PREFERRED
RELIABILITY
PRACTICES

CLASS S PARTS IN HIGH RELIABILITY APPLICATIONS

Practice:

Use Class S and Grade 1 or equivalent parts in all applications requiring high reliability or long life[1] to yield the lowest possible failure rates.

Benefits:

Low parts failure rates in typical circuit applications result in significant system reliability enhancement. For space systems involving serviceability, the mean-time-between-failure (MTBF) is greatly extended, which significantly reduces maintenance requirements and crew time demands.

Implementation Method:

Redundancy is an appropriate usage of resources-- especially in critical applications to protect against random failures-- but is not a justification for using less than Class S or "equivalent" parts. Establish a policy that Class S parts will be used without exception or that limited exceptions are only permitted with extensive testing and inspections for upgrading of Class B to an acceptable level (approximately Class S or Grade 1).

Programs That Certified Usage:

Viking, Voyager, and Galileo

Center to Contact for Information:

Jet Propulsion Laboratory (JPL)

Technical Rationale:

Basic reliability is a function of parts failure rates. In any analytical calculations of reliability, the usage conditions of parts (derating, temperature, stress, etc.) are expressed as a failure rate that integrates these conditions from empirical or analytical considerations. High reliability parts (Class S or Grade 1) are screened and tested to yield the lowest failure rate parts producible in large quantities. (Refer

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[1] Long life is defined as a requirement to perform the defined function without sacrifice to the primary mission objectives for a period longer than 3 years. Criticality of a function may require high reliability for any period of time and is not necessarily coupled to long life. However, when high reliability is coupled with long life, increased attention to the best reliability design practices is appropriate.

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to Table 1 for the relationship of Class S to Class B). The failure rates of Class S parts are generally about one fourth the rates for Class B. When parts failure rates are coupled into circuit applications, the effects can be significantly magnified, depending on the circuit configuration.

When spaceflight equipment is not serviceable in a system requiring high reliability and long life, the lowest possible failure rate parts should be selected. This is especially true when considering the economics associated with the launch costs. For example, when changing from Class S to Class B parts, the parts cost decreases by a factor of 4x → 10x but the reliability of the system decreases significantly (by 20 → 50 times in the typical 5-year mission example provided). When total system, mission operations, and launch costs are considered, the delta between the parts costs for Class S and Class B is a minute percentage of total cost. This is especially true for Space Shuttle payloads.

On systems that are serviceable, the MTBF of an assembly is extended in proportion to the basic failure expectation. This significantly longer MTBF reduces on-orbit service requirements with less time demands on the crew, less risk associated with extravehicular activity (EVA), fewer spares required, and fewer launches to transport spares.

Redundancy has a much lower reliability payoff than does parts class-- until it is needed. Maverick parts, workmanship flaws, and other uncertainties justify redundancy for critical circuits in high reliability, long life applications to protect against random failures. For long life, the use of high reliability hardware, Class S (or Grade 1) parts, and redundancy in critical applications, provide an optimum and cost-effective approach.

Impact of Noncompliance:

Figure 1 shows an analysis of a typical radio and digital subsystem for a flight instrument with a 3-year mission, no redundancy (except TWTs), and partial redundancy in critical circuits for both Class S and B parts. The parts count method provided in MIL-HDBK-217E was applied. These calculations are not considered accurate for any usage in an absolute sense, due to other design and test factors the database cannot estimate. However, relative comparisons are very useful and accurate for tradeoff studies of effects of redundancy and parts classifications.

The data are presented in graphical format for ease of understanding. On each plot, the basic reliability for the assumed conditions is plotted on the left ordinate, years are plotted on the abscissa, and the ratio of the analyzed condition is plotted on the right ordinate.

In a single-string (nonredundant) design like Figure 1, the decline in system reliability over time is much less for a system built entirely of Class S parts than if it were built of Class B parts. The ratio of the two reliabilities for a 5-year mission indicates the system built of Class S parts is 50 times more reliable than the system built of Class B parts.

