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Strategy for Equipping Ships for Onboard Electronics Test and Repair

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In January 1997, CNA published a report (CRM 96-133) that identified the most cost-effective and operationally suitable strategy for testing and repairing electronic components on AEGIS destroyers. The study concluded that alternatives that included the use of the USM-646 tester on board the DDGs (and, by implication, on other ships as well) were the most cost-effective. The USM 646 tester, which is based on a personal computer, uses diagnostic software (called gold disks) on a CD-ROM to test electronic components for faults. Once the faults are identified, they can be repaired if the correct equipment and parts are available. By doing tests and repairs on board, a ship can avoid considerable depot-level repair costs and other costs as well.

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Background

In January 1997, CNA published a report [1] that identified the most cost-effective and operationally suitable strategy for testing and repairing electronic components on Aegis destroyers. The study concluded that alternatives that included the use of the AN/USM-646 tester on board the DDGs (and, by implication, on other ships as well) were the most cost-effective. The AN/USM-646 tester, which is based on a personal computer, uses diagnostic software (called gold disks) on a CD-ROM to test electronic components for faults. Once the faults are identified, they can be repaired if the correct equipment and parts are available. By doing tests and repairs on board, a ship can avoid considerable depot-level repair costs and other costs as well.

A full test and repair capability requires five elements:

- The AN/USM-646
- A gold disk library
- A PACE 2000 tool station
- A supply of repair piece parts
- Qualified technicians.

After publication of [1], N43 in OPNAV asked us to develop an investment strategy that would state the order in which surface ships should receive the elements listed above. N43 further asked that we identify the costs and cost avoidances associated with the strategy.

A gold disk library is a set of CD-ROMs that contain the diagnostic software (gold disks) for individual electronic components. The gold disk for an individual component includes data for signature analysis, piece parts information, assembly drawings, and schematics. Several thousand gold disks have been developed to diagnose faults in specific electronic components and several thousand more will be developed when funds are available. Because the gold disk library is in CD-ROM form, it is considered part of the USM-646, and we do not include it as a separate element. Therefore, references to the AN/USM-646 in this paper include the gold disk library as well.

A PACE 2000 tool station includes tools for drilling, removing solder and faulty piece parts from electronic components, and inserting new piece parts. The piece parts kit is an upgraded version, tailored to current needs, that includes such items as transistors and diodes needed to repair faulty electronic components.

While there is a cost to the Navy to provide qualified technicians to ships, the required training courses have been established and there is no initial investment required as there is for the other elements listed above. Therefore, we do not consider technicians further in this analysis.

Approach

To set priorities for fitting out ships to do their own test and repair of electronic components, we had to determine:

- The potential cost avoidances that various classes of ships could generate by doing onboard test and repair. (This allows us to maximize the savings relative to investment.)
- The current distribution of AN/USM-646s, PRC 2000 tool stations, and piece parts kits among ships. (Most ships are at least partially equipped now.)
- Costs of the AN/USM-646, PRC 2000 tool station, and piece parts kits. (This allows us to determine the investments required to complete the outfitting of individual ships.)
- The fleet deployment schedules. (This is to help us determine when a ship experiences the heaviest demand for electronic components.)

The information above will help us determine, for individual ships, the return (cost avoidance) on investment (cost to outfit for module test and repair) and the best timing of that investment.

Sampling for demand

To establish the relative cost avoidance among ship classes, we first had to determine the annual demand for electronic components. Because we had limited time and resources, we examined only those ship classes we felt had the greatest demand. The Navy Inventory Control Point (NAVICP) at Mechanicsburg gave us requisition data for a 2-year period (1 January 1995 through 31 December 1996) for the following ships:

CVN 68	LHA 1
CVN 73	LHA 5
DDG 53	LSD 46
DDG 54	LSD 47
DD 966	LPD 6
DD 970	LPD 14
CG 56	MCM 5
CG 73	MCM 12
FFG 43	
FFG 56	

Every ship we sampled had completed a deployment in 1996 so the NAVICP requisition data captured demand for both the predeployment workups and the deployments.

Because of similarities between LHAs and LHDs, we collected demand data for electronic components only for LHAs and assumed the demand would be similar for LHDs. Likewise, we did not collect demand data separately for CVs, Kidd class DDGs, and CGNs. Instead, we included them in the CVN, DDG 51, and CG classes, respectively.

We did not include fleet support, material support, or underway replenishment ships in the analysis. These ships are important to Navy missions, but most are not equipped with the same density of electronic equipment as the other ships and thus have less potential for cost avoidance. Also, we did not include ships in the reserve force unless they showed up on the list of deployers in the fleet deployment schedules.

