AN EXAMINATION OF 60 MM MORTAR (E1065) RELIABILITY AND AVAILABILITY METRICS

1. Data Source. MCREM readiness database and the historical MCREM Deadline Serial Number Reports.

2. Measuring Down Time or Time to Repair. This value is supposed to represent the length of time that a serial number was being reported as deadlined.

Each week MCREM publishes a report of all serial numbers of the readiness reportable TAMCNs that are deadlined. Included with the serial number is a data field that represents that date that the serial number was initially classified as "deadlined". These serial numbers will appear each week on this report until they have been taken off "deadlined" status.

A down time observation is measured by subtracting the last date a serial number was reporting deadlined from its "initial deadlined date". A population of down time observations calculated for the E1065 from a January 1999 to December 2002 (approximately 4 years). This resulted in **571** observations of Down Time for the 60 mm Mortar. The average of these observations is **48 days**. The distribution of these Down Times are shown in the histogram below:

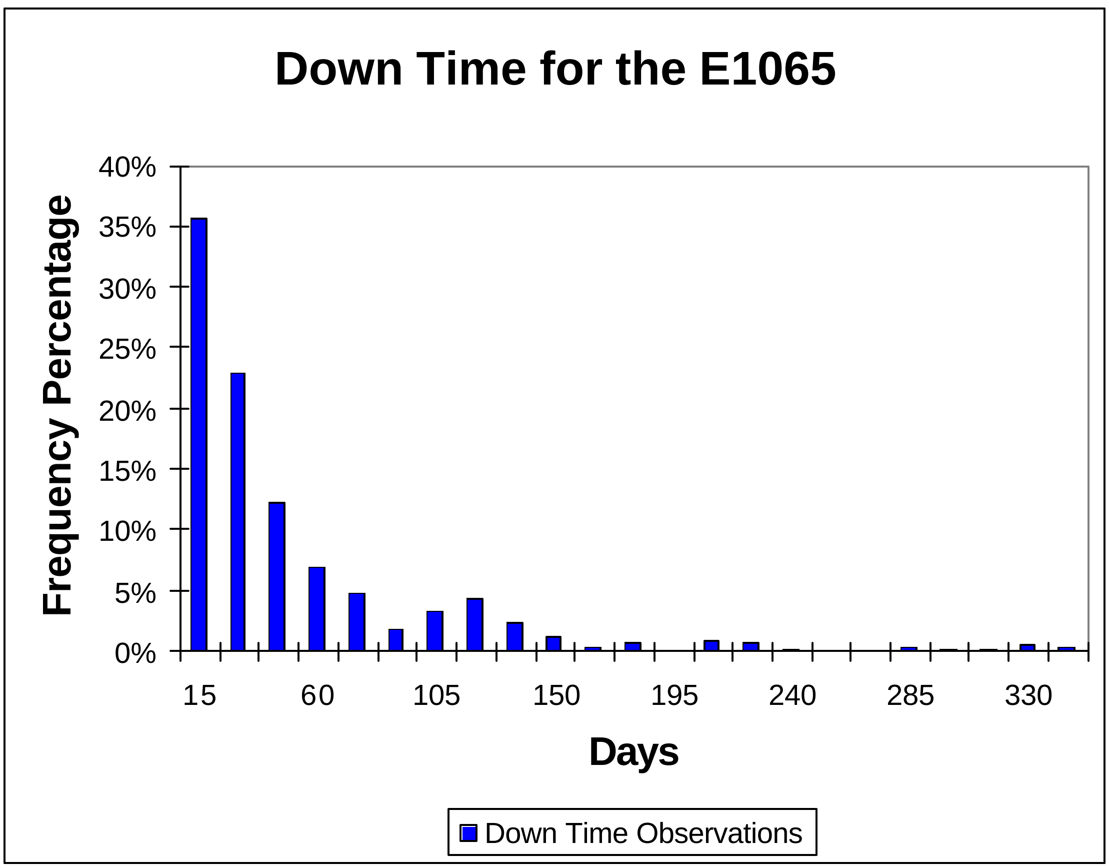

Figure 1. Distribution of E1065 Down Times from 1999 - 2002

3. Fitting a Distribution to Down Time. Using Crystal Ball Analysis Software, the standard probability function with the best fit was determined to be the LogNormal Function. The graph below depicts the fitted lognormal function as well as the actual observations.

