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# Development of Bus Maintenance Information

***FINAL REPORT***

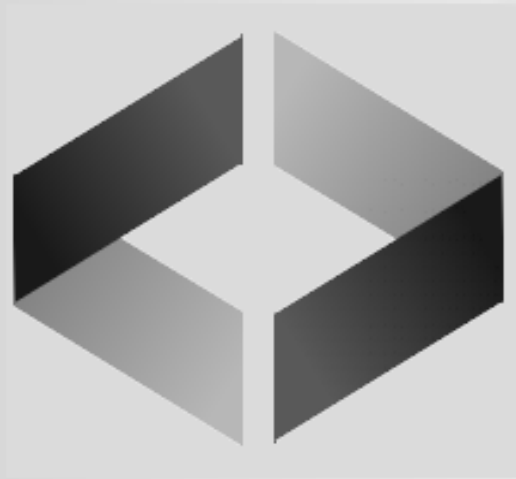
Prepared for the  
Region II University Transportation Research Center

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September 2002

1. Report No. <b>58635-01-02</b>	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle <b>Development of Bus Maintenance Information</b>		5. Report Date <b>September 2002</b>	
		6. Performing Organization Code <b>58635-01-02</b>	
7. Author(s) <b>Nohsen Jafari, Ph.D. Professor, Department of Industrial Engineering Rutgers University Piscataway, NJ 08854</b>		8. Performing Organization Report No. <b>58635-01-02</b>	
9. Performing Organization Name and Address <b>Region 2, University Transportation Research Center City College of New York New York, NY 10031</b>		10. Work Unit No.	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address <b>New York City Transit, MTA New York, NY</b>		13. Type of Report and Period Covered <b>Final</b>	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract  <p>New York City Transit's Department of Buses faced a problem where they found buses frequently breaking down during operation. In order to reduce the number of breakdowns, two approaches are being explored. First, it was felt, using the data present in their database, to develop statistical models to effectively predict the failures of critical components. This would also help in scheduling the buses for maintenance operations. In order to have an impact, using Pareto Analysis, systems that had the most number of failures were identified for the study. These systems consisted of a plethora of components, which were grouped into families. Relevant data was extracted from the central database and the data was validated before the data sets were reduced and prepared for statistical analysis. Various models were studied, but reliability analysis was preferred over the rest. A software application using Visual Basic was developed to automate the process and assist in determining the life various components in a bus.</p>			
17. Key Words  <b>Bus transit operations</b>		18. Distribution Statement  <b>No Restriction</b>	
19. Security Classif (of this report)  <b>Unclassified</b>	20. Security Classif. (of this page)  <b>Unclassified</b>	21. No of Pages  <b>24</b>	22. Price  <b>NA</b>

# BMIAS



Bus Maintenance Information Advisory System

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# 1.0 Introduction

The Bus Maintenance Information Advisory System (BMIAS) allows users to view pertinent information regarding major component failures, specifically for the Air and VCM Interlock systems.

## 1.1 User's Guide Overview

This Manual assumes that the user is familiar with using Microsoft Windows, Excel, and Word. If the user is not familiar with these applications reference to other manuals may be necessary. This manual is organized into the following chapters.

### **Chapter 2.0: Installing BMIAS**

System requirements, installation instructions, uninstall instructions

### **Chapter 3.0: Obtaining Component Life Information**

How to use different ways methods of viewing component life information, explanation of all analyses used

### **Chapter 4.0: Updating Component Life Information**

How to obtain new data, where to store updated data, how to update models

### **Chapter 5.0: Maintenance Operation Analysis**

How to obtain analysis for component grouping and selection, explanation of methods used

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## Acknowledgements

The development team would like to thank everyone who contributed to make BMIAS a reality. Thanks go to many people in New York City Transit, Department of Buses. In particular we would like to thank John Walsh CMO, Barbara Thompson ACO, Industrial Standards Group, and Bharath Patel, MIDAS team. Their encouragement led to our development and the release of this product.

We would like to thank Dr. Moshen Jafari for his supervision and guidance. Last but not least we would like to thank our liaison officer John O'Shea for giving us support throughout the course of this project.

### **Primary Design and Development Team**

Ramaswamy Annamalai  
Mark Weber  
Matthew Trout

## 2.0 Installing BMIAS

In order to access the BMIAS software the user must first install the software onto their computer. The only system requirements for BMIAS is that the computer utilizes Microsoft Windows 95/98 and Microsoft Office 97.

### 2.1 Getting Started

The user should place the BMIAS software disk into appropriate slot. The folder titled “BMIAS” should be selected, do not open the folder. The contents of the folder should then be copied to the C: drive. After the software has been copied to the C: drive the user can create a shortcut, an icon on the desktop, by right clicking on the desktop which will lead to the window seen in Figure 2.1.



Figure 2.1

In this window go to the “New” option and select the shortcut option as seen in Figure 2.2.

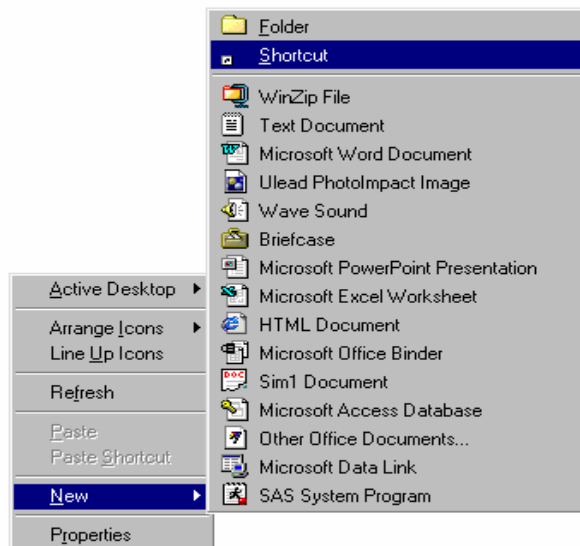


Figure 2.2

After the user has selected the shortcut option they will be presented with the “Create Shortcut” window (Figure 2.3).