Determining potential cost avoidance

The potential cost avoidance used here results primarily from avoiding depot level repair costs by making repairs onboard ships. As we noted in [1], further cost avoidances are possible by ships not having to stock as many spare parts when doing onboard repair. We did not quantify that cost avoidance here.

We must caution against assuming that 100 percent of the cost avoidances that we show will accrue. For that to happen, a series of successful events must take place. These events range from having a qualified technician on board to correctly identifying the fault to having the correct piece part available. For these reasons, we add the qualifier *potential* to the term cost avoidance.

Normalizing the data

Prices of electronic components reported by NAVICP include a surcharge added by NAVSUP to cover management of the supply system. We removed that surcharge from the prices because those management functions supported by the surcharges must continue even if maintenance is done on ships. We would erroneously inflate the potential cost avoidance by including the surcharge.

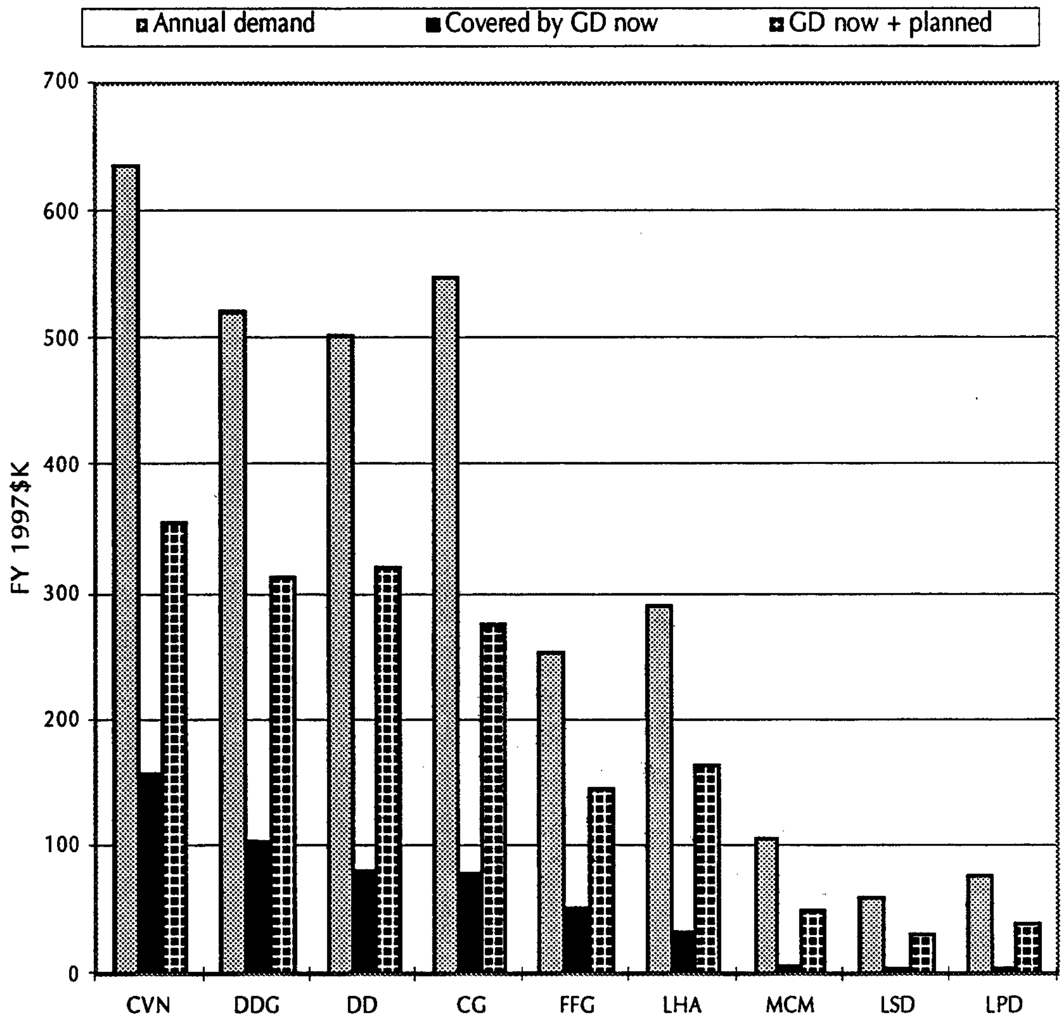
We multiplied the prices of the individual electronic components (either net or standard prices depending on whether the component was classified as consumable or repairable) by the number requisitioned over the 2-year period in our samples. We then divided the 2-year cost by two to put the demand on an annual basis.

