

# **RELIABILITY TRANSFORM METHOD**

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### 3.2.2 AOE-6 Background

The AOE-6 class ship is designed as a fast combat support ship and is the Navy's largest combat logistics ship. The first of the class, the USS Supply, was deployed on February 26, 1994. The class was designed to carry fuel, ammunition and stores which are distributed simultaneously to ships in a carrier battle group. This was to replace the three ships that distributed fuel, ammunition and stores separately, thus reducing the alongside time of the combat ships.

Four ships were built in the class to operate with carrier battle groups as a station ship. Station ships are resupplied by shuttle ships which operate between the battle groups and ports. The Supply was decommissioned on July 13, 2001, and the Artic was decommissioned on June 14, 2002. Both were recommissioned under the Military Sealift Command to perform the same function with a merchant marine crew.

### 3.2.3 AOE-6 RMA Timeline

The RMA timeline used in this analysis is based on a 90 day wartime mission profile for AOE-6 mission with the ship operating primarily in a task force or battle group environment. The mission profile is shown below in Table 2:

Table 2 - AOE-6 Timeline (90 Day Mission)

<u>Phase Description</u>	<u>Phase Sequence</u>	<u>Phase Type</u>	<u>Phase Duration</u>	<u>Cumulative time</u>
In port - at anchor	1	1	24	24
Transit in company	2	2	222	246
Fueling AOE-6 at sea	3	3	12	258
Replenish CV/CG	4	4	3	261
Vertical Replenishment / Transit in company	5	5	33	294
Replenish CV/CG	6	4	3	297
Vertical Replenishment / Transit in company	7	5	33	330
Fast Transit	8	6	15	345
Connected replenishment - DD	9	7	4	349
Vertical Replenishment / Transit in company - DD	10	8	17	366
Replenish CV/CG	11	4	3	369
Vertical Replenishment / Transit in company	12	5	33	402
Replenish CV/CG	13	4	3	405
Vertical Replenishment / Transit in company	14	5	33	438
Fast Transit	15	6	15	453
Connected replenishment - DD	16	7	4	457

AN/SPS-67(v) radar set and AS-936B/SPS-1QB antenna are backed up by the Radar Navigation Group described in Section 3.2.4.6.

- Ship's Position Group - The Ship's Position Group consists of an AN/SRM-19(v) satnav backed up by an LTM-211 omega, an AN/UQN-4 fathometer, and a DRT group.
  - DRT Group - The DRT Group consists of two AN/WQN-1 channel finders, a MK 8 MOD 4C dead reckoning tracer and a MK 10 dead reckoning analyzer indicator.
- Ship's Speed Group - The Ship's Speed Group consists of two rodmeters, an indicator transmitter, and a sea valve assembly. Backing up the entire system is a MK 4 MOD 2 dummy log.

#### **3.2.4.8 Exterior Communications System**

Communication between the AOE-6 and other ships, shore facilities, aircraft, satellites and all other external sources is handled by the Exterior Communications System. The system contains the following groups: audio distribution group, communications control group, switchboard group, Narrow band voice group, high frequency radio subsystem group, very high frequency radio subsystem group, satellite communications radio subsystem group, UHF line of site group, wide band secure voice group, special use items group, AN/SYQ-7(v)3 navmacs group, teletype group, link 11 receive only group, quality monitoring system group, and the AN/SAT-28. All of these groups are linked in series but the teletype group is used as a backup for the AN/SYQ-7(v)3 navmacs group and a group in series as well.

- Audio Distribution Group - The Audio Distribution Group consists of 13 TA-970/U phones, 4 TA-980/U phones, four H-169/U handset assemblies, and six loudspeaker groups. The first loudspeaker group contains two loudspeaker sets, each with a LS-474/U loudspeaker and an AM-3729/SR amplifier, one contains a C-10276/SSC Control. The second loudspeaker group contains six loudspeaker sets; three with a NT-49548 Loudspeaker, an AN-3729/SR amplifier, and a C-10276/SSC control; three with a J-550/U jackpot and a NT-49548 loudspeaker. The third group contains a single set with a LS-474/U loudspeaker and an AM/3729/SR amplifier. The fourth group contains eight loudspeaker sets all with two LS-474/U loudspeakers and AM-3729/SR sets, two of the loudspeaker sets also have a C-10278/SSC control. The fifth group contains two loudspeaker sets each with two LS-474/U

loudspeakers and AM-3729/SR sets, one of the loudspeaker sets contains a C-10276/SSC control. The six group contains a single loudspeaker set with two LS-474/U loudspeakers and AM-3729/SR sets, a C-9351/WSC-3 LOS control unit, and a C-10278/SSC control.

