A NEW LOOK AT WARRANTIES IN DEFENSE CONTRACTS

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The Rand Corporation Santa Monica, California

INTRODUCTION

In August 1974, various parts of the Office of the Secretary of Defense (OSD) asked the three military services to begin trial uses of the Reliability Improvement Warranty (RIW), a contractual technique aimed at improving reliability of weapon systems and reducing their life-cycle costs [4]. Under an RIW, a contractor assumes responsibility on a fixed-price basis for repairing or replacing (as he sees fit) warranted units that fail during the warranted period. (A variation combines the warranty with a guarantee that obligates the contractor to take whatever steps are necessary to meet specific reliability levels.)

Although commerical firms have abundant experience with product warranties, the Department of Defense (DoD) has had only three completed warranty programs. Its current warranty activities are substantial, however. The Air Force, which is the leading service in this regard, has 17 items, including nine F-16 components, under a form of RIW. Depending on the number of options exercised, its expenditure for warranty coverage could reach $65 million (and the value of the items purchased under warranty could reach $500 million). Unfortunately, data on the outcomes of these programs will not be complete until the early 1980s. While awaiting the results, we have explored the RIW concept by evaluating commercial analogs, past DoD warranty experience, and the current tri-service RIW trial.*

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COMMERCIAL WARRANTY EXPERIENCE

OSD's decision to promote RIWs was based in part on a high regard for commercial warranty experience. This study examined warranties in two commercial settings: consumer products and airline avionics.

Consumer product warranties have usually been either promotional or protective--i.e., they have either been marketing tools or devices to limit liability [2][5]. They have rarely improved product quality. Consumer product warranties have worked so poorly that the Congress recently empowered the Federal Trade Commission to monitor most aspects of warranty practices. Consumer goods warranty experience does not justify optimistic expectations for RIWs, at least from the perspective of the military services.

Commercial airline avionics, which usually carry warranties, appear at first sight to be generally more reliable than similar equipment used by the military. However, there are too many differences in the commercial and military environments to credit the warranties with being the major cause of commercial products' better reliability. These differences extend to definitions, operating and support environments, missions requirements, and procedures for data collection and retention. In fact, the effect of the warranties is not well-understood by even the airlines; they have developed no standard by which to measure the cost-benefit derived from the warranties [1:B-4].

PAST DOD WARRANTY EXPERIENCE

There have been three items purchased by the military services under RIW-like warranties for which the period of coverage has ended. This section discusses those procurements.

The Navy's APN-154 Radar Transponder

The APN-154 is an airborne X-band radar transponder--a "beacon"--that extends the range of surface radar, allowing identification of specially equipped airborne targets. First produced in 1965 by United Telecontrol, it has been used on a variety of fixed-wing and rotary-wing aircraft. In 1973, a warranty went into effect on 218 units.

Data collected under test conditions at the close of the warranty period indicated that the mean time between failures (MTBF) had increased almost four-fold from the pre-warranty level to 2025 hours, a seemingly striking success for the warranty application.

There is no evidence, however, to link the warranty and the reliability improvement. In fact, other factors more readily explain the improvement. For example, before the warranty, and independent of it, United Telecontrol undertook at its own initiative a company-funded study to develop longer-lived replacements for the local oscillator and magnetron assemblies. These two thermionic assemblies, produced before solid-state devices of sufficient reliability were affordable, were the major causes of earlier failure. The study produced a suitable solid-state replacement for the local oscillator design, requiring only minor power supply modification. Although the search for a solid state magnetron assembly was not successful, the contractor discovered that the magnetron's life could be extended by redesigning the existing cathode structure. United Telecontrol submitted an unsolicited proposal to the Navy to substitute the solid-state oscillator and modify the magnetron. When the changes were negotiated as an engineering change proposal to the existing production contract, provisions for warranty coverage were added.