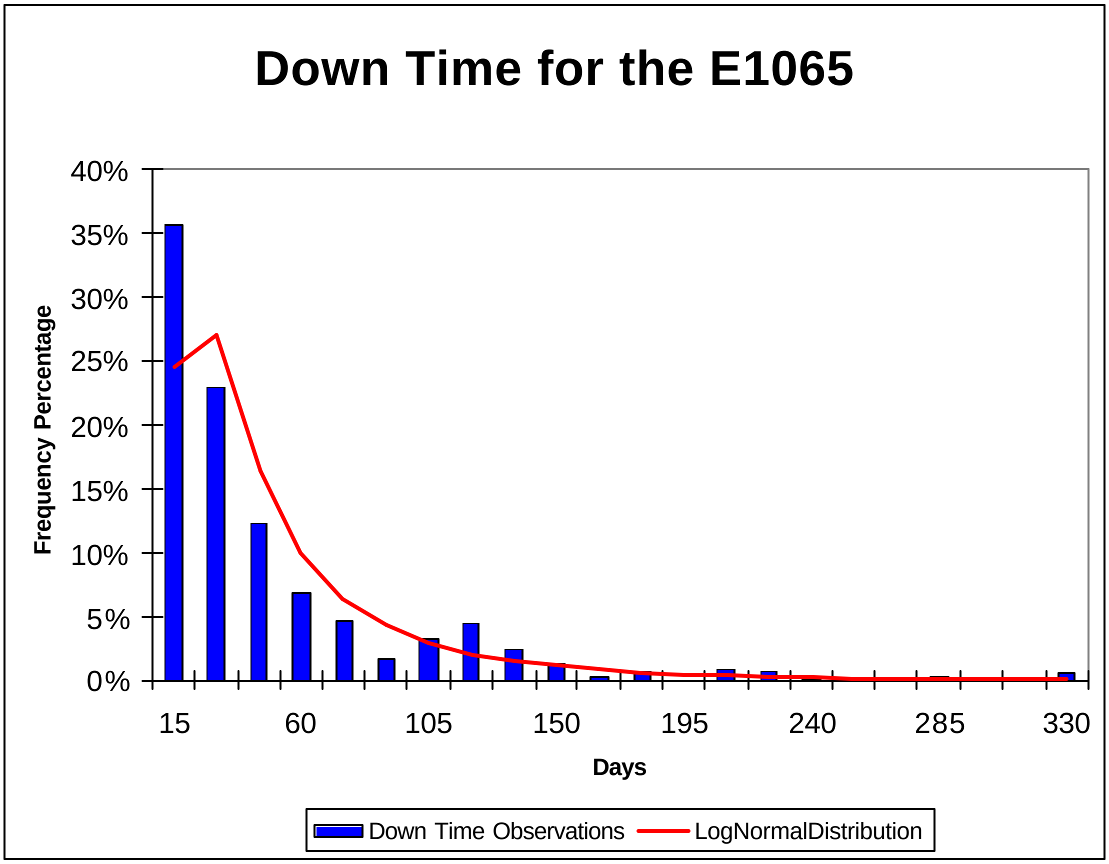

Figure 2. Distribution of E1065 Down Times along with Best Fit Distribution

4. Maintenance Readiness Ratings (R-Ratings). Weekly USMC Maintenance Readiness Ratings (R-Ratings) were calculated for the E1065 from 1999* to 2002. There were a total of 198 weeks of R-Ratings calculated. An R-Rating is defined as (The number of items possessed – the number of these items that are deadlined)/(The number of items possessed). The average R-Rating during this time period is **95.05%.** The graph of the 60 mm Mortar's readiness over time is displayed in Figure 3. Additionally, the distribution of these R-Ratings is displayed in Figure 4.

