Example Application
of
JetStat

Prepared by:

Dr. Alex Richman
President
AlgoPlus Consulting Limited
5670 Spring Garden Road
Halifax, Nova Scotia B3J 1H6
Canada
Tel: +1 (902) 423-5155
Fax: +1 (902) 484-7061
E-mail: arichman@algoplusaviation.com

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Preface

This example application has been prepared by the Algo Plus Consulting Limited in conjunction with the Global Aviation Information Network (GAIN) Working Group B (Analytical Methods and Tools) (WGB) as one of a number of such examples of the use of analytical methods and tools described in the "*Guide to Methods & Tools for Airline Flight Safety Analysis*". The intent of these example applications is to illustrate how various tools can be applied within an airline flight safety department, and provide additional information on the use and features of the tool and the value of such analysis. GAIN WG B hopes that these example applications will help increase the awareness of available methods and tools and assist the airlines as they consider which tools to incorporate into their flight safety analysis activities.

Each example application of an analytical method or tool is posted on the GAIN website (*www.GAINweb.org*). Readers are encouraged to check the website periodically for a current list of example applications, as further examples will be added as they become available.

JetStat—Mechanical Malfunction Analyses for Aviation Safety Management Systems

1 Introduction

The Seventh GAIN World Conference theme is *"Tools & Processes for Implementing Safety Management Systems."* The conference objectives are: demonstrate tools and processes that support safety management through the collection, analysis, and sharing of aviation safety information; explore evolving strategies to support just culture in the collection and sharing of safety information throughout the world; share approaches for improving safety management in an uncertain economic environment; and, expand your collaborative networks to improve aviation safety. In keeping with that theme, this document describes an aviation software system, which supports the collection, analysis, and sharing of aviation safety information in an economical way. This web-based system provides a cost effective means of identifying potential mechanical problems in commercial jets, turboprops (JetStat) and helicopters (HeliStat).

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

JetStat is available over the internet on a subscription basis and is designed to help managers involved with aviation safety to pinpoint safety issue priorities. Based on a sophisticated algorithmic data analysis system, the software analyses data to identify statistically significant potential problems, and automatically alerts the user to the identified areas of concern.

JetStat gives the user a customized "dashboard" of safety issues he/she wishes to monitor, and presents the information in easily understood color charts and graphs. It then automatically provides the user with relevant data corresponding to the dashboard criteria.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

How effective is JetStat? Well let's consider three real life examples. These examples were the result of running existing SDR data through the JetStat software. Although, the specific manufacturers and/or operators of these aircraft have not been identified, these are real life examples taken from Service Difficulty Reports (SDR) submitted through 2003-2004.

In-flight Entertainment Systems

There were 22 SDR reports of in-flight entertainment malfunctions for one recent model jet aircraft. The JetStat analysis of this data indicated that of the 19 unique SDR reports from USA, all were from a single operator. Of those, 17 events, nearly all of which reported 'burning odor', occurred during flight. One aircraft had three reports, one had two reports, and the remaining 12 aircraft each had a single report.

Other operators using the same model aircraft (with 3 times as many departures) had <u>no</u> malfunction reports for their in-flight entertainment system. The JetStat finding that in-flight entertainment system malfunctions are much more frequent with one operator than with other operators with the same aircraft model justifies a high priority for further analysis within a Safety Management System.

Computer Malfunctions

JetStat identified a preponderance of "computer" problems for one operator's turboprop model. This operator had one fourth of all the "computer" problems reported within the SDR database. Again, this JetStat finding gives a high priority for further Safety Management System analysis.

Flight Control System Components

JetStat found that one model had a Flight Control System component event rate 16 times higher than the norm for other jets. JetStat flagged this model as high priority and deserving of further attention.

In each of these examples, JetStat has "connected the dots" and generated a report to alert safety management personnel of a potential problem. It has done this by using sophisticated analytical techniques on existing data, and presenting the findings in a very easily understood threat matrix. These are only three examples of dozens, which could be brought forward.