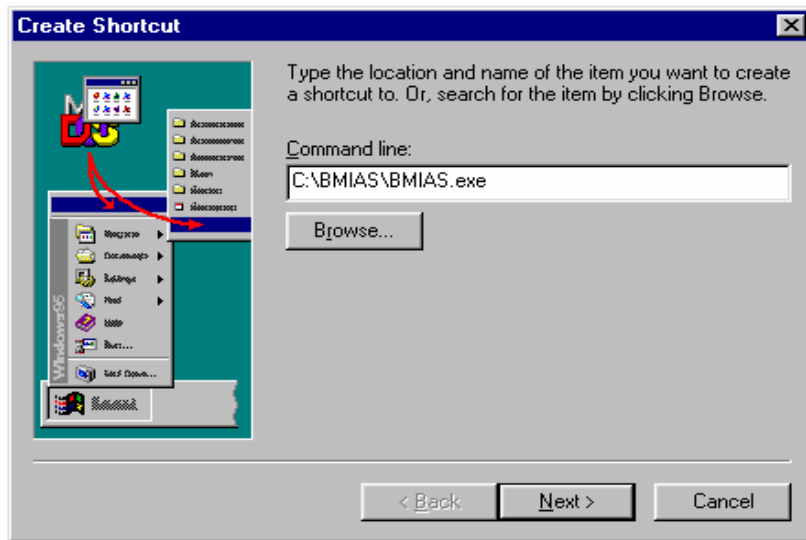


Figure 2.3

The user should enter C:\BBIAS\BBIAS.exe into the command line, as seen in Figure 2.3. After the command line has been completed the “NEXT>” button should be selected. A window will appear asking the user to enter a name for the shortcut, as seen in Figure 2.3. The user may enter any name, but BBIAS is suggested.

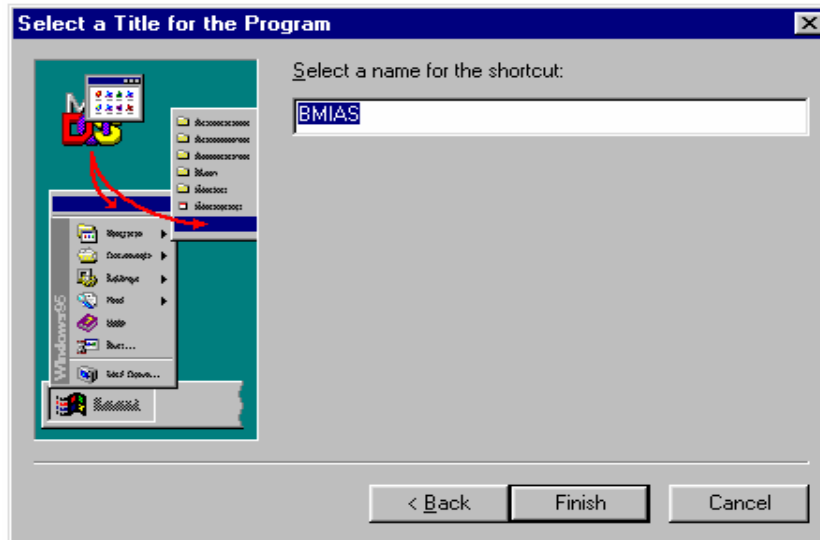


Figure 2.3



After a name is selected the user should select the “Finish” button from this window. The BMIAS icon (Figure 2.4) will then be added to the desktop.



Figure 2.4

## 2.2 File Placement

In order for the BMIAS software to run three files must be moved. These files are comprised of information pertaining to graphical data. **The movement of these files are very important, the software will not run properly otherwise.** The user should open the BMIAS folder that has just been placed on the C: drive. The files to be moved are **Mschrt20.ocx** , **Msvbvm.dll**, and **Mscmctl.ocx**. The user should select these files (these files should not be opened) and move them to C:/Windows/system. This operation can be completed by using simple Cut and Paste tools. If the desired files can not be located the user is prompted to select the View option located on the menu bar (as seen by Figure 2.5).

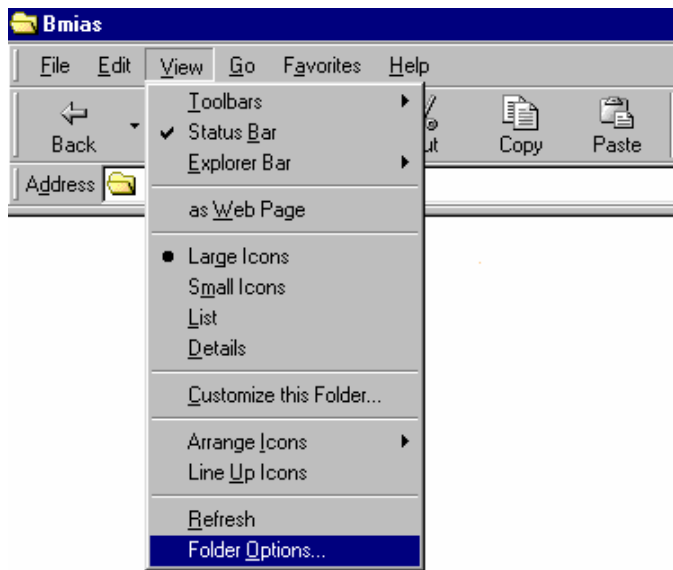


Figure 2.5

The “Folder Options” window will open from which the user is should select the view option, as seen in Figure 2.6. In this section the user should select the “show all files” option and then select OK. The desired files should then appear in the BMIAS folder.