(* Only 2/3rds of the Readiness data was available for 1999)

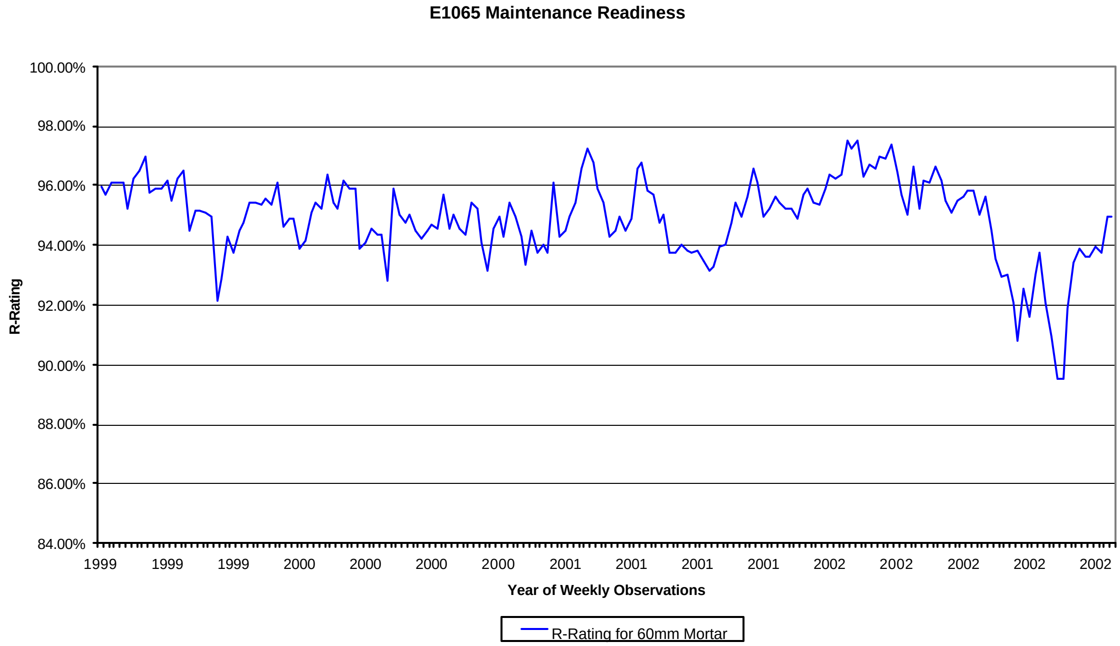

Figure 3. Maintenance Readiness for the 60mm Mortars

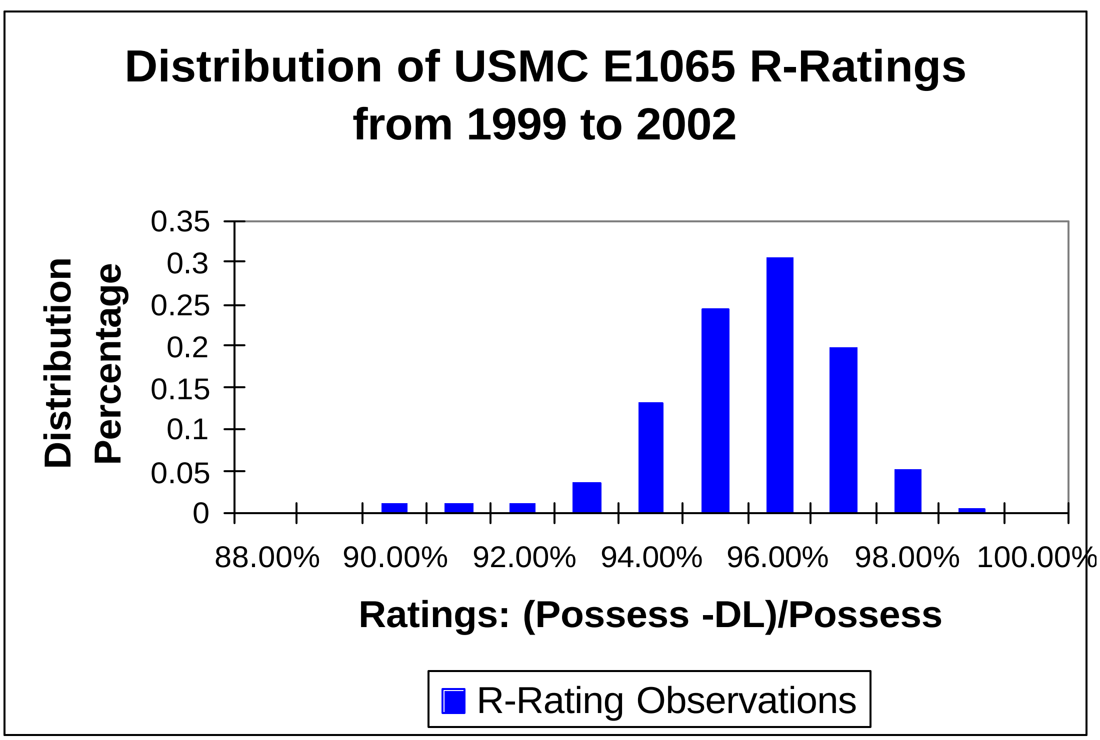

Figure 4. Distribution of 60mm Mortar R-Ratings (1999-2002)

5. Attempting to Measure Time Between Failures. Time between failures were calculated by measuring the time between when a serial number initially is considered "deadlined" to the earlier time when the serial number was taken off a previous deadlined status. This resulted in **231** Time Between Failure (TBF) observations. This is not a lot of observations, given that on average the Marine Corps reports readiness