Calculating the potential cost avoidance

Having completed the normalization process above, we compared the components that had been requisitioned first against a list of components for which gold disks have already been developed, and then we compared them against a list of components for which gold disks are planned. With that information, we could calculate the potential cost avoidance with current and planned gold disks. Finally, we averaged the data for the two ships sampled in each class to make it easier to make comparisons among the ship classes.

Figure 1 shows a comparison among the ship classes of the dollar value of annual demand, the part of the demand that could potentially be avoided by using existing gold disks, and the part that could potentially be avoided by using existing plus planned gold disks.

Figure 1. Annual demand and potential cost avoidances for electronic components



Of most interest in this analysis are the cost avoidances that may come from using gold disks already developed (the black bars in figure 1) because those savings can be achieved in the near term. By focusing on ship classes that maximize near-term savings, the Navy would also be focusing on the ship classes that promise the greatest long-term savings (the checked bars in figure 1) because they follow almost the same pattern. That is, classes that have the highest potential for near-term cost avoidance generally have the greatest long-term potential.

With this in mind, we consider the list in table 1 to show the order of potential cost avoidance, from highest to lowest.

Table 1. Ship classes in order of potential near-term cost avoidance from onboard test and repair

1. CVN	6. LHA
2. DDG	7. MCM
3. DD	8. LPD
4. CG	9. LSD
5. FFG	

We could not get demand data for electronic components managed by the Defense Logistics Agency (DLA). Based on other information, the DLA data might increase the demand shown by about 10 percent. Some increases in cost avoidances would also result.

Also, we could not get demand data for electronic components managed by the aviation side of NAVICP. Therefore, we have probably understated the CVN and LHA demand and cost avoidances.

Current ship capabilities and component costs

Current ship capabilities

To establish how individual ships are currently outfitted with any of the three test and repair elements, we collected information on all ships that will be in the active fleet through the end of FY 1998. That is, we included new ships entering the active fleet through the end of FY 1998, and we excluded ships leaving the active fleet through the end of FY 1998. We got this information from the *Department of the Navy Ships and Aircraft Supplemental Data Tables* [2]. We included ships in the reserve fleet if they appeared in any of the fleet deployment schedules.

Table 2 shows how the individual ships are outfitted for onboard test and repair. An "x" in a block means that the test and repair element has been issued to the ship.

Table 2. Status of issue of individual test and repair elements by ship

	USM-646	Tool set	Piece parts		USM-646	Tool set	Piece parts		USM-646	Tool set	Piece parts		USM-646	Tool set	Piece parts		USM-646	Tool set	Piece parts
CV 63	x	x	x	CGN 36	x	x		DD 963	x	x		FFG 08				LHA 1	x	x	
CV 64	x	x	x	CGN 37	x	x		DD 964	x	x		FFG 23	x			LHA 2	x	x	
CVN 65	x	x	x					DD 965	x	x		FFG 28	x			LHA 3	x		
CVN 68	x	x		DDG 51	x			DD 966	x	x		FFG 31				LHA 4	x	x	
CVN 69	x	x		DDG 52	x	x		DD 967	x			FFG 32				LHA 5	x	x	
CVN 70	x	x	x	DDG 53	x	x		DD 968	x	x		FFG 33							
CVN 71	x	x		DDG 54	x			DD 969	x	x		FFG 36				LHD 1	x	x	
CVN 72	x	x		DDG 55	x	x		DD 970	x	x		FFG 37				LHD 2	x	x	
CVN 73	x	x	x	DDG 56	x	x		DD 971	x	x		FFG 38		x		LHD 3	x	x	
CVN 74	x	x	x	DDG 57	x	x		DD 972	x	x		FFG 39				LHD 4	x	x	x
CVN 75	x			DDG 58	x	x		DD 973	x	x		FFG 40				LHD 5			
CVN 76				DDG 59	x	x		DD 974	x	x		FFG 41	x			LHD 6			
				DDG 60	x	x		DD 975	x	x		FFG 42		x		LHD 96A			
CG 47	x			DDG 61	x	x		DD 976	x	x		FFG 43		x					
CG 48	x	x		DDG 62	x	x		DD 977	x	x		FFG 45		x		LPD 4	x		
CG 49	x			DDG 63	x	x	x	DD 978	x	x		FFG 46	x	x		LPD 5	x		
CG 50	x	x		DDG 64	x	x	x	DD 979	x	x		FFG 47		x		LPD 6	x		
CG 51	x	x		DDG 65	x	x	x	DD 980	x	x		FFG 48				LPD 7	x		
CG 52	x	x		DDG 66	x	x	x	DD 981	x	x		FFG 49	x			LPD 8	x		
CG 53	x	x		DDG 67	x	x	x	DD 982	x	x	x	FFG 50		x		LPD 9	x		
CG 54	x	x		DDG 68		x	x	DD 983	x	x		FFG 51				LPD 10	x		
CG 55	x			DDG 69	x	x	x	DD 984	x			FFG 52		x		LPD 12	x		
CG 56	x	x		DDG 70				DD 985	x			FFG 53		x		LPD 13	x		
CG 57	x	x		DDG 71		x		DD 986	x			FFG 54				LPD 14	x		
CG 58	x	x		DDG 72				DD 987	x	x		FFG 55		x		LPD 15	x		
CG 59	x	x		DDG 73				DD 988	x	x		FFG 56	x	x					
CG 60	x	x		DDG 74				DD 989	x	x		FFG 57				LSD 36	x		
CG 61	x	x		DDG 75				DD 990	x			FFG 58				LSD 37	x		
CG 62	x	x		DDG 76				DD 991	x	x		FFG 59				LSD 38	x		
CG 63	x	x		DDG 77				DD 992	x			FFG 60		x		LSD 39			
CG 64	x	x		DDG 78				DD 997	x	x		FFG 61				LSD 40	x		
CG 65	x	x														LSD 41	x	x	
CG 66	x	x		DDG 993	x	x						MCM 5				LSD 42	x		
CG 67	x	x		DDG 994	x	x						MCM 6				LSD 43	x		
CG 68	x	x		DDG 995	x	x						MCM 7				LSD 44	x		
CG 69	x			DDG 996	x	x						MCM 8				LSD 45	x		
CG 70	x	x										MCM 9	x			LSD 46	x	x	
CG 71	x	x										MCM 10				LSD 47	x		
CG 72	x											MCM 11				LSD 48	x		
CG 73	x	x										MCM 12				LSD 49	x	x	
												MCM 13				LSD 50	x	x	
												MCM 14				LSD 51	x	x	x
																LSD 52			