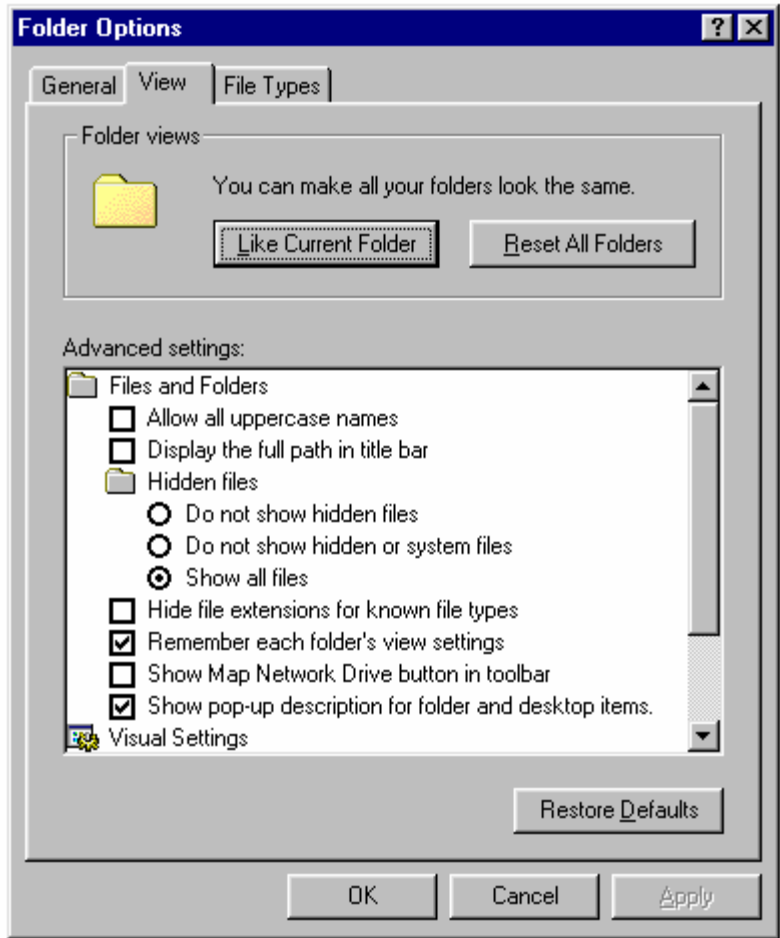


Figure 2.6

## 2.2 Uninstalling BMIAS

In order to uninstall the BMIAS software the user should select the BMIAS folder on the C: drive and delete it. The BMIAS icon on the desktop should also be selected and deleted as well. The “Recycle Bin” should also be emptied

### 3.0 Obtain Component Life Information

This section of the BMAIS software allows the user to view information dealing with important aspects of the major components of NYCT buses. Presently, this information is limited to the Air and VCM Interlock Systems of all active NYCT buses. To see the analyses used to determine the major component groups of the different bus types see Chapter 5.

#### 3.1 Getting Started

In order to obtain information dealing with components the user must first select the "Obtain Component Life Information" button from the main menu, as seen in Figure 3.1.

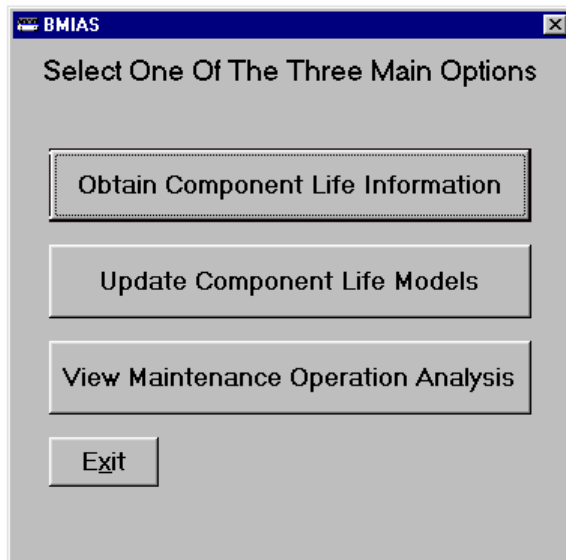


Figure 3.1

#### 3.2 Conducting Your Search

After the "Obtain Component Life Information" button has been selected a menu titled "How Would You Like to Conduct Your Search" will open, as seen in Figure 3.2. There are two ways in which the component life information may be viewed. These options are either by Bus Make or by Bus Number.

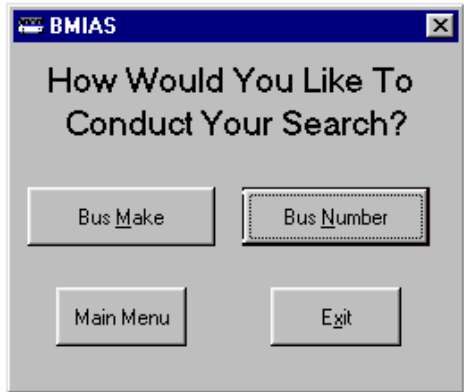


Figure 3.2

### 3.2.1 Bus Make

This option should be chosen if the user desires general information dealing with a specific type of bus. After the "Bus Make" button has been selected a menu of several bus models will open. See Figure 3.3 to view this menu.

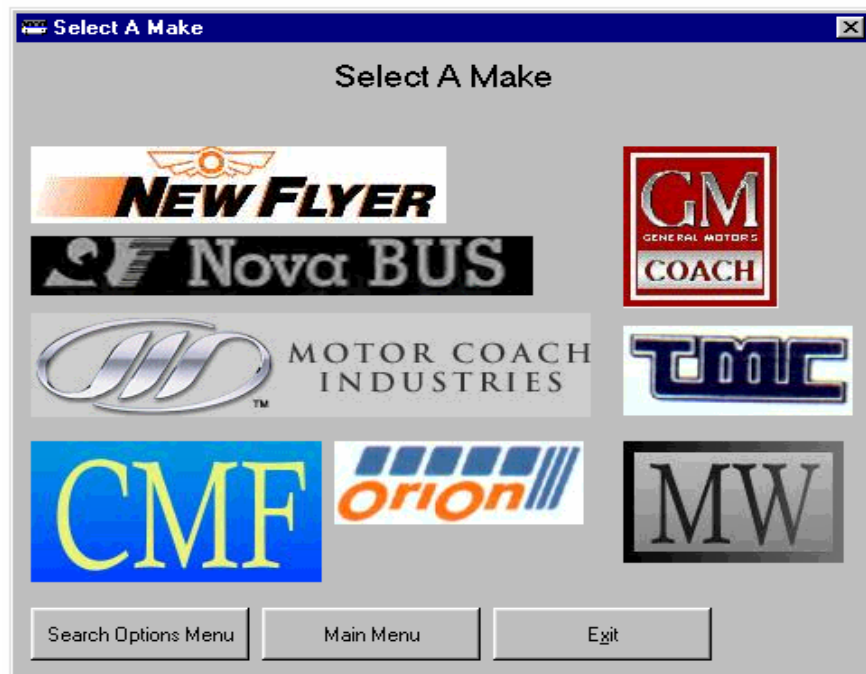


Figure 3.3

The user should then select the graphic of the model of bus they wish to view. This leads to a menu of the different types of buses included in the selected model. The desired bus type should then be selected. An example of this menu can be seen in Figure 3.4.