on (**426**) 60mm Mortars. Therefore, at least 46% of the 60mm Mortars in the Marine Corps, did not register a single TBF over the 4 year observation period. The average of the TBF observations (from 1999 – 2002) is **302.8 days**. The distribution of the observations is displayed below in Figure 5.

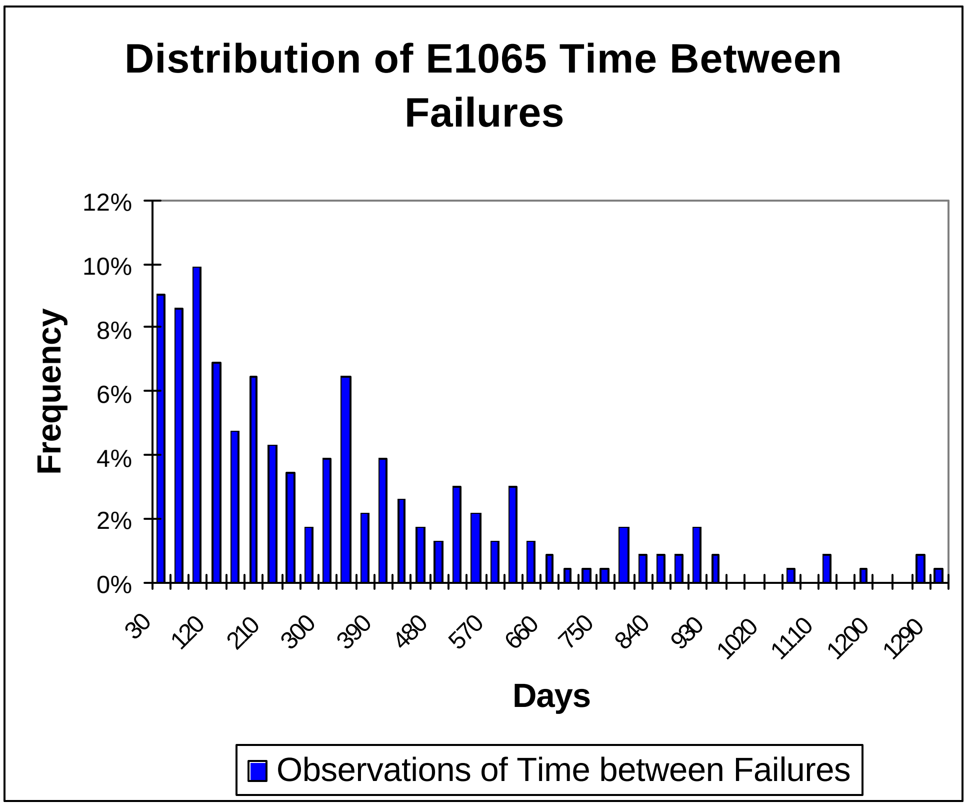

Figure 5. Distribution of USMC 60mm Mortars Time between Failures (1999-2002)

Using Crystal Ball Analysis Software, the standard probability function with the best fit was determined to be the Exponential Distribution. The graph below (Figure 6) depicts the fitted Exponential Distribution as well as the actual observations.

