ESTIMATING THE VALUE OF SHIP AVAILABILITY

BY

COMMANDER M. N. COLLIS, M.B.E., R.N., C.ENG., M.I.MAR.E.

Synopsis

Planning generally, and the making of management decisions is hampered by the lack of a proper method of costing the value of H.M. ships. A method is suggested, and an example is worked out on very simplified assumptions in order to illustrate it. The conclusion is drawn that non-availability may be more expensive than is commonly supposed, e.g., £89,000 per day for an SSN.

The Problem

The logical, scientific deployment of the Navy's resources to the best advantage (i.e., the achievement of maximum cost effectiveness or 'the biggest bang for a buck'), is hampered by the lack of a proper means of costing the value of the end product of the process, namely the Fleet-in-Being. This is a necessary preliminary to the rational assessment of innumerable investment problems in the MOD(N). For example:

(*a*) Is it worthwhile to invest £x in order to shorten the refits of y ships by z days each?

(*b*) Is it worth having two crews per ship or not?

Previous Methods of Solving the Problem

It is known that efforts have been made to solve the problem, although the only one seen by the author is a DGD & M paper entitled 'Through Costing of Ships in relation to Maintenance and Availability'. This concludes that a frigate in commission costs about £5,000 per day in pay, depreciation, stores, etc. The aim of this paper is to contribute to the debate on the subject and to stimulate others to produce a better answer than this one.

Proposed Method—Basic Data and Assumptions

The following assumptions are made, some of them in order to simplify the calculations in this paper. These have been made in order to demonstrate the method rather than as serious, credible answers. In calculations made for use in decision-making, depreciation would probably be included, and the Naval Accounts used rather than the Estimates, and so forth.

(*a*) If there were no ships, etc. capable of going to sea there would be no need for the MOD(N) at all.

(*b*) The entire MOD(N) effort exists to provide an effective naval system namely:-

(*i*) Ships (and aircraft) at sea.

(*ii*) Trained men in ships, aircraft and ashore.

(*iii*) Naval staff to direct (*i*) and (*ii*): Communications.

(*iv*) Dockyards, stores and bases to sustain (*i*), (*ii*) and (*iii*).

(*v*) Research and Development effort to improve (*i*) and *iv*).

(*c*) Having added to the annual naval vote the estimated cost of running the Central Defence Staff the total can fairly be allocated to H.M. ships so that each ship bears a proportion according to her value to the Navy.

(*d*) The value of a ship to the Navy is proportional to her first cost: it is probable that this underrates the value of the larger ships which may have proportionately more spent on modernizations than smaller vessels. A better criterion might be proportional to the first cost to the power of 1·5 to even first cost squared. This would complicate the calculations. Aircraft carriers should perhaps be treated as a special case because of their very high support and R and D costs for aircraft, etc., but have not been so treated herein.

(*e*) The armament costs of a ship are proportional to her other building costs: full Armament costs are not given in the Estimates and have therefore been ignored.

(*f*) No costs are borne by RFA vessels: this is because their building costs are not readily available to the author.

(*g*) The naval value of a ship does not depreciate in service: although ships clearly do 'date' they are often modernized and hence rejuvenated.

(*h*) Effective Naval Value of a ship varies with her availability (but is never negligible. Even in refit she has a potential value). Each ship operates on a planned basis of A days/year at normal notice; B days/year at 7 days' notice (leave and maintenance periods, dockings), C days/year at more than 7 days' notice (major repairs, refits, modernizations). It is assumed that the ratios of the ENVs are as follows:-

State	A		B		C
ENV ratio	10	:	3	:	1

The value of a ship is measured in ENV units, i.e., one day in State A = 10 ENVUs.

(*i*) The total MOD(N) vote for 1967/68 was M£620·884, from the Naval Estimates.
The Central Defence Staff cost was M£21·167. On a manpower basis 22 per cent of this was naval.

(*j*) The building cost of each ship as given in the Naval Estimates is given in the Appendix. The cost corrected to 1967 prices is also given, based on tables of the internal purchasing power of the £ sterling provided by the Central Statistical Office of the Cabinet Office.

(*k*) The Naval Estimates are a reasonably accurate guide to the money actually spent.