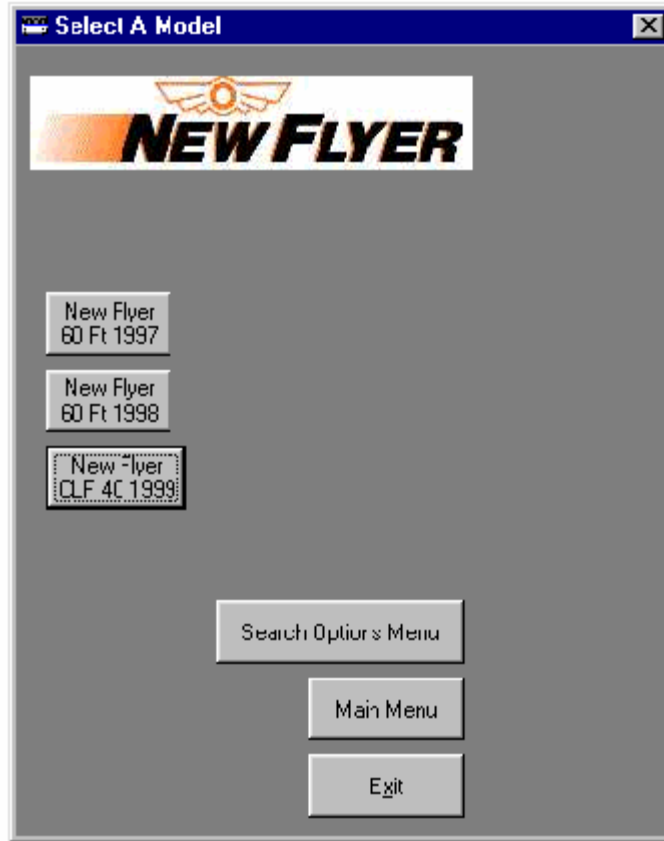


Figure 3.4

If this type of bus has a VCM Interlock System then the user will be presented with a choice between the Air System and the Interlock System after which the “Component Life Information” window will open (Figure 3.5). If the desired bus does not have a VCM Interlock System the “Component Life Information” window will open immediately.

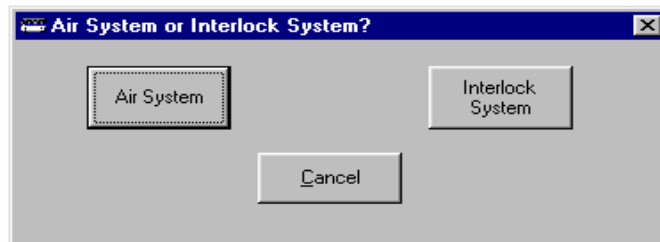


Figure 3.5

### 3.2.2 Bus Number

If the user desires information for one specific bus, the “Bus Number” option should be chosen. After the "Bus Number" button has been selected a window asking the user to enter the number of the bus they wish to view opens (Figure 3.6). This leads to the Component Life Information window.

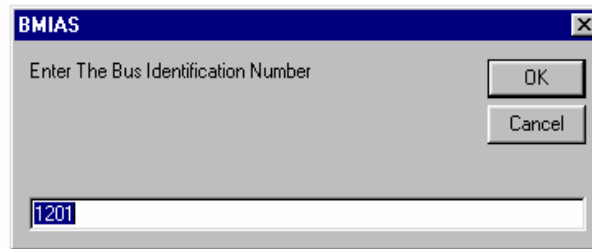


Figure 3.6

If this type of bus has a VCM Interlock System then the user will be presented with a choice between the Air System and the Interlock System after which will lead to the “Component Life Information” window. If the desired bus does not have a VCM Interlock System the “Component Life Information” window will open immediately.

### 3.3 Component Life Information

The “Component Life Information” Window includes various tables, graphs, and tools that provide the user with intimate details of the major component groupings. The analysis for the first component grouping opens immediately. To view the other component groupings the user should use the scroll bar at the top of the window seen in Figure 3.7. Simply click the arrows at either end of the bar to move to the next component grouping analysis.



Figure 3.7

### 3.4 Detailed Analysis Report

The following sections discuss in detail the charts and graphs that are included with the “Component Life Information” window. If there were insufficient data for a type of bus (minimum of 40 data points) only a “Simple Component Life Analysis” table and a “Repair Code” pie chart would appear on the report.

### 3.4.1 Tables

#### Simple Component Life Analysis

This table (Figure 3.8) supplies a simple average and standard deviation of the time of failure, in miles, for the specified component grouping.

Simple Component Life Analysis	
Average	12157
Standard Deviation	7820

Figure 3.8

#### Reliability Analysis

This table (Figure 3.9) supplies the expected lifetime, in miles, of the specified component for selected reliabilities.

Reliability Analysis	
Reliability	Lifetime
0.95	2376
0.90	3637
0.85	4699
0.80	5668
0.75	6587
0.70	7480
0.65	8363

Figure 3.9

### 3.4.2 Charts and Graphs

Any of the charts or graphs can be enlarged by double-clicking on the desired graph. If a print out of the individual chart is desired, while the chart is enlarged, chose the File option of the menu bar and by selecting the print option. The chart or graph can be minimized by double clicking on the enlarged graph. The charts can also be enlarged or printed by selecting the “Charts” option of the menu bar, see section 3.5.

### Component Code Pie Chart

This chart (Figure 3.10) is a display of the percentage of time each specific repair code has occurred during a maintenance operation.

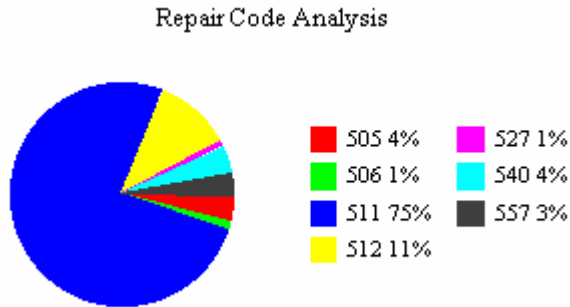


Figure 3.10

### Reliability Bar Graph

This graph (Figure 3.11) represents the different survival times for a range of reliabilities (0.70-0.95).