- Communications Control Group - The communications control group consists of three C-9351/WSC-3 LOS control indicators, two sets containing two TSEC/KG-84A security equipment and machinery and a C-11328/S digital data control interface unit, seven J-9395/U jackboxes, a supervisory control panel, a OK-454(v)/WSC group, and an AN/SAT-2.
  - OK-454(v)/WSC Group - The OK-454(v)/WSC Group contains an MX-10342/WSC, SB-4124/WSC data& control switchboard, TD-1271 B/U multiplexer, KGV-11/TSEC comsec equipment and machinery, SB-4125/WSC IF patch panel, and a CY-7970/WSC rack.
- Switchboard Group - The Switchboard Group consists of eight SB-27278/SSR Switchboards, a SB-985 comm patching switchboard, three SB-3686 secure comm patching switchboards, three SB-3686 non-secure comm patching switchboards, eight SB-863/SRT XMTR/XFER switchboard, a SB-863/SRT XMTR/XFER switchboard, and an SA-2112(v)2/STQ switching matrix.
- Narrow Band Secure Voice Group - This group contains two sets with an ANDVT and a HMF-3-1/TSEC interconnecting group. One ANDVT is backed up with TSEC/KY-75 security equipment and machinery the other with a second ANDVT.
- High Frequency Radio Subsystem Group - The High Frequency Radio Subsystem Group contains two groups the high frequency receiver group and the high frequency broad band transmitter group.
  - High Frequency Receiver Group - The consists of two sets containing an AS-3606 (XN-1)/ERC-109(v) antenna and radar suppression filter, the group also contains two receiver outfit groups.
    - Receiver Outfit - Each Receiver Outfit consists of a 1 MHz distribution unit, five R-2249(XN-1)/URC-109V radio receivers, a CU-2303(XN-1)/URC-109(v) receiver multicoupler, a power supply, and a terminal block.
  - High Frequency Broadband Transmitter Group - The High Frequency Broadband Transmitter Group consists of a radio frequency terminal box, a broadband antenna, two

AS-2537A/SR(MOD) antennas, an MX-10463 (XN-1)/URC-109(V), four 1 kW radio frequency amplifiers, an MX-10482 (XN-1)/UGC-109(V) input hybrid, two exciter outfit groups, and an ancillary group.

- Exciter Outfit Group - Each Exciter Outfit Group consists of a 1 MHz distribution unit, three T-1474 (XN-1)/URC-109(V) transmitter exciter, a power supply, a terminal block, and a MX-10491 (XN-1)/ URC-109(V) exciter combiner
- Very High Frequency Radio Subsystem Group - The Very High Frequency Radio Subsystem Group consists of a 30-76 MHz VHF line of sight radio group, a 115-150 MHz VHF radio group, and a 156-162 MHz VHF radio group. The 156-162 MHz VHF radio group is not considered in the reliability calculation, to stay consistent with the original calculation.
  - 30-76 MHz VHF Line of Sight Radio Group - The 30-76 MHz VHF Line of Sight Radio Group consists of an AS-3226 URC antenna, an AN-VRC-48A VHF transceiver, an MX-1986A/SRC control adapter, and an SA-2254/UR switching unit.
  - 115-150 MHz VHF Radio Group - The 115-150 MHz VHF Radio Group consists of a PP-2953C/U power supply, an AS-2809/SPC antenna, an AN/GRT-21(V)3 radio transmitter, an MX-1956C/SRC control adapter, and an AN/GRR-23(V)5 radio receiver.
- Satellite Communications Radio Subsystem Group - The Satellite Communications Radio Subsystem Group consists of the satcom fleet broadcast group and the UHF satcom send/receive subsystem group. The satcom fleet broadcast group is backed up by the high frequency radio subsystem group described above.
  - Satcom Fleet Broadcast Group - The Satcom Fleet Broadcast Group consists only of the AN/SSR-1A satellite signal receiving set.
  - UHF Satcom Send/Receive Subsystem Group - The UHF Satcom Send/Receive Subsystem Group consists of the UHF RF satellite communications group, the satcom secure voice group, and the OK-454(V)/USQ group. The UHF RF satellite communications group is backed up by the teletype group and the high frequency radio subsystem group described in this section.
    - UHF RF Satellite Communications Group - The UHF RF Satellite Communications Group consists of an ON-143(V)/USQ interconnect group, an OE-82C/WSC-1 antenna group and an OK-367A/WSC-3 satellite communications control group.