In addition, several other changes were identified before the warranty entered the picture. Many of the earlier equipment failures were environmentally related. For example, in one case, the transponder was mounted adjacent to the jet exhaust tail cone. During normal flight and ground operation, the equipment temperature was maintained well within its limit, but in extended jet engine ground operation, as might occur during engine test or a prolonged taxi situation, the equipment temperature would rise more than 30°C above the maximum limit, causing equipment failure. Design changes in the heat sink and new component part selections provided satisfactory operation at the higher temperature and contributed to an unspecified increase in MTBF.

To the extent that the reliability improvement is traceable to such *pre-warranty* redesign and externally generated component technology advances, the warranty appears simply to have come along in time to receive the credit.

The Navy's 2171 Gyroscope

The 2171 gyroscope (the contractor's nomenclature) was initially designed and produced by Lear Siegler in the 1950s and was introduced into service with A-4 Skyhawks and F-4 Phantoms in the early 1960s. By 1967, there were about 3200 units, of various configurations, in the inventory. Using the data and experience gained during its maintenance of the gyro, Lear Siegler proposed a warranty for 800 of the 3200 fielded gyros. MTBF was expected to improve 30 percent, but a third of the increase was expected to result merely from updating the 800 units to the most reliable configuration then in the field. The results were favorable: The MTBF of the warranted gyros improved from 400 to 520 operating hours in three years (the MTBF of the non-warranted gyros improved to 442 hours during the same period).

Although some of the difference between the MTBFs of the warranted and non-warranted sub-populations cannot be attributed to the warranty (that part due to updating to the most reliable configuration), it would be unfair not to regard the warranty as a contributing factor. Two things must be considered, however, before generalizing from these results. First, the activities that probably led directly to the reliability improvement could have been promoted without the warranty. In this instance, Lear Siegler conducted a continuous test program, using laboratory units, which accounted for 50,000 hours of testing and provided data for corrective design change decisions. Second, whether the warranty approach saved the Navy money is also uncertain. A study prepared for the Naval Air Systems Command found that after a two-month contract extension designed to compensate for underutilization during the basic warranty period, the warranty costs were less than the probable costs of support without a warranty [1:31-32, App. A]. Independent recalculations by Rand revealed the differential to be much less than the Navy's calculation; in fact, after the period extension the warranty costs very slightly exceeded the predicted costs of the non-warranty alternative [3:48]. This difference is probably offset by the savings from reduced spares requirements made possible by the higher MTBF levels of the warranted units (about 23 percent fewer spares in the case of the 2171 gyro warranty population), whatever the cause, and by the greater operational readiness rates themselves.

The Air Force's F-111 Gyroscope

The F-111 gyroscope was originally designed in the early 1960s by General Electric specifically for use in the F-111. The first 534 units produced by General Electric experienced disappointingly low reliability, which prompted the Air Force to call for a new procurement in a competitive environment. The new contract, won by Lear Siegler in January 1969, contained a warranty provision. The MTBF of the warranted gyros peaked at 1214 operating hours, but later fell to 995 hours. The non-warranted gyros, which had an MTBF of 681 hours in 1968, achieved an MTBF of 749 hours.

The differences in reliability levels cannot be traced to the warranty. Lear Siegler incorporated no major design changes during the warranty period.* Several factors, other than measurement imprecision, may have accounted for the difference. The warranted units were produced by a new manufacturer at a later date and as a result of a *competitive* source selection; these changes may themselves have improved reliability. In addition, there was extensive additional failure mode testing conducted before the warranty period. As in the 2171 gyro program, this augmented test regimen could be duplicated even within a warranty.

When the cost implications of the F-111 gyro warranty program are considered, two circumstances must be kept in mind:

- The initial plans called for the purchase of 601 warranted units. The initial contract was influenced by cutbacks in the F-111 program and called for only 332 units. Additional revisions reduced the number to 128.
- When the warranty period ended, the operating hours of the warranted units were about half the expected amount. The underutilization was due to recurrent groundings of the F-111 fleet and frequent delays in installations of the gyros. The warranty period began when the gyros were delivered to the Air Force; the F-111 prime contractor, General Dynamics, often installed them six months later.