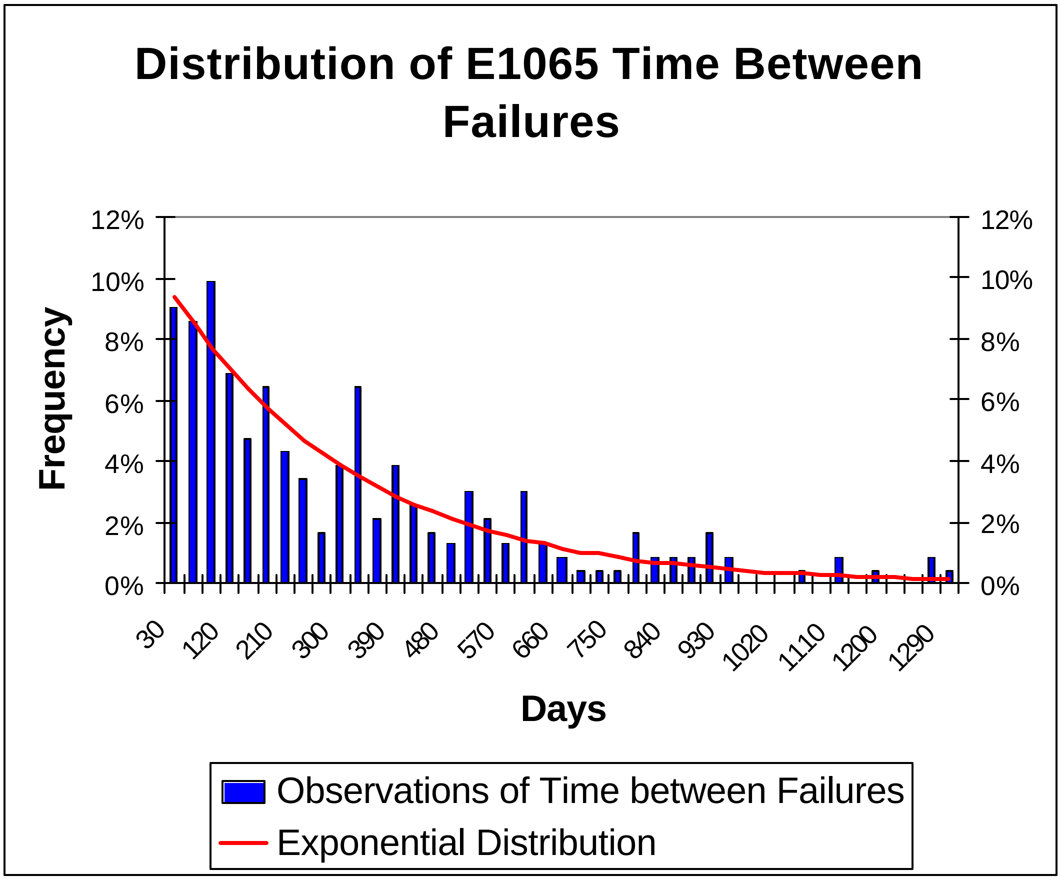

Figure 6 Distribution of E1065 Times Between Failures with Best Fit Distribution

Because of the few Time between failure observations for the E1065, the Mean Time between Failure (MTBF) calculated (**302.8 days)** might not be a very good estimator for the True MTBF.