- ❖ OK-367A/WSC-3 Satellite Communications Control Group - The OK-367A/WSC-3 Satellite Communications Control Group consists of a C-9597A/WSC-1 control unit, two control indicator sets, and a J-3532/WSC-3 interconnecting group. Each control indicator set contains an RT-1107A(V)3/WSC-3(V) radio transceiver, a C-9351/WSC-3 control indicator, and a C-9899/WSC-3 control indicator unit.
  - Satcom Secure Voice Group - The Satcom Secure Voice Group consists of ON-143(V)4/USQ interconnecting group, CV-3333/U audio digital converter, and two TSEC/KG 38-4s.
- UHF Line of Sight Group - The UHF Line of Sight Group consists of two identical sets. Each set contains an AS-1735/SRC antenna, an OA-9123/SRC antenna coupler group, four RT-11-7(V)7/WSC03(V) radio transceiver and an MT-6069A/WSC-3(V) equipment rack.
- Wideband Secure Voice Group - The Wideband Secure Voice Group consists of three security sets, a J-3562/WR interconnecting group, KYB-6/TSEC W/J-3584U security equipment, an HYP-2/TSEC power supply, and an SA-1711A/UR switching unit. Two of the security sets contain three TSEC/KY-58 Security Equipment and HYX-58/TSEC interfacing unit sets, and a HNF-2/TSEC interconnecting group. The last security set consists of a TSEC/KY-58 security equipment, an HYX-58/TSEC interface unit and an HNF-2/TSEC interconnecting group.
- Special Use Items Group - The Special Use Items Group consists of an AN2123A(V)/U radio frequency amplifier, two AN/URQ-23 frequency time standards, an IC/SM-10 alarm switchboard, a frequency standard outfit, a C-4421/SR transmitter control, a J-9398/U audio jackbox, and a SB-3158/U telegraph key control panel.
- AN/SYQ-7(V)3 Navmacs Group - The AN/SYQ-7(V)3 Navmacs Group consists of two SYM low level junction box, two AN/USH-26(V) recorder/reproducer, two AN/UYK-20X(V) data processor, a peripheral switching unit, an ON-143(V)4/USQ interconnecting group, an RD-3975(V)2/U tape reader punch, three AN/USQ-59(V) data terminal set, two TT-624(V)5/UO teleprinter, two TSEC/KG-36-4 security equipments, and a mount.
- Teletype Group - The Teletype Group consists of ten CV-3510 signal data converter, an AN/USQ-83(V) data terminal set, four TWK-8/TSEC function remote control units, seven AN/UGC-143(V)4 teletypewriters, two TSEC sets, and a PP-6521 power supply assembly.

Each TSEC sets consist of two TSEC/KWR-48 comsec devices and a HNF-1/TSEC interconnecting group.

- Link 11 Receive Only Group - The Link 11 Receive Only Group consists of an RD-3798A(V) UNH recorder/reproducer, an SYM 453 connection box, and an SB-973/SRR receiver transfer switchboard
- Quality Monitoring System Group - The Quality Monitoring System Group consists of an AT-150/SRC antenna and an AN-SSQ-88 QMS. Neither of these pieces of equipment are considered in the availability calculation

### **3.2.5 AOE-6 Availability Modeling**

The systems for the AOE-6 described in Section 3.2.4 are arranged in an AOE-6 reliability block diagram, using the Tiger input program. The reliability block diagram shows the connectivity of the equipment and machinery on the ship, see Appendix B – AOE-6 Deactivation Diagrams. The mission profile is input using Table 2. Using Table 3 specific equipment and machinery is associated with appropriate mission phase types. MTBF and MTTR for the equipment and machinery is input using the data in Appendix C – AOE-6 Machinery List [10].

Duty cycles are used in the Tiger model to reduce the number of hours equipment and machinery is operating if the equipment and machinery is not used continuously during the mission phase type. Based on Appendix B – AOE-6 Deactivation Diagrams some equipment and machinery use different duty cycles for different mission phase types. For simplification the duty cycle was averaged for all phase types that the equipment and machinery is operating in this model.

Once the model is created the availability simulation is run. Defaults for the simulation are detailed in the output presented in the following section.