Costs

Table 3 shows the costs of the individual elements needed on board a ship to properly test and repair electronic components.

Table 3. Costs of individual elements for ship electronic component test and repair capability in FY 1997 dollars

AN/USM-646	$23K
PACE 2000 tool station	10K
Piece parts kits	
Organizational level	12K
Intermediate level (CV/CVN/LHA/LHD)	37K

Return on investment

Table 2 shows that many ships are already at least partially fitted out to do onboard test and repair. For example, most DDGs and CGs have at least two of the three elements needed. Other ships, such as MCMs and FFGs, are only partially fitted out or not fitted out at all. The fact that ships within classes are fitted out to different degrees means that different investments can lead to the same annual cost avoidance. For example, some DDGs have only the USM-646 whereas others have both the USM-646 and PACE 2000 and yet others have all three elements. Therefore, some DDGs would require a $22,000 investment to complete the test and repair capability (for PACE 2000 and the piece parts kit) whereas others would require only $12,000 (for the piece parts kit). But we would expect all DDGs to provide roughly the same level of cost avoidance.

To produce the greatest return on investment (ROI), the best strategy would be to set priorities for further investment in the test and repair components. For example, a $12,000 investment for a piece parts kit (table 3) for the DD 965 would complete the fitting out and provide a potential $81,000 in annual, near-term cost avoidance (the black bar in figure 1). The annual ROI for that near-term cost avoidance would be $81,000/$12,000 or 6.8 (i.e., it would take about 1.8 months of cost avoidances to repay the investment). On the other hand, it would require $22,000 (PACE 2000 + piece parts kit) to finish fitting out the LPD 9 to achieve an annual near-term cost avoidance of only $6,000. The annual ROI in this case would be only 0.3 (i.e., it would take about 40 months of cost avoidances to repay the investment).

Table 4 shows calculations for ROI for all ship classes based on the numbers and types of test and repair components they are missing (i.e., USM-646, PACE 2000, piece parts kit).