2 Input Data

JetStat deals with the automated risk assessment of aircraft mechanical malfunctions by using software to analyze aviation mechanical malfunction databases. There are two public databases for mechanical malfunctions – one administered by the Federal Aviation Administration (FAA), and one administered by Helicopter Association International (HAI).

The FAA has a Service Difficulty Report (SDR) system for mechanical malfunctions affecting safety. SDR reporting is required for FAR parts 121, 125, 135 and 145. The website, http://av-info.faa.gov/isdr/SDRQueryControl.ASP?vB=IE&cD=32, contains SDR reports from Canada and Australia as well as the USA. The Helicopter Association International operates a Mechanical Malfunction Information Report (MMIR) system (http://www.mmir.com), which includes inspection and maintenance reports.

Both systems use the Joint Aviation System/Component code (JASC) that identifies the aviation system and component within the malfunctioning part, which the website is located at http://av-info.faa.gov/sdr/documents/JASC-code. JetStat needs no data cleansing or formatting to be used

A "typical" airline has about 36 reports of mechanical problems per 100 departures per month. Very few of these problems affect safety. Although airlines are not consistent in reporting, these databases provide instructive reports for safety, reliability and quality studies. Even though mechanical problems affecting safety are relatively rare, thousands of SDRs are generated each year. The reports provide data on similar events from across the industry for specific aircraft models and parts. They describe problems that have occurred with other operators or in other parts of the country, or even in different countries.

Some reports contain "Lessons learned". For example, the following commentary is cited directly from an SDR report:

> "DURING CLIMB FLIGHT CREW RECEIVED AN INDICATION FOR SMOKE IN LAVATORY WITH AN ACCOMPANIED BURNING ODOR. AIRCRAFT LANDED NORMALLY AND PASSENGERS DEPLANED NORMALLY. MAINTENANCE FOUND THAT LAVATORY RETURN TO SEAT SIGN SHOWED SIGNS OF LOCAL OVER HEATING. FURTHER INVESTIGATION REVEALED THAT NUMEROUS INCORRECT P/N BULBS HAD BEEN INSTALLED IN THIS 28V LIGHT ASSEMBLY. THE COVER OF LIGHT ASSEMBLY WAS DISCOLORED DUE TO OVERHEATING, SEVERAL OF THE BULB BASES BAKED TO THE POINT OF FRACTURING. ISSUED A SMP REGARDING

> THIS EVENT AND AN FCD TO INSPECT THE FLEET FOR ANY LIKE CONDITION. INCLUDED IN PRE-SHIFT BRIEFS THAT SPECIAL CARE MUST BE TAKEN WHEN INSTALLING THESE BULBS TO INSURE THE PROPER BULB IS INSTALLED"

However, this goldmine of data has to date been underutilized because the focus has been on reporting individual events, rather than looking for meaning in the commutative total of the events through a systemic, analytical assessment of all the data to identify statistical patterns, trends or priorities. When identified, these reports provide the aviation industry with an early warning system of low-frequency high-risk occurrences and an opportunity to take pre-emptive action.

3 Analytical Process

While the SDR and MMIR systems have many benefits, they were not designed to facilitate risk assessment or trend analysis. They are primarily report repositories, not data analysis vehicles. The aviation industry needs analytical tools for these datasets.

Through JetStat, AlgoPlus designed a set of sophisticated analytic and graphic tools, which use the SDR and MMIR databases for automated aviation safety analyses. The JetStat system quickly analyzes data identifying areas where the performance is significantly different from the statistical norm. These are items that need to be assessed further within Safety Management Systems.

Once identified, JetStat issues an ALERT to its users indicating the priorities for further investigation and/or action. The analysis is presented in a threat matrix report issued to the user, which indicates the seriousness of the risk and the likelihood of it occurring within that model. The ALERT system helps ease the workload when there are small safety management staffs.