### **3.2.6 Validation Results**

In Appendix H – Tiger Results the output file created by Tiger for the AOE-6 validation case is presented. It details the file information, global defaults, and the average availability through the mission. Table 4 shows a summary of the AOE-6 availability simulation results. This details the availability of the ship during the mission phases and the average availability through the

<u>Equipment</u>	<u>QTY</u>	<u>MTBF</u>	<u>MTTR</u>
MK 4 MOD 2 Dummy Log	1	6000	0.5
Exterior Communications Audio Distribution Group			
TA-970/U Telephone Set	13	4000	0.5
TA-980/U Telephone Set	4	4000	0.5
H-169/U Handset Assembly	4	50000	0.2
LS-474/U Loudspeaker	17	10000	0.3
AM-3729 SR Audio Frequency Amplifier	20	3000	0.25
C-10276/SSC Remote Channel Selector	8	5000	1
NT-49546 Loudspeaker	6	10000	0.5
J-560/U Jackbox	3	25000	0.5
C-9351/WSC-3(V) LOS Control Indicator	1	5000	0.5
Communications Control Group			
C-9351/WSC-3(V) LOS Control Indicator	3	5000	0.5
TSEC/KG-84A COMSEC Equipment	4	2000	1
MT-4841/U Shelf Assembly	2		
C-11328/S Digital Data Control Interface Unit	2	2500	2
J-9398/U Audio Jackbox	7	20000	1
Subervisory Control Panel	1	750	0.75
OK/454(V)/WSC Single DAMA Control Monitor Group			
MX-10342/WSC Monitor Panel	1	1600	2
SB-4124/WSC Data & Control Switchboard	1	10000	1
TD-1271B/U Multiplexer	1	1640	0.4
KGV-11/TSEC COMSEC Equipment	1	10000	1
SB-4125/WSC IF Patch Panel	1	10000	1
Switchboard Group			
SB-2727B Sitchboard	6	10000	1
SB-988 Communications Patching Switchboard	1	29000	1
SB-3686 Secure Comm Patching Switchboard	3	18000	1
SB-3686 Non-Secure Comm Patching Switchboard	3	10000	1
SB-863/SRT Transmitter/Transfer Switchboard	9	78000	1
SA-2112(V)2/STQ Switching Matrix	1	2200	3.6
Narrow Band Secure Voice Group			
TSEC/KY-75 Security Equipment	1	1800	2
ANDVT	3	10000	1
HNF-3-1/TSEC Interconnecting Group	2	10000	1
High Frequency (HF) Radio Subsystem Group			
High Frequency (HF) Reciever Group			
AS-3606(XN-1)/URC-109(V) Antenna	2	11300	3
Radar Supression Filter	2	11000	1



<u>Equipment</u>	<u>QTY</u>	<u>MTBF</u>	<u>MTRR</u>
Receiver Outfit			
1 mHz Distribution Unit	2	10000	1
R-2249(XN-1)/URC-109(V) Radio Receiver	10	2175	2
CU-2303(XN-1)/URC-109(V) Receiver	2	1400	2
Multicoupler			
Power Supply	2	2900	2.6
Terminal Block	2	50000	1
High Frequency (HF) Broadband Transmitter Group			
Radio Frequency Terminal Box	1	50000	1
Broadband Antenna 2-9 MHz	1	45000	5
AS-2537A/SR (MOD) Antenna 9-30 MHz	2	45000	3.9
MX-10463(XN-1)/URC-109(V)	1	50000	1
1kW Radio Frequency Amplifier	4	3100	2
MX-10463(XN-1)/URC-109(V) Input Hybrid	1	338000	2
Exciter Outfit			
1 mHz Distribution Unit	2	10000	1
T-1474(XN-1)/URC-109(V)			
Transmitter Exciter	6	2200	1.5
Power Supply	2	2900	2.6
Terminal Block	2	50000	1
MX-10461(XN-1)/URC-109(V)			
Exciter Combiner	2	29000	1
Very High Frequency (VHF) Radio Subsystem Group			
30-76 mHz VHF Line of Sight Radio Group			
AS-3226/URC Antenna	1	100000	1.9
AN/VRC-46A VHF Transceiver	1	1100	9.8
MX-1986A/SRC Control Adapter	1	1600	2
SA-2254/UR Switching Unit	1	10000	1
115-150 mHz VHF Radio Group			
PP-2953C/U Power Supply	1	2000	0.2
AS-2809/SRC Antenna (VHF)	1	4500	2
AN/GRT-21(V)3 Radio Transmitter (VHF)	1	10000	0.2
MX-1986C/SRC Control Adapter	1	1600	2
AN/GRR-23(V)6 Radio Receiver (VHF)	1	1600	0.25
156-162 mHz VHF Radio Group			
RT-1155/URC-80(V)5 Receiver/Transmitter	1	2900	0.5
C-8980/URC-80(V)5 Rcvr/Xmtr Control	1	7200	1
LS-609/U Loudspeaker	1	10000	0.3
H-169/U Handset Assembly	1	50000	0.2
AM-3729/SR Audio Frequency Amplifier	1	3000	0.25
S3JR5 Multipole Potary Illum Switch	1	5000	1
AS-2809/SRC Antenna (VHF)	1	45000	2
Satellite Communications (SATCOM) Radio Subsystem Group			
SATCOM Fleet Broadcast Group			