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TABLE 1. THE DIFFERENCE BETWEEN CLASS S AND CLASS B PARTS

ISSUE	CLASS S	CLASS B	IMPACT
Wafer lot acceptance	Required	--------------	Uniformity and pedigree traceability
Certification of production facilities	To specific assembly lines	To technologies and general facilities only	Burn-in and screening value relates to consistency of original product
Precap internal inspection	100%	Sampled	Significant driver on level of reliability - criteria much more stringent in MIL-M-38510H
PIND for loose particle detection	Required	--------------	Loose metallics in zero g field can cause failures
Serialization	Required	--------------	Traceability lost
Interim electrical test between test phases	Required	--------------	Potential of passing over problems and their causes
Burn-in	240 hours	160 hours	Later problem discovery
Reverse bias burn-in	Required	--------------	Impurity migration not detected
Interim electrical test after reverse bias burn-in	Required	--------------	Effects of reverse bias burn-in may be masked by subsequent actions
Radiographic inspection	Required	--------------	Observation of latent defects
Nondestructive 100% bond pull test	100%	Sampled	Parts with mechanical deficiencies get into equipment

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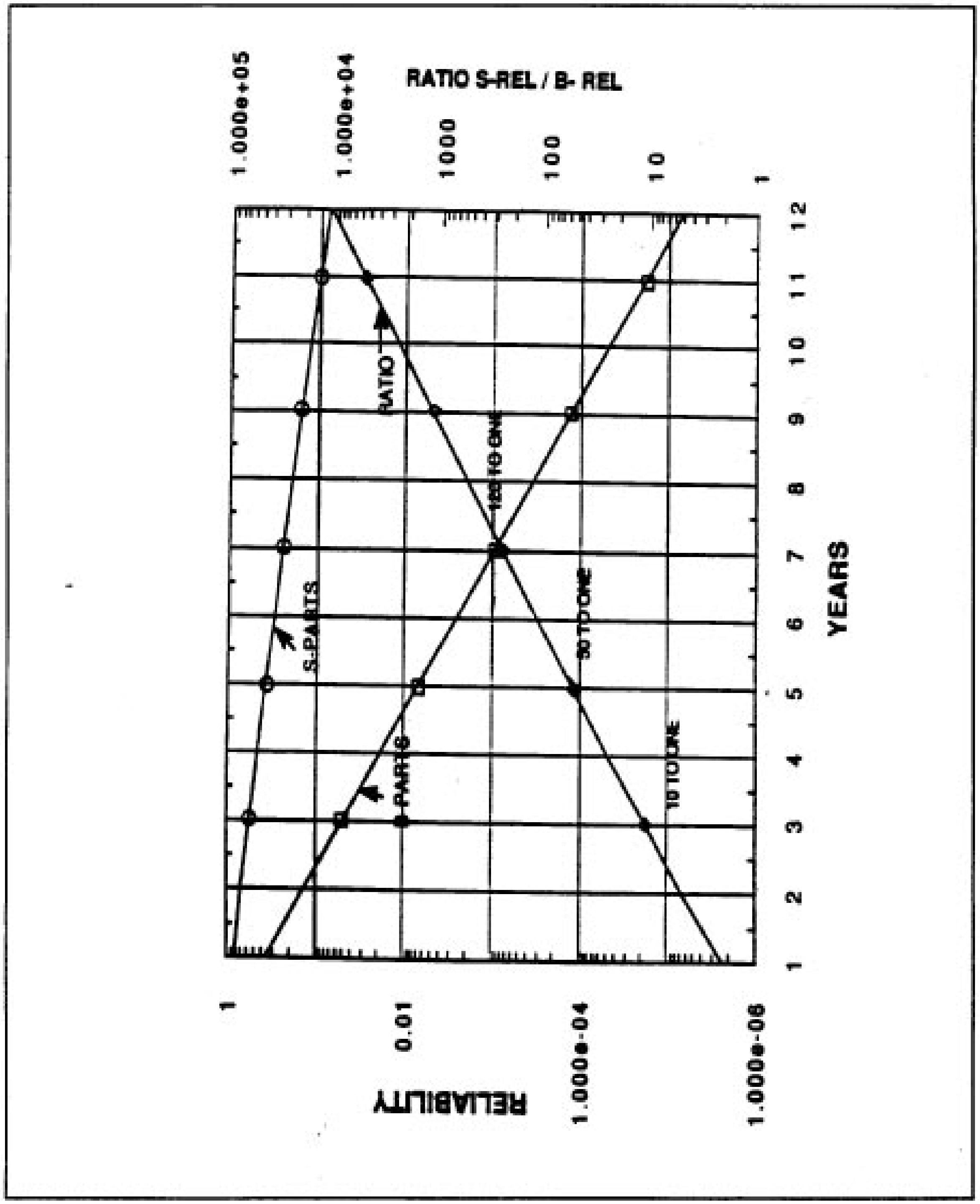

Figure 1: Reliability of Nonredundant System (Except for TWTA)

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When critical system circuits are made redundant, the time dependent reliability with both Class S and B parts is improved, but the improvement for the system built with B parts is greater (Figure 2). However, the 5-year mission reliability for the system built with B parts is still 20 times less than for the system built with Class S parts.