JetStat requires no special computer skills or additional programming by the user. JetStat delivers fully analyzed reports directly to the user, thus minimizing the need for special training and skills. Users who can handle e-mail are able to use JetStat.

The system is automatically delivered over the Internet. The user's only task is to specify the aircraft models, the frequency of reports (weekly or monthly) and the e-mail address of the recipients. Users can concentrate on applying their subject matter skills to the safety management process.

Users no longer have to sift through reams of SDR/MMIR data looking for information about their particular model. Instead, reports tailored to the user's models are automatically generated and distributed to specified persons at various frequencies. More importantly, the time JetStat saves aviation safety personnel on the number crunching analytic functions and on checking source data can be utilized more effectively on the high priority areas identified in the JetStat reports.

JetStat is beneficial to any operator, regardless of the number of aircraft. Small operators can easily keep abreast of safety-related mechanical difficulties in their specific model. Operators with several models can keep up to date with mechanical anomalies for all of their models. Larger operators need a structured process for the identification of factors that could ultimately lead to an accident/incident (CASS FAR 121.373).

Manufacturers and regulators also benefit from this multinational, system-wide perspective as well as from the system's profiles for a specific model, which display the strengths, and weakness of each mechanical system. Alternatively, JetStat can analyze a mechanical system's reliability for different aircraft models.

JetStat is primarily made available through an e-mail subscription service using SDR publicly available data. However, the JetStat system can be provided on a stand alone basis to individual companies desiring an in-house system on which to run private legacy data for Safety Management Systems, quality control purposes, competitor comparisons, or to identify priorities and act on internal trends and/or anomalies. When used in house, a considerable number of additional managerial functions/components are available for the JetStat system.

Automated processes

JetStat has automated the following tasks for its users:

1. Data base maintenance
    - Monitor public databases continuously
    - Download source data and update database
    - Check for duplicates, validate model name
    - Near-real-time shared data
    - Gather denominator data-traffic, census
2. Data mining and visualization
    - Analyze dataset
3. Risk assessment and decision support
    - Develop event rates for each model/component
    - Benchmark data for each model against system-wide statistical norms
    - Perform risk assessment with threat matrices
    - Red flag (prioritize) potential mechanical problems
4. Trend monitoring and follow-up
    - Analyze and graphically display significant trends
    - Continuously update the analyses to cover the most recent 6 months
5. Report generation
    - Send timely safety ALERT reports via email
    - Display the narratives of the source data
    - Make summary reports
    - Produce report-ready fully-labelled graphics
6. Report sharing and tracking
    - Enable sharing of ALERT reports with colleagues
7. Input data
    - No data preparation is required for the e-mail subscription service

8. Interface
   - User-friendly JetStat is accessible from any computer (Windows 98 or higher) with access to the Internet. Subscribers use the initial JetStat e-mail to connect with the JetStat website for detailed information on mechanical malfunction reports for their specified models.

9. Actions By User
   - The only action required by a JetStat subscriber after signup is to open the email and review the customized report – all the analytical work has been already been done by JetStat.

4 Tool's Output

The following roadmap shows the 5 basic elements of the JetStat system.

1. An **e-mail list** for each model showing all the mechanical components with reports during the past 6-month period, ranked by traffic lights that summarize the risk-assessment and trends, see figure 1.
2. A **threat matrix** showing trends over time, see figure 1.
3. **Source report** including the full text of the narratives.
4. **Share report** sent to colleagues - Matrix and narratives for a selected component.
5. **Outmail list** showing which risk assessments have been sent out to whom and when the recipient opened the e-mail.