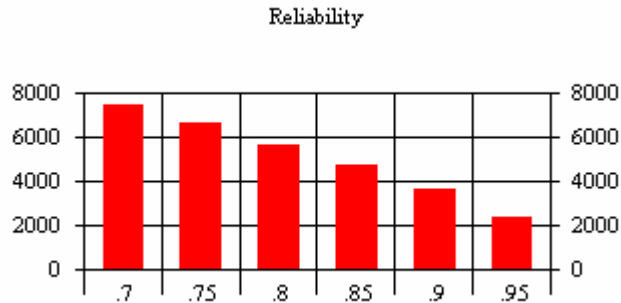


Figure 3.11

### Reliability Line Graph

This graph (Figure 3.12) represents the different survival times for a larger range of reliabilities (0.05-0.95).

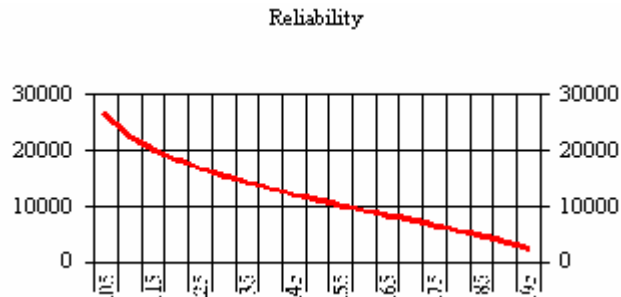


Figure 3.12



## CDF Line Graph

The Cumulative Distribution Function graph (Figure 3.13) plots the probability that the variable takes a value less than or equal to a value  $x$  (in this case  $x$  is equal to lifetime to date miles).

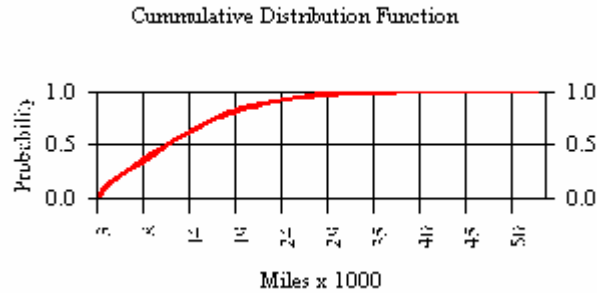


Figure 3.13

## PDF Line Graph

The Probability Distribution Function graph (Figure 3.14) plots the probability that the variable takes a value equal to a value  $x$  (in this case  $x$  is equal to lifetime to date miles).

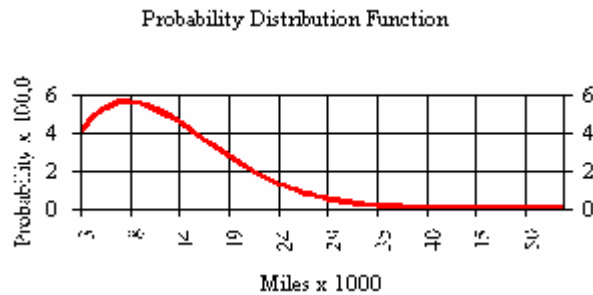


Figure 3.14

## 3.5 What You Don't See (Menu Bar Options)



Figure 3.15

## File

By choosing the File option the user is able to either print the page or to exit the BMIAS software.

## Menus

By choosing the Menu option the user is able to return to any of the previous menus.

## Tools

The BMAIS software provides users with several options in which to analyze component data. These options can be seen in Figure 3.16 and are discussed in detail below.

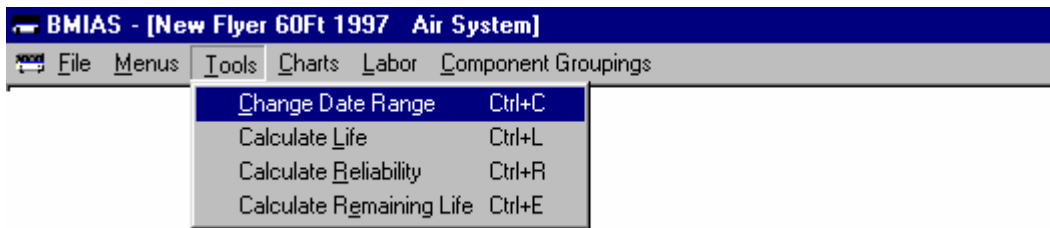


Figure 3.16

## Change Date Range

The user may desire to analyze a certain bus for a specific period of time, this can be done by selecting the "Change Date Range" option of the "Tools" pull down menu. A window will appear, as in Figure 3.17, asking for the lower bound of the new desired date range. The user should enter the date that the new analysis should begin. This window's default value is the lower bound used for the current analysis. After the user selects the "OK" button a new window will appear asking for the upper bound of the new desired date range. The user should enter the date that the new analysis should stop. This window's default value is the upper bound used for the current analysis.

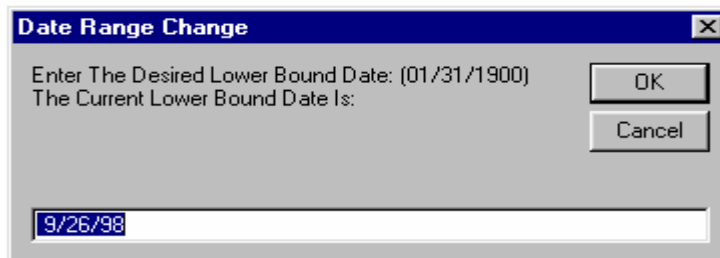


Figure 3.17

If this range is insufficient to perform an analysis the user will be presented with an error message (Figure 3.18) asking the user to enter a broader range.

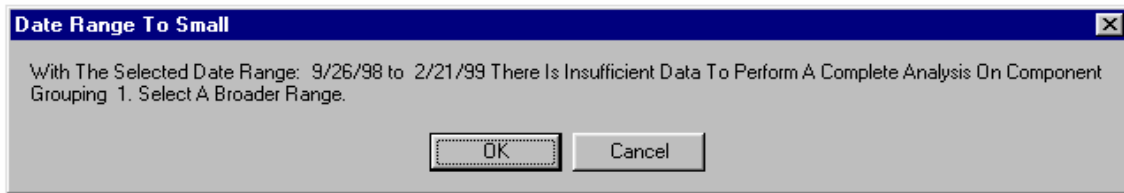


Figure 3.18

If there is sufficient data to perform an analysis the user will be brought back to the “Component Life Information” window where all the charts and graphs will have been altered to reflect the chosen date range.