A correlation is made between the single string (nonredundant) system built with Class S parts and the system with redundant critical circuits and Class B parts (Figure 3). In this correlation, it is clear that for a 5-year mission the single-string system with Class S parts was still 10 times more reliable than the system with redundancy made from Class B parts.

This example reflects that the payoff in reliability is significant for Class S parts compared to Class B parts (for a 5-year mission, Class S is 20 → 50 times more reliable depending on redundancy). Additionally, the return on reliability, addressing non-random failures, is higher for Class S parts than for redundancy used with Class B parts. The highest reliability is obtained with Class S parts with redundancy in the critical circuits.

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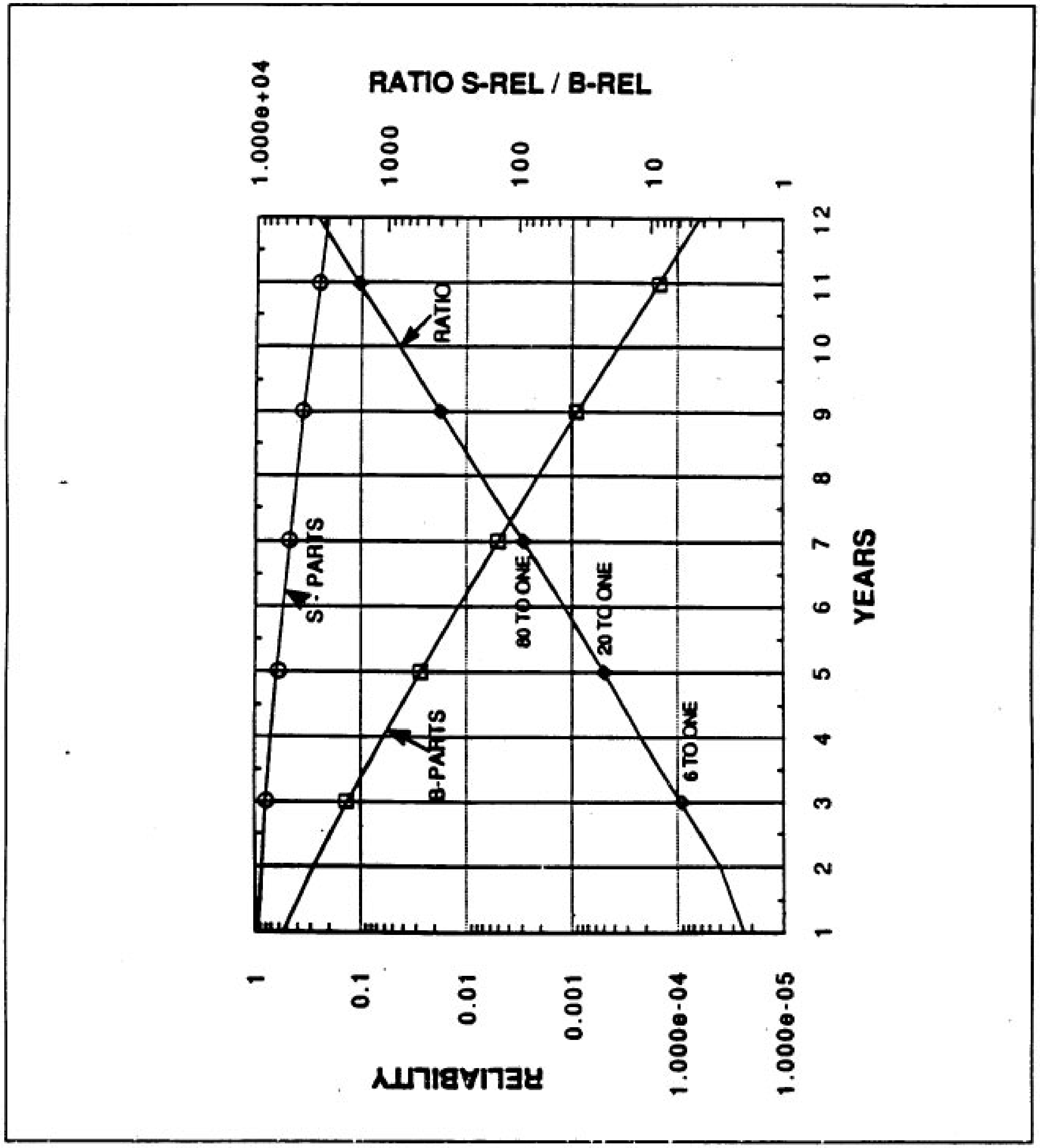