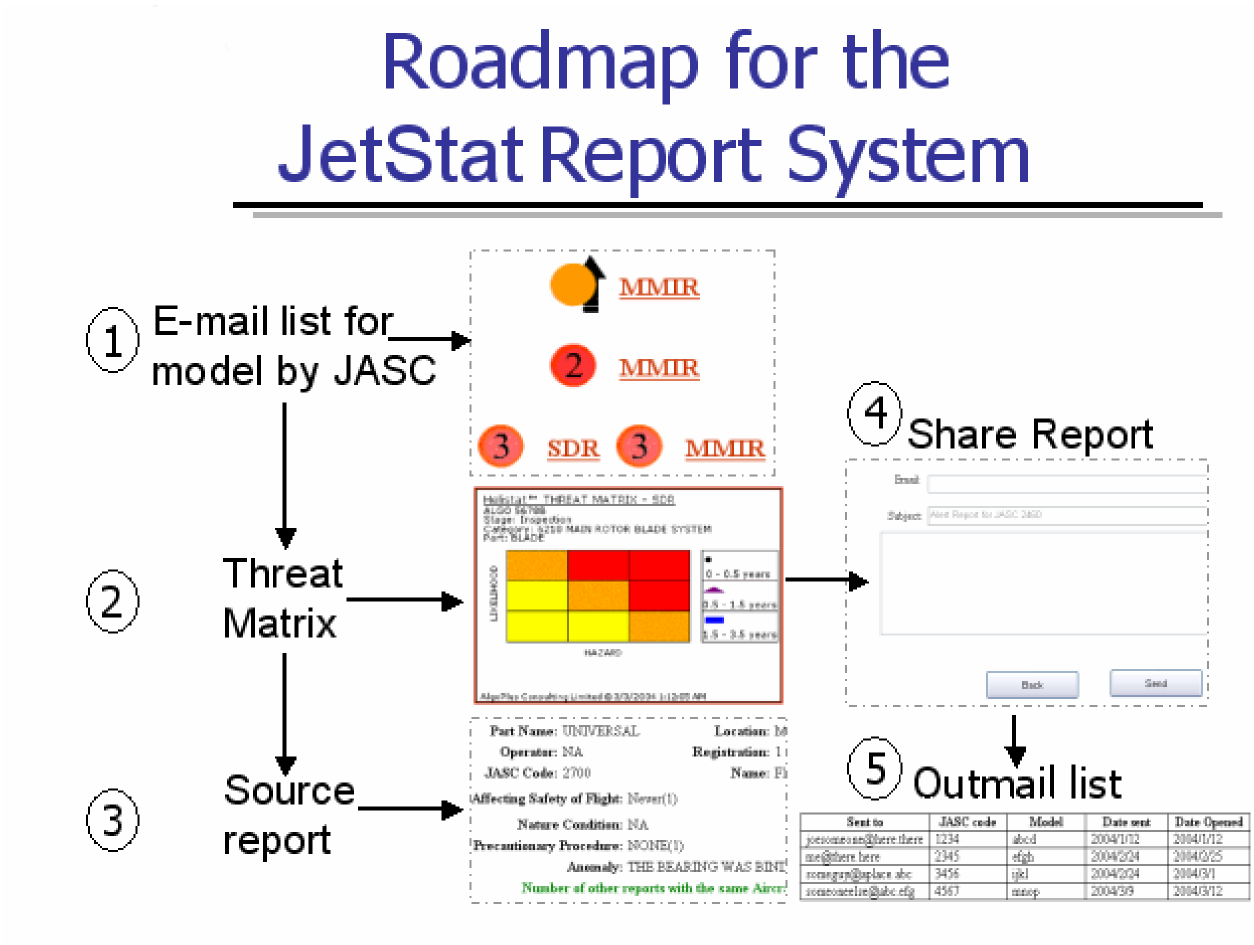

Figure 1 **Elements of the JetStat System**

The JetStat system e-mails reports for a specific model to subscribers weekly or monthly. The report summarizes all SDR and MMIR reports for the past 6 months, and is displayed in priority order (traffic lights). The following sample in figure 2 shows two mechanical malfunctions. The subscriber has previously viewed the first JASC 6210. The second JASC 6320 “NEW to you” has not been previously viewed.