Table 4. Return on investment by ship class

Ship class	Components needed	Cost of components ($K)	Annual near-term cost avoidance ($K)	Annual ROI
CV/CVN	Piece parts	37	157	4.2
DDG	Piece parts	12	104	8.7
	Piece parts, PACE 2000	22	104	4.7
DD	Piece parts	12	81	6.8
	Piece parts, PACE 2000	22	81	3.7
CG	Piece parts	12	80	6.7
	Piece parts, PACE 2000	22	80	3.6
FFG	Piece parts	12	53	4.4
	Piece parts, PACE 2000	22	53	2.4
	USM-646, piece parts	35	53	1.5
	USM-646, PACE 2000, piece parts	45	53	1.2
LHA/LHD	Piece parts	37	33	0.9
	Piece parts, PACE 2000	47	33	0.7
	USM-646, PACE 2000, piece parts	70	33	0.5
MCM	Piece parts, PACE 2000	22	7	0.3
	USM-646, PACE 2000, piece parts	45	7	0.2
LPD	Piece parts, PACE 2000	22	6	0.3
LSD	Piece parts	12	6	0.5
	Piece parts, PACE 2000	22	6	0.3

All else being equal, it would make economic sense to finish outfitting ships for onboard test and repair in the order of annual ROI expected.

Table 5 shows the total one-time cost and annual cost avoidance we could expect for each level of priority. We do not include new construction ships here (such as DDGs 68 and newer) because test and repair elements for new ships are funded out of the SCN account and are not an issue in this analysis.

Table 5. One-time costs and annual cost avoidances by priority in FY 1997 dollars

Priority	Components needed by ship class	No. of ships	Total one-time cost ($K)	Annual near term cost avoidance ($K)
1	DDGs needing only piece parts kit	14	168	1,456
2	DDs needing only piece parts kit	24	288	1,944
3	CGs needing only piece parts kit	24	288	1,920
4	DDGs needing piece parts kit and PACE 2000	2	44	208
5	FFGs needing only piece parts kit	2	24	106
6	CV/CVN's needing only piece parts kit	4	148	626
7	DDs needing piece parts kit and PACE 2000	6	132	486
8	CGs needing piece parts kit and PACE 2000	5	110	400
9	FFGs needing piece parts kit and PACE 2000	3	66	159
10	FFGs needing USM-646 and piece parts kit	10	350	530
11	FFGs needing all three components	15	675	795
12	LHAs/LHDs needing only piece parts kit	7	259	231
13	LHAs/LHDs needing piece parts kits and PACE 2000	1	47	33
14 a.	LHAs/LHDs needing all three components	1	70	33
14 b.	LSDs needing only piece parts kit	4	48	24
15 a.	MCMs needing piece parts kits and PACE 2000	1	22	7
15 b.	LPDs needing piece parts kits and PACE 2000	11	242	66
15 c.	LSDs needing piece parts kits and PACE 2000	10	220	60
16	MCMs needing all three components	9	405	63
Total costs			$3,606	$9,147

We could expect further near-term cost avoidances from those few ships that are already outfitted with all three of the test and repair elements (see table 2). Those include six CV/CVNs, six DDGs, one DD, one LHD, and one LSD. The annual potential near-term cost avoidance from these ships would be about $1.66 million. Thus, the total potential near-term cost avoidance would be the sum of savings from table 5 of ships not yet completely fitted out ($9.15 million) plus the savings from ships already fitted out ($1.66 million) or about $10.81 million.

The impact of deployments on cost avoidance

A detailed analysis of requisition data for three ships in our sample shows that, over the 2-year period covered, demand for electronic components is the highest during the 6 months before a deployment (34 percent of the entire 2-year demand) and lowest in the 6 months after a deployment (16 percent of the entire 2-year demand). Therefore, maximum cost avoidance would accrue if ships were fitted out for onboard test and repair at least 6 months before a deployment.

Fleet concerns

Some concerns have been raised by members of fleet staffs regarding potential savings from efficiency measures such as onboard test and repair. They feel that their budgets have been prematurely reduced in anticipation of savings that have not yet been fully realized. The savings haven't been fully realized in some cases because many ships are not yet fully equipped for module test and repair. They also feel that further budget reductions should not be made until they have recovered from the premature cuts. Finally, some think that a share line should be established to allow fleets to retain some of the savings they generate.

Conclusion

The potential annual near-term ROI for ships that have not been completely fitted out for onboard test and repair of electronic components ranges from 8.7 to 0.2. The Navy will receive the highest dollar return by fitting out ships in the order of highest to lowest ROI. Within the ROI parameter, the best returns would accrue by fitting out individual ships at least 6 months before a deployment. That is when ships experience the greatest demand for electronic components.

References

[1] Leonard J. Kusek, Stephen C. Goodwyn, Robert A. Levy, and Lawrence A. Lynn. *Maintenance of Shipboard Electronics,* Jan 1997, (CNA Research Memorandum 96-133)

[2] Director, Department of the Navy Program Information Center, Ser N801L/7S640100, *Department of the Navy Ships and Aircraft Supplemental Data Tables* (*SASDT*), Secret, 9 Jan 1997

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