16

Maintenance of Leased Equipment

D.N.P. Murthy and J. Pongpech

16.1 Introduction

Businesses need equipment to produce their outputs (goods/services). Equipment degrades with age and usage, and eventually fails (Blischke and Murthy 2000). This impacts business performance in several ways – reduced equipment availability, lower output quality, higher operating costs, increased customer dissatisfaction, etc. The degradation can be controlled through preventive maintenance (PM) actions whilst corrective maintenance (CM) actions restore failed equipment to its working state.

Prior to 1970, businesses owned the equipment, and maintenance was done in house. Since 1970, there has been a shift towards outsourcing of maintenance. This was primarily due to a change in the management paradigm where activities in a business were classified as either core or non-core, with the non-core activities to be outsourced to external agents if this was deemed to be cost effective. Also, as technology became more complex it was no longer economical to carry out in-house maintenance due to the need for expensive maintenance equipment and highly trained maintenance staff.

Since 1990, there has been an increasing trend towards leasing rather than owning equipment. According to Fishbein et al. (2000) there are several reasons for this. Some of these are as follows:

- Rapid technological advances have resulted in improved equipment appearing on the market, making the earlier generation equipment obsolete at an ever-increasing pace.
- The cost of owning equipment has been increasing very rapidly.
- Businesses viewing maintenance as a non-core activity.
- It is often economical to lease equipment, rather than buy, as this involves less initial capital investment and often there are tax benefits that make it attractive.
In the USA, the Equipment Leasing Association (ELA) conducted a survey in 2002 (ELA, 2002a) and the results of their findings were as follows:

- 80% of businesses acquire equipment through leasing.
- Leasing accounts for roughly 30% of business capital investment.
- Nearly 50% of office equipment is leased.
- Leasing companies own more equipment than companies in other US industries.

The leasing industry grew from 1990 till the last quarter of year 2001 when it experienced an economic downturn due to the impact from 9/11. In 2002, the predictions made by the Department of Commerce for equipment leasing volume for 2003 and 2004 were $208 and $218 billion respectively.

The ELA Online Focus Groups Report (ELA 2002b) states that 60% of leasing benefits come from maintenance options. This is because some equipment leases come with maintenance as an integral part of the lease so that the physical equipment is bundled with maintenance service and offered as a package under a lease contract. This implies that the lessee can focus on the core activities of the business and not be distracted with equipment maintenance.

Maintenance of leased equipment raises several new issues for both the lessor and the lessee (Desai and Purohit 1998; Kleiman 2001). The strategic issues deal with the size and composition of the equipment fleet, the number and the location of lease centers, workshop facilities, warehouse for spares, etc. The operational issues include logistics, pricing, marketing, and maintenance strategies. In this chapter we touch on these issues and then focus our attention on maintenance strategies for leased equipment.

The outline of the chapter is as follows. Section 16.2 starts with a general introduction to equipment leasing and then the different types of leases are discussed. Section 16.3 deals with a framework to study equipment leasing and reviews the relevant literature. In Section 16.4, we look at the maintenance of equipment under operational lease. We discuss the modeling issues and propose various maintenance policies. Section 16.5 looks at the analysis of two of these policies and the optimal selection of the policy parameters. We conclude with a brief discussion of topics for future research in Section 16.6. We use the following abbreviations and notation.

**Abbreviations**

- **AFT**: Accelerated failure time
- **PH**: Proportional hazard
- **NHPP**: Non-homogeneous Poisson process
- **ROCOF**: Rate of occurrence of failure
- **CM**: Corrective maintenance
- **PM**: Preventive maintenance

**Notation**

- $F(t)$: Failure distribution for the time to first failure of new equipment
- $f(t), r(t)$: Failure density and hazard functions associated with $F(t)$
- $\lambda_{CM}(t)$: Intensity function with only CM actions