Calculations (*by Slide Rule*)

1967/68 Naval vote = M£620·884

22% of the Control Defence Staff Cost = M£4·65

MOD(N) cost attributable to ships = M£625·534

Total building costs of H.M. Ships (at 1967 prices) from Appendix = M£753·89

Annual expenditure attributable to each ship =

$$\text{Ship's 1967 building cost} \times \frac{625 \cdot 5}{753 \cdot 9} = 1967 \text{ building cost} \times 0 \cdot 83$$

Example 1—Nuclear Fleet S/M (H.M.S. *Valiant*)

1967 Building Cost = M£25·3

1967/68 Cost Attributable = 25·3 × 0·83 = M£21

Planned days/year = 178A + 71B + 116C (average over $5\frac{3}{4}$-yr cycle)
= 1780 + 213 + 111 = 2,109 ENVUs

$$\text{Thus cost of 1 ENVU} = \frac{\text{M£}21}{2{,}109}, \text{ say } \frac{\text{M£}21}{2{,}110}$$

If one planned State A day becomes a State C day, then 10 − 1 = 9 ENVU have been lost.

$$\text{Cost of loss} = \frac{9 \times 21 \times 10^6}{2110} = \text{£}89{,}600 \text{ per day}$$

If one planned State A day becomes a State B day, loss = £69,700 per day

Example 2—'O' Class S/M (H.M.S. *Oberon*)

1967 Building Cost = M£2·89

1967/68 Cost Attributable = M£2·4

Planned days/year 122A + 136B + 107C (averaged over 4 yr cycle)
= 1220 + 408 + 107 = 1,735 ENVU

$$\text{Cost of 1 ENVU} = \frac{\text{M£}2 \cdot 4}{1735}$$

Cost of one planned State A day becoming State C:

Cost of loss = £12,450 per day

Cost of one planned State A day becoming State B, loss = £9,700 per day

Example 3—Type 14 Frigate (H.M.S. *Jaguar*)

1967 Building Cost = M£4·6

1967/68 Cost Attributable = M£3·82

Planned Days/Year (DCI 1667/66 modified by H.M. Dockyard, Chatham experience) 150A + 147B + 78C (averaged over 6–7½-yr cycle) = 1400 + 441 + 78 = 1,919 ENVU

Cost of 1 ENVU $= \frac{\text{M£3·82}}{1{,}919}$

Cost of one planned State A day becoming State C:

Cost of loss = £18,000 per day.

If one State A day becomes State B, loss = £14,000 per day

Effect of Altering the Assumptions

A criticism of the above attempt to cost availability that has already been made is that 'You can produce any answer you like by twisting the figures'. This reflects a proper distrust of over-simplified mathematical models which frequently lead to the production of answers which are obviously at variance with common sense and experience. However, this has not prevented many models (for example modern financial accounting methods; Critical Path Analysis) from being found to be very useful as guides within their limitations. The author's assumptions are based on averaging over a period of time. Assumptions (*d*) on the value of a ship might be quite wrong in a particular case where a small ship was of vital importance for a short time. This does not however invalidate the general appreciation of her value over her life span.

If the value of a ship is taken to be not that of ther building cost but some function of it, say Cost^2, what effect would this have? Clearly it would emphasise the cost of a large ship being not available and reduce that of a small one.

If the relative values of a ship in States A, B and C are disputed (as they no doubt will be since they are a matter of subjective judgement by the operators) what effect would different ratios have?

For example, if a ship in State A is only worth 5 times as much as a ship in State C, what effect does it have on the cost of the loss of a State A day to State B or C?

State	A	B	C	Loss A5B	Loss A–C
NVU Ratio	10	3	1	£69,000	£89,600
NVU Ratio	5	3	1	£34,500	£69,000

Thus the change in ratio of the losses is not nearly as great as the change in the NVU ratios.

Conclusions

If the above argument is accepted as being valid as a rough measure of the cost of breakdown and non-completion of refits, etc., then this provides a method which, when refined, will produce a yardstick with which alternatives can be measured. The expenditure of money on methods of shortening refits, such as river dredging, building dockyard facilities or simplifying ship design, can then be argued on a rational basis. For example: it is seven-times as important that a nuclear S/M should be made available on time than a conventional one. If H.M.S. *Valiant* fails to catch her tide say on a Friday and sails on the following Monday instead, the cost is not less than £209,100. Conversely, if the ship can be made available three days early (whether she is used or not) the same sum is saved.

