

BREAKDOWN MAINTENANCE BY ARTIFICERS

BY

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In the current assessment of the artificer complement required for the Marine Engineering Department, the assumption was made that ships' artificers would deal with all breakdown maintenance and 'below 4-monthly' preventive maintenance demanding artificer effort. The '4-monthly and above' preventive maintenance was planned to be done by an augmented Fleet Maintenance Unit during each Assisted Maintenance Period.

This article examines the day-to-day fluctuations to be expected in the breakdown maintenance requirement for ERAs in the Patrol Frigate, and uses the Poisson distribution to describe the expected fluctuations. So that the problem can be contained by the elementary mathematics used, the assumptions made are gross simplifications.

Despite this, the answers obtained are valid, and reflect (as would an imperfect mirror) what will happen in practice. A more correct answer could be obtained by using a Monte Carlo technique, but this would be costly in time if processed manually, or in money if a computer were programmed.

Simplification

So that the problem can be handled by a Poisson distribution, the following simplifying assumptions are made:

- (a) The requirements for undertaking all breakdown maintenance during any particular day are known at the start of that working day.
- (b) Artificers can be moved without delay from preventive to breakdown maintenance, and without involving them in nugatory work.
- (c) Each breakdown maintenance item takes 8 man-hours to complete. The effectiveness of the labour force does not change when more than one artificer works on a particular item.
- (d) In a 30-day month, the ME Department is aware of items demanding breakdown maintenance on 15 days of that month. There are twelve such months in a year.

Maximum Acceptable Level of Breakdown

The artificer maintenance load for the ME Department of the Patrol Frigate is expected to be about 4200 man-hours per year for ships staff, approximately divided during the operational period in the proportion of 700 man-hours for preventive and 3500 man-hours for breakdown maintenance, i.e., a preventive/breakdown ratio of 1:5 when operational*. The artificers would therefore appear able (by temporarily deferring preventive items) to accommodate a 20 per cent rise above the mean breakdown level without either working excess hours or, alternatively, reducing the availability of the ship (see FIG. 1).

Applying the simplifications (c) and (d), the annual breakdown load can be expressed as an expectation of $2\frac{1}{2}$ breakdowns per day on the average. Adding the 20 per cent rise which can be accommodated, a maximum acceptable level of 3 breakdowns per day is determined.

*This was a special exercise endeavouring to establish a minimum complement, and did not follow normal maintenance policy.

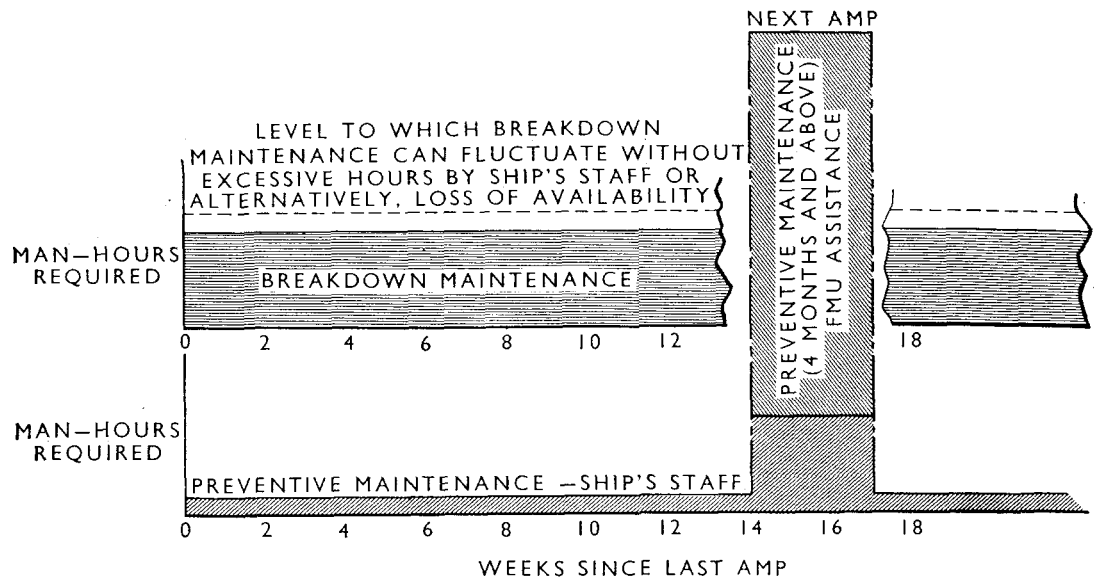


FIG. 1—EFFECT ON MAXIMUM ACCEPTABLE LEVEL OF PLANNING THAT AS MUCH PREVENTIVE MAINTENANCE AS POSSIBLE IS DONE BY THE FMU DURING THE AMP—SENIOR RATINGS' LOAD

Application of the Poisson Distribution

The chance in any particular day of a given number of equipments demanding breakdown maintenance can be expressed as a Poisson distribution where:

$$e^{-z}, ze^{-z}, \frac{z^2 e^{-z}}{2!}, \frac{z^3 e^{-z}}{3!}, \text{ etc. describe the chances of 0, 1, 2, 3, etc. occurring.}$$

In the problem under consideration, z is the mean number of breakdowns per day, i.e., 2.5. Thus the chance of the breakdown load exceeding 3 items per day (defined above as the 'maximum acceptable level') is:

$$0.08208 + 0.2052 + 0.2565 + 0.21375 = 0.75753$$

(0) (1) (2) (3) (up to 3)

This result can also be stated as: 'The maximum acceptable level will be exceeded on about 25 per cent of all running days'.