The “traffic-lights” condense the risk matrix, see figure 3, showing the frequency, severity and trends. Here, the JASC 6320 orange traffic light indicates an intermediate risk, but the rating has increased to orange from yellow in the past 6 months. The SDR narrative (from Australia) is shown in full as well as the date of occurrence.

SDR MMIR JASC: 6210 MAIN ROTOR BLADE SYSTEM

NEW to You SDR MMIR JASC: 6320 MAIN ROTOR GEARBOX

SDR Anomaly: "(AUS) MAIN ROTOR TRANSMISSION INPUT PINION GEAR FAILED. GEAR TEETH STARTING TO BREAK DOWN WITH DISTINCT WEAR PATTERN AND PITTING ON THE FLANK OF ALL GEAR TEETH AND ADVANCED BREAKING DOWN OF SOME OF THE TEETH. METAL CONTAMINATION OF TRANSMISSION."(5/3/2004 11:00:00 PM)

Figure 2 **JetStat E-mailed ALERT**

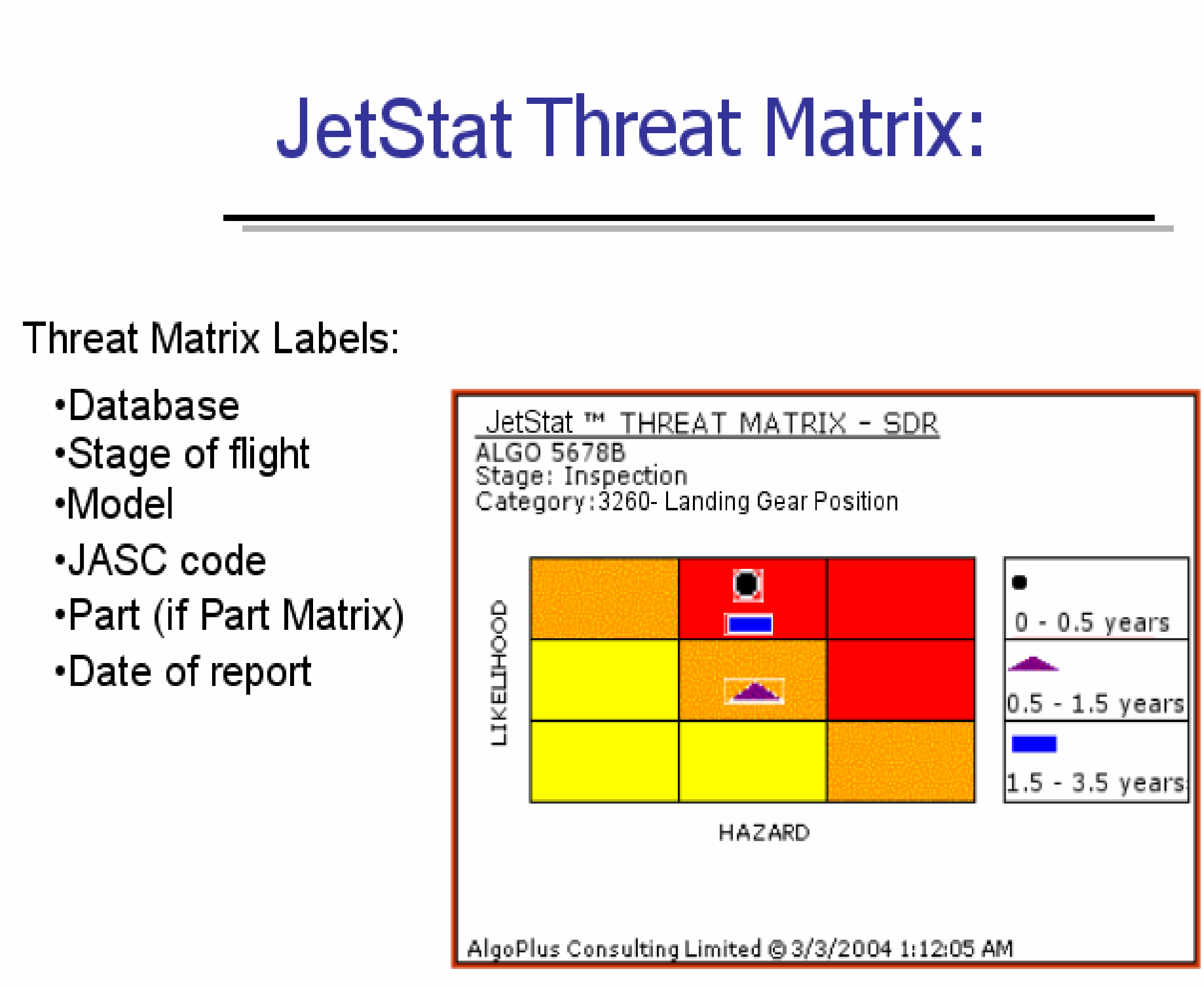

Figure 3 **JetStat Threat Matrix**

This threat matrix, see figure 3, is produced for each mechanical component with a malfunction reported for the specific model during the previous 6-month period. The JetStat threat trajectory analytic algorithm considers three factors related to aviation safety: 1) the likelihood, 2) the hazard severity, and 3) the trajectory of changes over time. The likelihood and hazard severity are combined in a 3x3 risk matrix. The risk matrix distinguishes anomalies, which are of low relative likelihood and low severity from those with higher likelihood and high severity. Furthermore, changes are tracked over three time periods to reveal the trajectory. This trajectory also reveals reductions in risk over time

The threat matrix is fully labeled. The labeling identifies the data source, the manufacturer and model, the phase of flight at which the malfunction was identified and the JASC code and name. The JetStat threat matrix vividly portrays the analytical results on the likelihood of the event, the hazard severity, and a trajectory for changes over time.

1. Likelihood of the event: How often is the anomaly likely to occur? Instead of relying on qualitative estimates (like frequent, probable, occasional, remote or improbable), JetStat quantifies the likelihood. This likelihood is based on the concept of “achievable reliability”. The frequency of occurrence in the model is compared to benchmark rates for all other models in the database and produces a relative likelihood. Although the event is relatively rare in overall system-wide operations, the relative likelihood can be higher for a specific model than in other models. Likelihood has three categories: lower, intermediate and higher.