6. Testing the Calculated Estimate for MTBF. Using Crystal Ball Analysis Software, the MTBF Estimate was testing by conducting a simulation. This was accomplished by using information previously mentioned regarding Down Time and Readiness Ratings. The analysis that measured Mean Down Time and Average R-Ratings is assumed to be accurate, given the quantity of data and previous data scrubbing efforts. The small-scaled simulation included treating the Time between Failures and Down Time as Random variables that behave similar to the fitted distributions previously discussed. Using these random variables on 10 separate items (serial numbers), I computed times for 10 failures and 10 fixes to occur for each item (total of 200 events, 20 per item). I then apply this to a number of weeks (week 1 to week 400) and see how many of these ten items are operational on a given week. After having this accomplished, an R-Rating is computed for each week. The final part of the simulation is to collect statistics on the average R-

Rating after completing 1,000 trails of the simulation. After collecting the statistics, they are then compared to the actual readiness ratings, found in Figure 4.

7. <u>Results of Simulated Test.</u> The results of the simulation indicate that the MTBF Estimate of **302.8 days** is not very accurate. The mean of the simulation's Average R-Rating was **86.7%** and standard deviation (measurement of variation) of **3.0%**. Comparing 86.7% to 95.05% (Average computed between 1999 – 2002) produces a **delta of 8.35%**. Subjectively speaking, this is not a good estimate. The graphs below show the distribution of the simulation's Average R-Ratings and below that is the actual distribution of R-Rating observations.

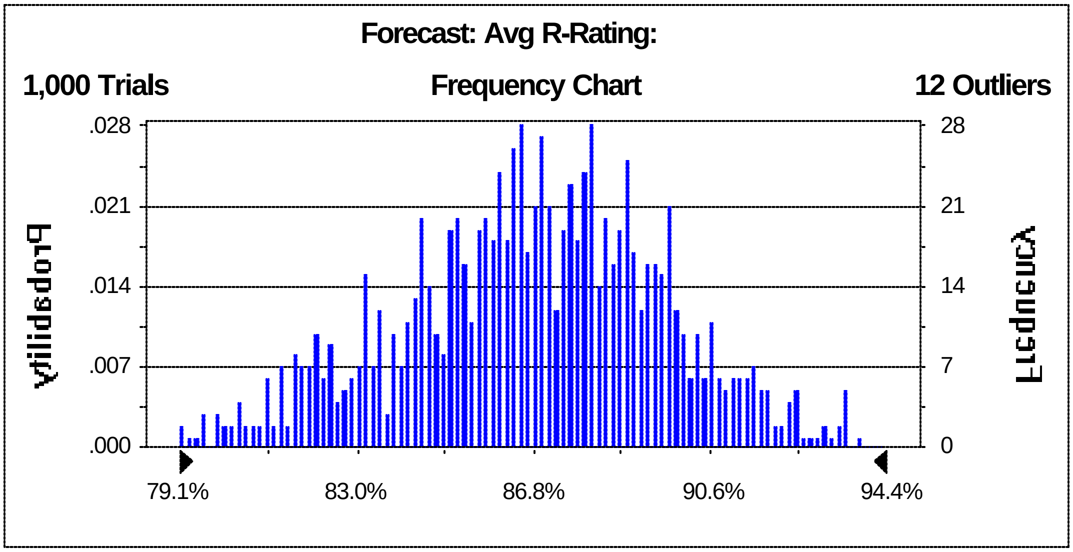

Figure 7. Simulation's Distribution of Average R-Rating, Given MTBF is 302.08 days