### Calculate Life

The user may desire to obtain a lifetime of a component for a certain reliability not given in the “Reliability Chart”, this can be done by selecting the “Calculate Life” option of the “Tools” pull down menu. A window will appear, as seen in Figure 3.19, asking the user to enter the desired reliability, the default for this window is 0.95. Only values between zero and one are accepted. If a number is chosen outside of this range an error message will appear asking the user to enter a value between zero and one.

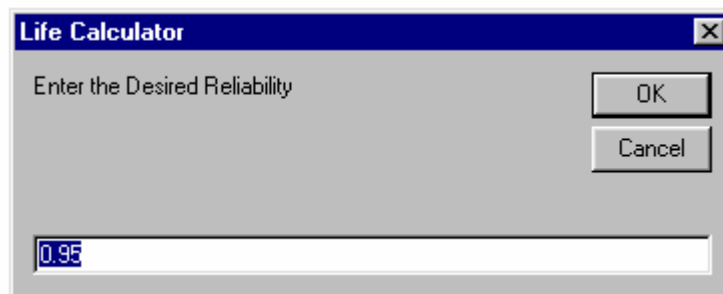


Figure 3.19

### Calculate Reliability

The user may desire to obtain the reliability of a specific lifetime of a component not given in the “Reliability Chart”, this can be done by selecting the “Calculate Reliability” option of the “Tools” pull down menu. A window (Figure 3.20) will appear asking the user to enter the desired life, in miles, of the component. If there is not sufficient data for the given lifetime the user will be presented with an error message. Values above 80,000 miles will not be accepted.

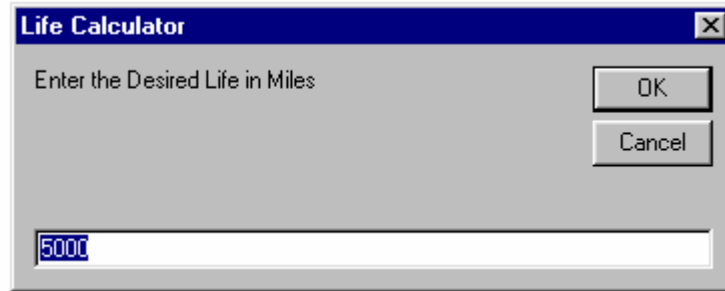


Figure 3.20

### Calculate Remaining Life

The user may desire to determine the remaining life of a certain component. Selecting the “Calculate Remaining Life” option of the “Tools” pull down menu will do this. A window (Figure 3.21) will appear asking the user to enter the current age, in miles, of the component (a value below 80,000 miles must be entered).

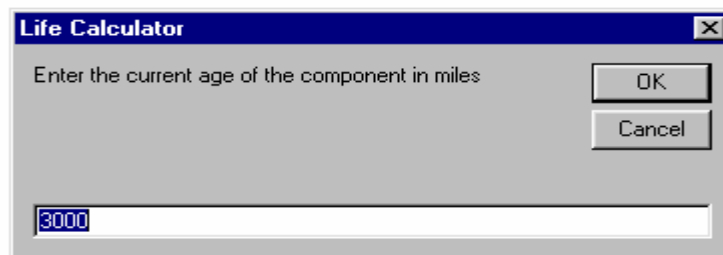


Figure 3.21

A new window (Figure 3.22) will then appear asking the user to enter the desired reliability (a value between zero and one must be entered).

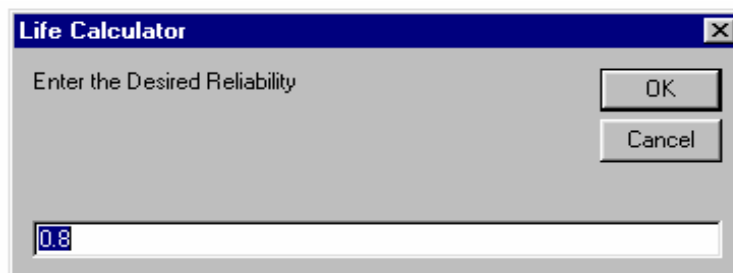


Figure 3.22

The user will then be presented with a window (Figure 3.23) that gives the calculated remaining life of the component.

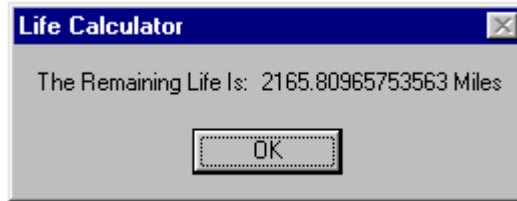


Figure 3.23

## Charts

Any one of the charts can be enlarged or printed by pulling down the “Charts” menu and selecting the desired chart, as seen in Figure 3.24. The user can obtain information about the different types of charts by selecting the “About Charts” option.

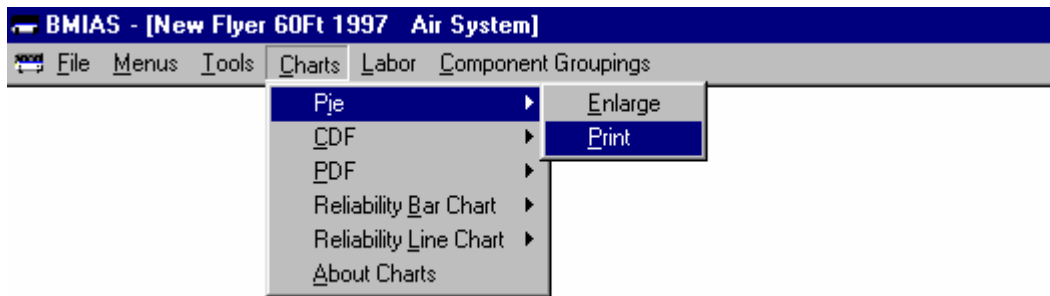


Figure 3.24

## Labor

The “Labor” option of the menu bar (figure 3.25) gives the user an option of viewing either the existing Core Job Times or Flat Rate Times as determined by NYCT. These times are given in an excel sheet and can be exited as any excel sheet. The user will not exit the BMAIS software by exiting the excel sheet.