<u>Equipment</u>	<u>QTY</u>	<u>MTBF</u>	<u>MTRR</u>
AN/SSR-1A Satellite Signal Receiving Set	1	1000	3.7
UHF SATCOM Send/Receive (S/R) Subsystem Group			
UHF RF Satellite Communications Group			
ON-143(V)4/USQ Interconnecting Group	1	3000	0.2
OE-82C/WSC-1 Antenna Group	1	1000	2.5
OK-367A/WSC-3(V) SATCOM Control Group			
C-9597A/WSC-1(V) Control Unit	1	10000	1
RT-1107A(V)3/WSC-3(V) Radio Transceiver	2	1300	1
C-9351/WSC-3(V) Control Indicator	2	5000	0.5
C-9899/WSC-3 Control Indicator	2	5000	0.5
J-3532/WSC-3	1	20000	1
Teletype Group			
CV-3510 Signal Data Converter	10	10000	2
AN/USQ-83(V) Data Terminal Set	1	13000	8
KWX-8/TSEC Function Remote Control Unit	4	10000	1
AN/UGC-143(V)4 Teletypewriter	7	2200	0.2
TSEC/KWR-46 COMSEC Device	4	2000	1
HNF-1TSEC Interconnecting Group	2	10000	1
PP-6521/FG Power Supply Assembly	1	5000	1
SATCOM Secure Voice Group			
ON-143(V)4/USQ Interconnecting Group	1	3000	0.2
CV-3333/U Audio Digital Converter	1	2000	0.3
TSEC/KG-36-4	2	1600	0.2
OK-454(V)/WSC Single DAMA Control Minitor Group			
MX-10342/WSC Monitor Panel	1	1600	2
SB-4124/WSC Data & Control Switchboard	1	10000	1
TD-1271B/U Multiplexer	1	1600	0.4
KGV-11/TSEC COMSEC Equipment	1	10000	1
SB-4125/WSC IF Patch Panel	1	10000	1
UHF Line of Sight (LOS) Group			
AS-1735/SRC Antenna (UHF)	2	59000	1
OA-9123/SRC Antenna Coupler Group	2	3000	1
RT-1107(V)7/WSC-3(V) Radio Tranceiver	8	1500	1
Wide Band Secure Voice Group			
TSEC/KY-58 Security Equipment	7	2500	2
HYX-58/TSEC Interface Unit	7	10000	1
HNF-2/TSEC Interconnecting Group	3	10000	1
J-3562/WR Interconnecting Box	1	20000	1
KYB-6/TSEC Security Equipment	1	2500	2
HYP-2/TSEC Power Supply	1	10000	1
SA-1711A/UR Switching Unit	1	2000	1
Special Use Utems Group			
AM-2123A(V)/U Radio Frequency	1	12400	2

**Equipment**

	<b><u>QTY</u></b>	<b><u>MTBF</u></b>	<b><u>MTRR</u></b>
Amplifier			
AN/URQ-23 Frequency Time Standard	2	10000	2.5
Frequency Standard Outfit	1	10108	2
Sym 433.1 Low Level Junction Box	2	7800	18.8
AN/USH-26(V) Recorder Reproducer	2	4055	4.6
AN/UJK-20X(V) Data Processing Set	2	5000	1
Peripheral Switching Unit	1	2000	3
ON-143(V)4/USQ Interconnecting Group	1	3000	0.2
RD-377B(V)2/U Tape Reader/Punch	1	2210	3.6
AN/USQ-69(V) Data Terminal Set	3	5000	1
TT-624(V)5/UG Teleprinter	2	1000	1
AN/SYQ-7(V)3 NAVMACS Group			
Teletype Group			
Link 11 Receive Only Group			
RD-379A(V)/UNH Recorder/Reproducer	1	5000	1
Sym 453 Connection Box	1	7800	18.8
SB-973/SRR Receiver/Transfer Switchboard	1	10000	1