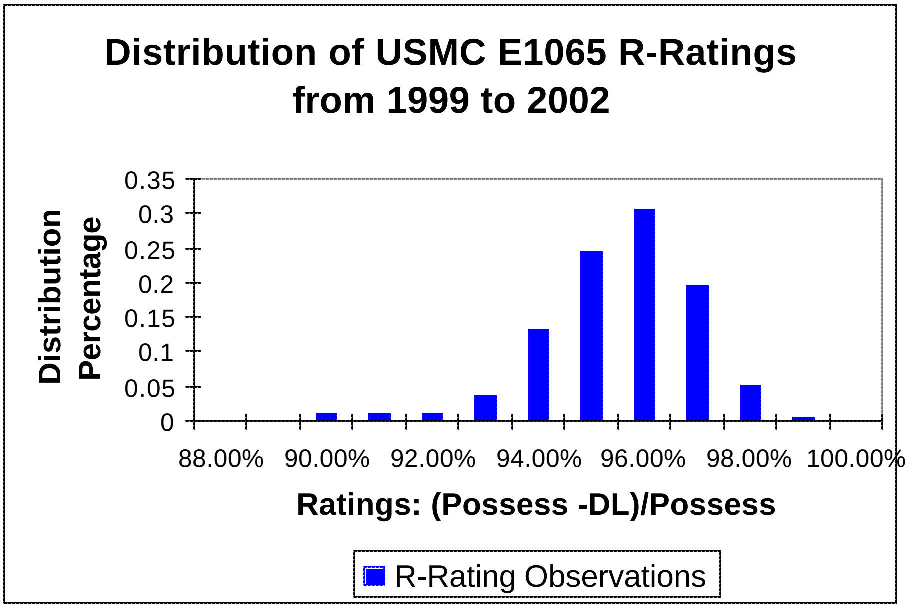

Figure 8. Distribution of 60mm Mortar R-Ratings (1999-2002)

Comparing these two charts tells us that something is not accurate with our MTBF and MDT estimates. Continuing with the assumption that MTBF is the estimate that needs improvement, simulations are then run for incremental changes to MTBF so that we can observe the effect upon average R-Rating. The information below contains these results:

MTBF (days)	Mean (Avg R-Rating)	Confidence>85% Avg R-Rating	Confidence>90% Avg R-Rating	Confidence>95% Avg R-Rating
303	86.7%	73.3%	11.80%	0%
400	89.4%	94.6%	43.1%	.6%
450	90.5%	97.9%	61.1%	1.1%
550	92.0%	100.0%	83.4%	4.6%
650	93.1%	100.0%	96.2%	12.3%
750	94.0%	100.0%	100.0%	28%
850	94.6%	100.0%	100.0%	42.5%
950	95.2%	100.0%	100.0%	61.1%

Table 1. The Effect that Varying MTBF has Upon R-Rating (Simulation)

For the 8 different Simulation Scenarios above, the distribution of Time Between Failures was modeled as an exponential distribution. Of the MTBFs modeled above, the MTBF = 950 produces a distribution of Average R-Ratings (refer to Figure 9) that closely resembles the distribution of R-Ratings from 1999-2002.

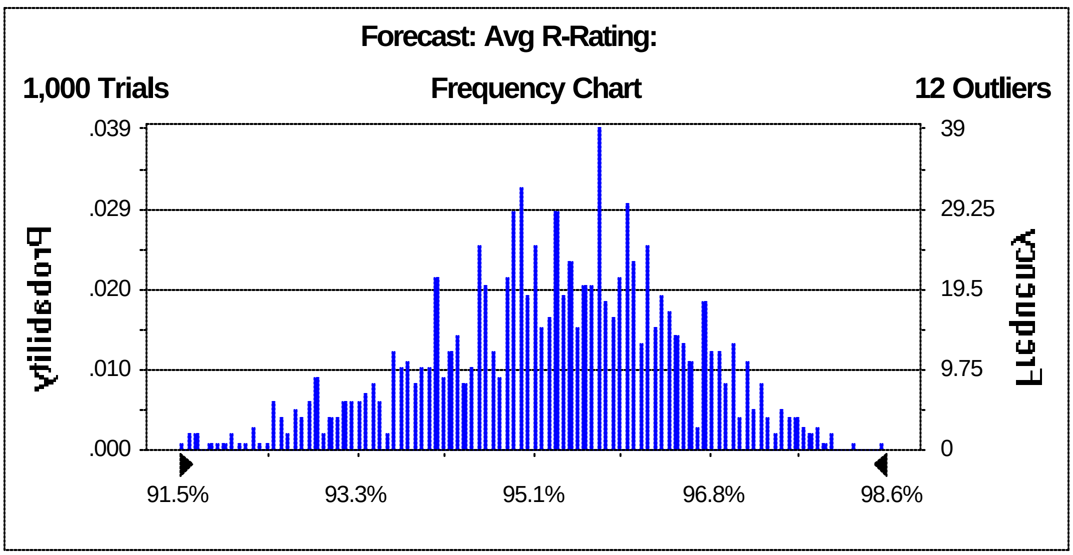

Figure 9. Frequency Distribution of Average R-Ratings for MTBF = 950 Days