Distortion Imposed by the Model

Thus, even under the gross simplification imposed by the model, on 25 per cent of the days excess work is needed if availability is not to suffer unduly. Where breakdown occurs randomly throughout the twenty-four hours of the day (as it obviously does, for the equipment does not know what time it is), rectification must start also at any time in the twenty-four hours. If it starts before the working day, the artificer can be recompensed on that day for working outside of normal hours. Should it start after normal working hours commence and extend until after work would normally cease, the artificer will already have spent some time that day on preventive maintenance and compensation can only be offered from days yet to come.

In the latter case, nugatory work is often involved where preventive maintenance must be interrupted to meet a breakdown demand. Further, while the figure of 8 man-hours is reasonable as a mean breakdown load per item, the distribution of breakdown maintenance load is likely to follow a Log Normal Distribution. For these and similar reasons, it is considered that the assessment that the maximum acceptable level will be exceeded 25 per cent of the time is a conservative figure.

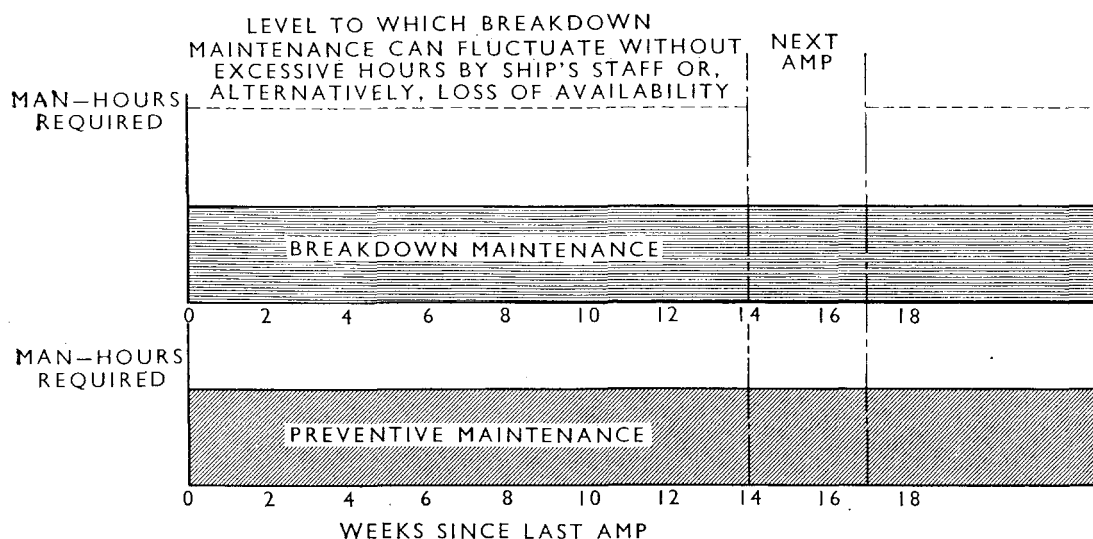


FIG. 2—EFFECT ON MAXIMUM ACCEPTABLE LEVEL OF PLANNING THAT PREVENTIVE MAINTENANCE IS EVENLY SPREAD—SENIOR RATINGS' LOAD

Effect of Increasing Preventive Maintenance

Maintenance is of two kinds, preventive and breakdown. The former can be and is planned. The latter, though it can be assessed over a period as a mean, occurs randomly and cannot be planned. Preceding paragraphs have described how this may be expected to fluctuate. Rearrangement of the maintenance plan enables ships staff to accommodate some of these fluctuations without strain, but only so far as the preventive maintenance mean load provides a cushion against fluctuations in the breakdown maintenance load. In short, the preventive maintenance mean load defines the effort which can be made available for 'peaking' of the breakdown maintenance load.

Suppose, in the Patrol Frigate, it were planned that ships staff would also undertake all '4-monthly and above' PM items. The annual preventive load would increase from about 700 hours to about 3500 hours. This would raise the maximum acceptable level to 5 breakdowns per day (see FIG. 2).

The fifth and sixth terms of the Poisson distribution are:

0.13359375 and 0.066796875 and if these are both added to the chance of 'up to 3' occurring, the sum is the chance of 'up to 5' occurring. This is 0.95792, or 'the maximum acceptable level will be exceeded on less than one day in twenty'.

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Conclusion

The effort available for preventive maintenance in a ship constitutes her contribution to the reliability of her equipment. The effort available for breakdown maintenance in a ship constitutes her insurance against *unreliability* of her equipment. The former also constitutes her insurance against temporary surges of excessive *unreliability*. Of the ratings engaged in maintenance, it is the senior ratings who contribute most to insurance against *unreliability*.

It is considered that the correct policy is to insure against a fluctuation of 100 per cent above the mean of the breakdown maintenance requirement, accepting the approximately 5 per cent risk that on occasion this insurance is not enough. To accept a lesser insurance, particularly in a department on the correct functioning of whose equipment the availability of all ship functions chiefly depend, is to invite severe risk, not only of loss of availability, but also of engendering dissatisfaction in senior ratings whose capabilities have cost the Service much to instil.