APPENDIX

Year	*Ship*	£M 1967/68 *Cost Attributable*	*Cost* £M	*Factor*	1967 *Cost*
1948–49	*Corunna*	1·33	0·898	1·78	1·60
	Agincourt	1·40	0·942		1·68
	Acheron	0·84	0·567		1·01
	Alliance	0·61	0·407		0·73
	Ambush	0·64	0·433		0·77
	Artemis	0·72	0·488		0·87
	Anchorite	0·2	0·421		0·75
	Artful	0·70	0·473		0·84
	Andrew	0·60	0·403		0·72
	Repairs	—	13·212		23·60
1949–50	*Dalrymple*	0·80	0·554	1·75	0·97
	Dampier	0·71	0·489		0·86
	Reclaim	0·56	0·389		0·68
	Repairs	—	17·844		31·20
1950–51	*Owen*	0·84	0·593	1·70	1·01
	Repairs	—	22·586		38·40
1951–52	Repairs	—	24·914	1·56	35·70
1952–53	*Eagle*	19·25	15·795	1·47	23·20
	Daring	2·70	2·221		3·26
	Diamond	2·79	2·280		3·36
	Repairs	—	36·593		54·00
1953–54	*Defender*	2·47	2·047	1·45	2·98
	Dainty	2·59	2·143		3·12
	1 Coastal Minesweeper—*Coniston*	0·54	0·447		0·65
	Repairs	—	43·093		62·50
1954–55	*Centaur*	12·00	10·434	1·42	14·50
	Diana	3·39	2·880		4·09
	Decoy	3·33	2·833		4·02
	Delight	3·14	2·667		3·79
	11 Coastal Minesweepers	5·92	5·020		7·14
	22 Inshore Minesweepers	5·93	5·029		7·15
	Brittania	2·47	2·098		2·98
	Vidal	1·53	1·345		1·84
	Repairs	—	40·679		55·80
1955–56	*Ark Royal*	24·40	21·428	1·37	29·40
	Albion	11·20	9·836		13·50
	Bulwark	11·60	10·386		14·00
	32 Coastal Minesweepers	16·25	14·267		19·60
	35 Inshore Minesweepers	0·90	7·875		10·80
	Repairs	—	47·786		65·50
1956–57	*Dundas*	1·57	1·434	1·32	1·89
	Hardy	1·59	1·449		1·91
	26 Coastal Minesweepers	12·60	11·521		15·20
	19 Inshore Minesweepers	4·90	4·473		5·90
	Repairs	—	48·115		63·50
1957–58	*Lynx*	2·89	2·720	1·28	3·48
	Salisbury	3·08	2·900		3·72
	Whitby	3·27	3·081		3·94
	Torquay	2·95	2·769		3·55
	Grafton	1·50	1·411		1·81
	Keppel	1·60	1·506		1·93
	Murray	1·73	1·625		2·08
	Pellew	1·68	1·584		2·02