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*Lear Siegler did make one minor change: incorporation of a new bearing actuation to correct a directional gyro drift problem.

The combination of these events had two important results. First, ultimate cost per operating hour of the warranty coverage was very high. Later contracts have used special price adjustment provisions to address this problem. A more troublesome result, one not addressed by new contractual clauses, is the deleterious effect on the contractor's motivation to make changes. The few units in the field and the low rate at which they were used meant that a representative failure distribution was not achieved until the warranty period was 80 percent complete. Lear Siegler justifiably chose not to make any investments in engineering improvement: Its remaining period of responsibility for the reliability of its gyros was not very long, and the prospect for recoupment of its investment was reduced by the small number of units in the field.

Lessons from the Programs

Although examination of completed DoD warranty programs does not reveal conclusive evidence that the warranty was a major factor in the observed improvement, it does permit the following observations:

- Modification after some operational use or appropriate operational testing is almost always desirable to take advantage of field experience and advances in component state of the art and can be promoted without a warranty.
- Implied in the above statement is the worth of schedule flexibility to allow incorporation of test data in the subsequent development and production process.
- To the extent that modification is envisioned or desired, the contractor should be involved in the initial overhaul and repair activities to improve his ability to formulate product improvements.
- Because the prospect for reliability growth is dimmed by program quantity reduction and underutilizations, RIWs should not be applied to programs subject to extreme quantity or utilization uncertainty.

FINAL OBSERVATIONS: THE CURRENT TRIAL APPLICATIONS

Several aspects of current trial applications diminish the likelihood that they will yield conclusive evidence on the value of RIWs. Because an RIW is a collection of complex contractual terms, such an experiment can identify preferred contractual constructions. This opportunity may be lost if, as in the case of the present set of contracts, important terms and penalties vary widely and not in accordance with a conscious plan for evaluation [3:11-28]. Two other facts make the variation of terms disturbing: the absence of adequate "control" groups and conditions and the continued consideration of new applications. The design of the experiment should be improved by at least three actions:

- *Reduce the variation in contractual terms and penalties.* A first step is the careful development of hypotheses about desirable constructions so that variations can be consciously and systematically devised to test them.
- *Develop better control conditions.* The same difficulty in isolating the warranty as the cause of the reliability improvement in the completed DoD programs is likely to plague the analysis of current programs.
- *Bound the experiment.* Rather than beginning new trial warranty programs for an indefinite period, the experiment, which has a discernible birthdate, should have a finite number of trial programs. This would permit better assessment of interim data and prompt final evaluation.

The experiment is also hampered by deficiencies in a number of associated methodologies. For example, both the contractor and the services have limited ability to price warranty and non-warranty alternatives in confidence. Methods for reliability measurement and prediction are similarly imprecise. Improvements in these areas would enhance selection, monitoring, and evaluation of warranty programs.

Evaluation of the warranty concept will be further complicated by the multiple, independent objectives that an RIW can serve and the failure to establish priority among them. These objectives include:

- *Reliability improvement.* This objective is attained if the contractor is motivated to change his behavior so that the item he produces is more reliable.
- *Life-cycle cost reduction (cost shifting).* This objective is attained if the service "makes a good deal"--i.e., if the price of the warranty coverage is less than the price of alternative logistics support arrangements and if the warranty does not cause increases in acquisition cost or support cost after the warranty period (or during transition out of it).
- *Insurance (risk shifting).* This objective is attained if the service and the contractor execute a binding indemnification contract, enforceable in court.

Any one of these objectives can be attained without either of the others. That is (assuming the ability to establish cause and effect), a warranty might induce reliability improvement but increase life-cycle cost; or it might reduce life-cycle cost but have no effect on reliability; or it might fail either to reduce life-cycle cost or improve reliability but might be binding on the contractor to provide interim product support. The Department of Defense must agree on the priority of these objectives to create a framework for evaluating RIW data and formulating RIW policy.

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