Figure 3.25

## Component Groupings

The “Component Groupings” option of the menu bar (Figure 3.26) provides the user with the report of the different component groupings for each bus type

analyzed. This document is in MS Word context and can be viewed and exited as a Word document. Exiting the Word document will not force the user to exit the BMAIS software.



Figure 3.26

## 4.0 Update Component Life Models

In order for the BMIAS software to keep current and to keep learning it must be updated from time to time. The length of the period in between updates is up to the user. It is suggested that the user select a standard period of at least one month.

### 4.1 Obtaining Information via Oracle Discoverer

The user is responsible for the periodic updating of the BMIAS software. New data is obtained through the use of Oracle Discoverer to query data stored in the MIDAS system. It is assumed that the user has sufficient Oracle Discoverer experience. The information desired should be displayed in a simple table (data sheet) format. The information to be queried is found in the “Depot Training” section. The desired information is as follows:

1. **Unit** (found under Bus Master Data)
2. **Completion Date** (found under WO Data)
3. **Ltd. Miles** (found under WO Data)
4. **Component Code** (found under WO System Data)
5. **Repair Code** (found under WO System Data)
6. **Unit Description** (found under Bus Master Data)
7. **Bus Year** (found under Bus Master Data)
8. **System Code** (found under WO System Data)

This information should follow the order given above. This information should also be sorted, first by Unit (lowest to highest) and then by Ltd. Miles (lowest to highest). The user is required to enter conditional information pertaining to the range of dates desired, desired unit description, desired bus year, and desired system code. After the query is complete the user should export the Oracle data sheet as “comma delimited text” (files ending in .csv) into the desired bus type file located in the Input Folder folder.

### 4.2 Where to Store New Information

New information should be stored in the Input Folder located in the BMIAS folder in the user’s C: drive. The names of the bus type files in the Input File should not be altered.

### 4.3 Getting Started

In order to update the analyses included in the “Component Life Information” section of the BMIAS software the user must first select the "Update Component Life Information" button from the main menu, as seen in Figure 4.3.

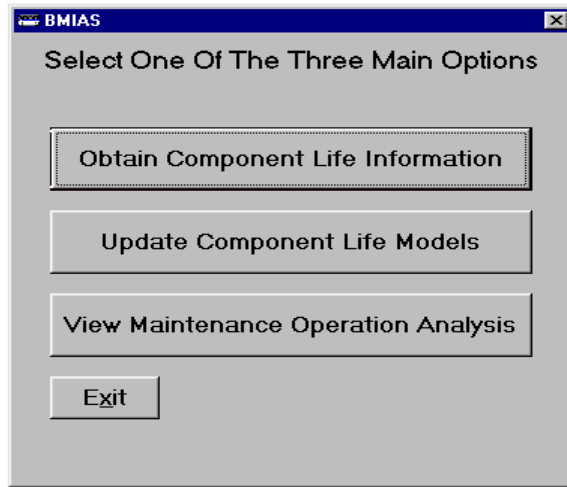


Figure 4.3

#### 4.4 Selecting Models to Update

After selecting the “Update Component Life Models” button the user will be presented with a form as seen in Figure 4.4, note the form is in a folder layout. The user has the option to select one or more bus types from either the Air or Interlock System. In order to access either system the user must select the desired system tab located at the top left of the form.

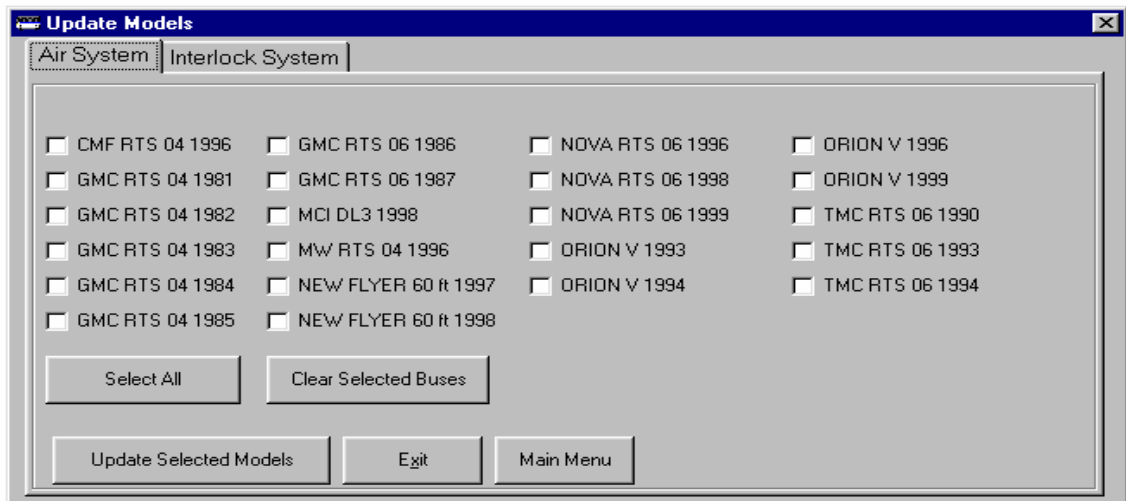


Figure 4.4

The user should update the model by selecting the white box next to the desired bus type, there is also a “Select All” button if all types are to be updated. A bus is selected to be updated if a check appears in the white box. If a bus is chosen



incorrectly the user may select the box that has been checked off and it will be unselected. There is also a “Select All” button that will unselect all buses that have been checked off. To update the models the user should use the “Update Selected Models” button after desired bus types have been chosen. A window will appear to warn the user that the updating procedure may take several minutes (Figure 4.5).

