TPS; 676 TILES

ANOTPST1/ID1111

1.75E-04

TPS STUDY

CATASTROPHIC FAILURE OF RIGHT SIDE NEAR MAIN LDG GEAR (AFT) TPS; 156 TILES

ANOTPST1/ID1211

1.23E-04

TPS STUDY

CATASTROPHIC FAILURE OF RIGHT SIDE TPS; FWD MID EDGE; 624 TILES

ANOTPST1/ID2121

2.49E-04

TPS STUDY