APPENDIX—*continued*

Year	*Ship*	£M 1967/68 *Cost Attributable*	*Cost* £M	*Factor*	1967 *Cost*
	Russell	1·68	1·581		2·03
	15 Coastal Minesweepers	7·44	7·000		8·96
	11 Inshore Minesweepers	2·90	2·728		3·50
	1 S.D.B.	0·188	0·176		0·226
	Repairs, etc.	—	44·167		56·60
1958–59	*Puma*	3·00	2·914	1·24	3·62
	Scarborough	2·82	2·737		3·40
	Tenby	3·00	2·822		3·62
	Eastbourne	2·90	2·774		3·50
	Blackwood	1·82	1·769		2·19
	Exmouth	1·45	1·422		1·75
	Malcolm	1·63	1·582		1·96
	Palliser	1·66	1·620		2·00
	12 Coastal Minesweepers	7·00	6·786		8·42
	8 Inshore Minesweepers	1·98	1·933		2·40
	7 F.P.B.s (*Dark* Class)	2·44	2·365		2·94
	1 S.D.B.	2·16	0·208		0·26
	Repairs, etc.	—	38·870		48·20
1959–60	*Tiger*	13·20	12·820	1·23	15·80
	Porpoise	2·26	2·219		2·73
	Rorqual	1·90	1·864		2·29
	Grampus	2·23	2·186		2·69
	Leopard	3·64	3·545		4·38
	Llandaff	3·46	3·393		4·17
	Chichester	3·36	3·291		4·05
	Blackpool	3·34	3·269		4·02
	Duncan	2·00	1·960		2·41
	10 Coastal Minesweepers	6·30	6·194		7·60
	8 Inshore Minesweepers	2·04	1·994		2·46
	1 Inshore Survey Vessel	0·27	0·259		0·32
	3 F.P.B.s (*Dark* Class)	1·05	1·022		1·26
	1 S.D.B.	1·98	0·192		0·24
	Repairs	—	40·041		49·70
1960–61	*Hermes*	17·80	17·500	1·22	21·40
	Narwhal	2·02	1·986		2·43
	Cachalot	2·22	2·186		2·67
	Jaguar	3·82	3·772		4·60
	Yarmouth	3·56	3·505		4·29
	2 Inshore Minesweepers	0·55	0·546		0·66
	2 Inshore Survey Vessels	0·56	0·549		0·67
	1 *Brave* Class	0·90	0·880		1·08
	1 B.D.V.	0·57	0·562		0·69
	Repairs	—	44·549		54·50
1961–62	*Lion*	14·30	14·375	1·19	17·20
	Blake	14·80	14·940		17·80
	Orpheus	2·22	2·255		2·68
	Finwhale	2·45	2·480		2·95
	Walrus	2·32	2·350		2·80
	Oberon	2·40	2·425		2·89
	Lincoln	3·64	3·685		4·38
	Rothesay	3·67	3·715		4·42
	Londonderry	3·53	3·570		4·25
	Rhyl	3·58	3·625		4·32
	2 Coastal Minesweepers	1·15	1·165		1·38
	2 Inshore Minesweepers	0·54	0·547		0·65
	1 *Brave* Class	0·63	0·640		0·76
	1 B.D.V.	0·56	0·565		0·67
	Repairs	—	49·624		59·00

APPENDIX—*continued*

Year	*Ship*	£M 1967/68 *Cost Attributable*	*Cost* £M	*Factor*	1967 *Cost*
1962–63	*Sealion*	2·59	2·705	1·15	3·12
	Berwick	3·49	3·650		4·20
	Plymouth	3·36	3·510		4·04
	Falmouth	3·64	3·805		4·38
	Brighton	3·44	3·600		4·14
	Lowestoft	3·36	3·510		4·04
	Ashanti	5·08	5·315		6·12
	Repairs	—	49·789		57·30
1963–64	*Devonshire*	13·20	14·080	1·13	15·90
	Hampshire	11·90	12·625		14·30
	Odin	2·59	2·760		3·12
	Olympus	2·34	2·500		2·82
	Onslaught	2·37	2·535		2·86
	Otter	2·47	2·625		2·97
	Oracle	2·56	2·735		3·09
	Leander	4·36	4·630		5·24
	Nubian	4·10	4·360		4·93
	Eskimo	4·28	4·560		5·15
	Gurkha	4·58	4·865		5·50
	Repairs	—	51·799		58·60
1964–65	*Kent*	12·45	13·650	1·10	15·00
	London	12·70	13·900		15·35
	Dreadnought	16·60	18·400		20·00
	Ocelot	2·74	3·000		3·30
	Otus	2·65	2·900		3·19
	Osiris	2·65	2·900		3·19
	Dido	4·20	4·600		5·06
	Penelope	4·20	4·600		5·06
	Ajax	4·38	4·800		5·28
	Mohawk	4·34	4·750		5·23
	Tartar	3·93	4·300		4·74
	Repairs	—	48·777		53·70
1965–66	*Opossum*	2·66	3·050	1·05	3·20
	Opportune	2·61	3·000		3·15
	Euryalus	3·77	4·350		4·55
	Naiad	4·15	4·750		5·00
	Galatea	3·93	4·500		4·73
	Aurora	4·06	4·650		4·89
	Zulu	4·45	5·100		5·36
	Repairs	—	49·360		51·80
				Total	753·89

Note: Yearly repair cost are quoted for interest, but not used in the calculations.