Figure 2: Reliability for Selectively Redundant Systems (for Critical Circuits)

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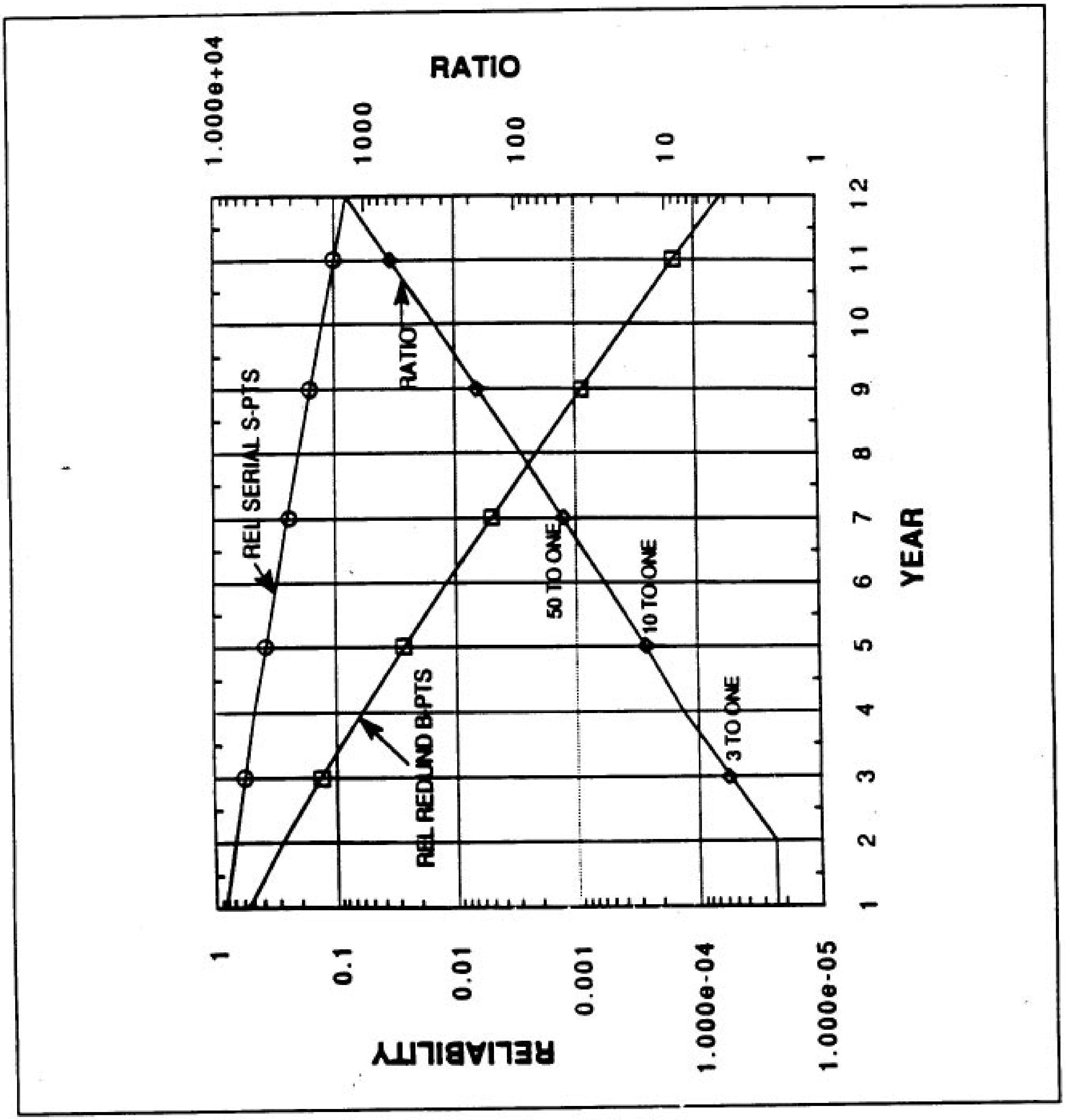

Figure 3: **Comparison of Serial System with S Parts with Selectively Redundant System with B Parts (for Critical Systems)**