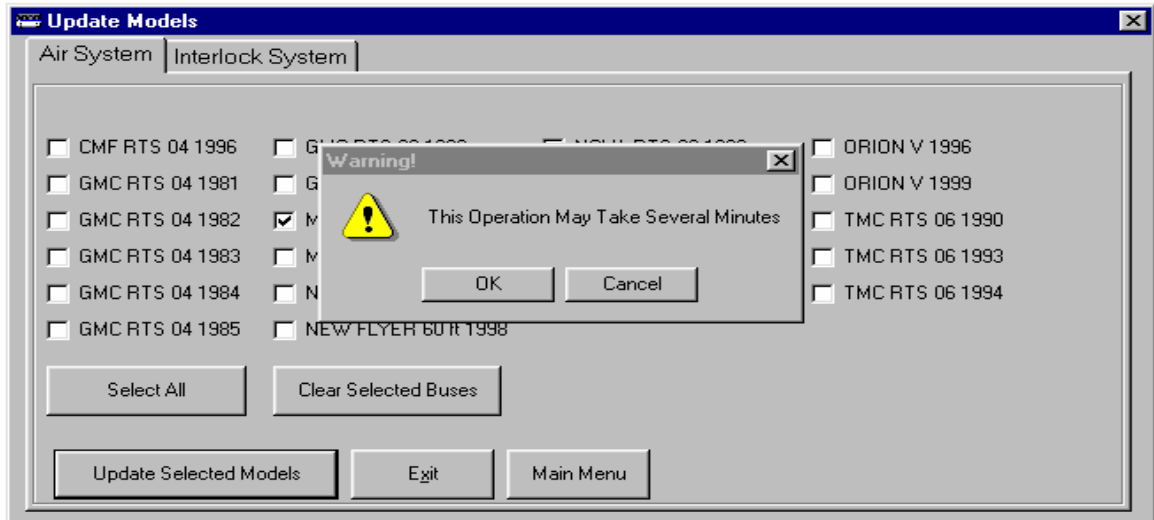


Figure 4.5

Selecting the “OK” button will continue with the updating procedure. The white boxes will “Grey-out” as the software continues with the updating procedure. After the completion of the updating procedure the user will be brought back to the form seen in Figure 4.4. Selecting the “Cancel” button will also bring the user back to the form seen in Figure 4.4 but without updating any models.

## 5.0 Maintenance Operation Analysis

### 5.1 Getting Started

In order to view the analyses through which the major component groupings were determined the user must first select the "View Maintenance Operation Analysis" button from the main menu, as seen in Figure 5.1.

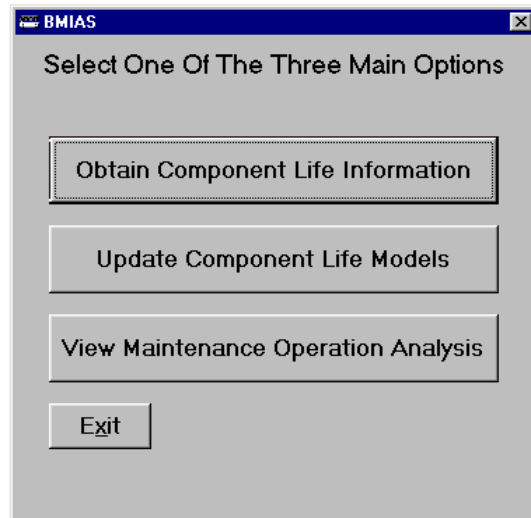


Figure 5.1

### 5.2 Conducting Your Search

After the "Maintenance Operation analysis" button has been selected a menu titled "Select Bus Maintenance Operation Analysis You Wish To View" will open, see Figure 5.2. There are two pull down menus available, one for the Air System and the other for the Interlock System (Only buses with VCM Interlock Systems have been considered).

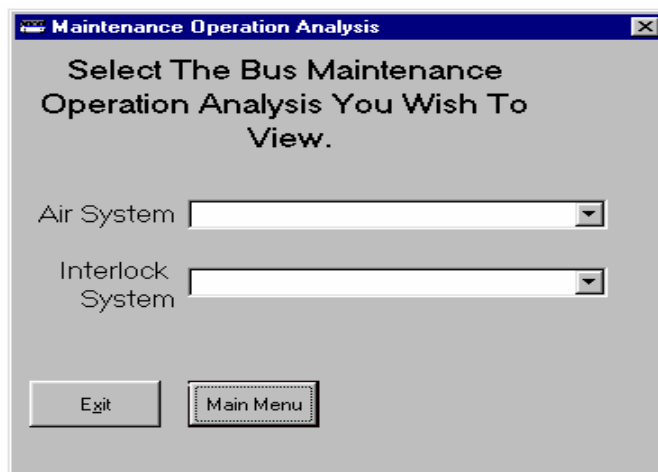


Figure 5.2

The user should click the down arrow of the chosen system's pull down menu to select the type of bus desired, as seen in Figure 5.3.

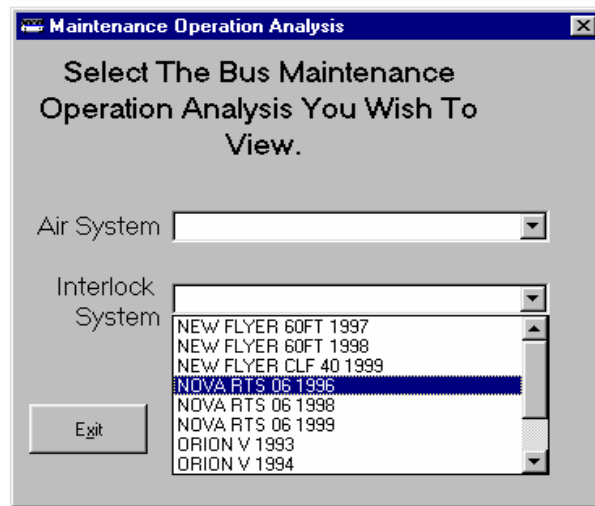


Figure 5.3

This will open an excel sheet containing two types of analyses. These two analyses are of Maintenance Operation and Road Call causes for the specified bus.

### 5.3 System Analysis

The Air and VCM Interlock Systems analyses includes tables and Pareto charts for both Maintenance Operation and Road Call causes for components included in each system.

#### 5.3.1 Table

Each table contains a list of components that have failed for the specified bus type between January 1997 and September 1999. An example of these tables can be seen in Figure 5.4. These components are organized by frequency of failure beginning with components that have the highest frequency of failure. The table includes each component's percent of total failures as well as a cumulative percent of failures.