2. Hazard severity: What is the potential for harm? JetStat uses specific criteria for determining this projection. For anomalies reported through inspections or routine maintenance, JetStat uses the FAA-developed severity rating of the likelihood of association of the JASC 4-digit code with an incident or accident. For in-flight reports, JetStat assigns the hazard ratings developed by the Flight Safety Foundation CARE project.

3. Trajectory changes over time: The risk assessment is performed for three time periods - the most recent six months, the preceding 12 months and the earlier two-year period. A geometric icon for each of these time periods is inserted into the risk matrix indicating the trend. If all three icons are in the same cell, the threat has been stable over the 42 months.

Managerial Overviews

In addition to the “traffic light” graphs for specific JASC codes, JetStat/HeliStat users can get specialized summary malfunction profiles. One kind of profile compares the malfunction ratios for a specific model against various competitor norms. Another kind of profile compares malfunction ratios of various models for a specified mechanical system.

The following are examples of these profiles intended to provide real life examples of the practical managerial application of HeliStat. One set profiles models; the other set profiles specific mechanical systems. HeliStat using existing SDR data generated both types of reports. As you will see, the HeliStat analysis identified some areas of significant importance for this particular helicopter manufacturer.

The first set of charts in figure 4 profiles two models, showing the malfunction ratios for various mechanical systems. The system-wide malfunction norm (from all competitor models) is 100%. Malfunction ratios below the competitors’ norm are under 100%. The difference from 100% is shown in yellow. Malfunction ratios above the competitors’ norm are over 100%. The difference from 100% is shown in red.

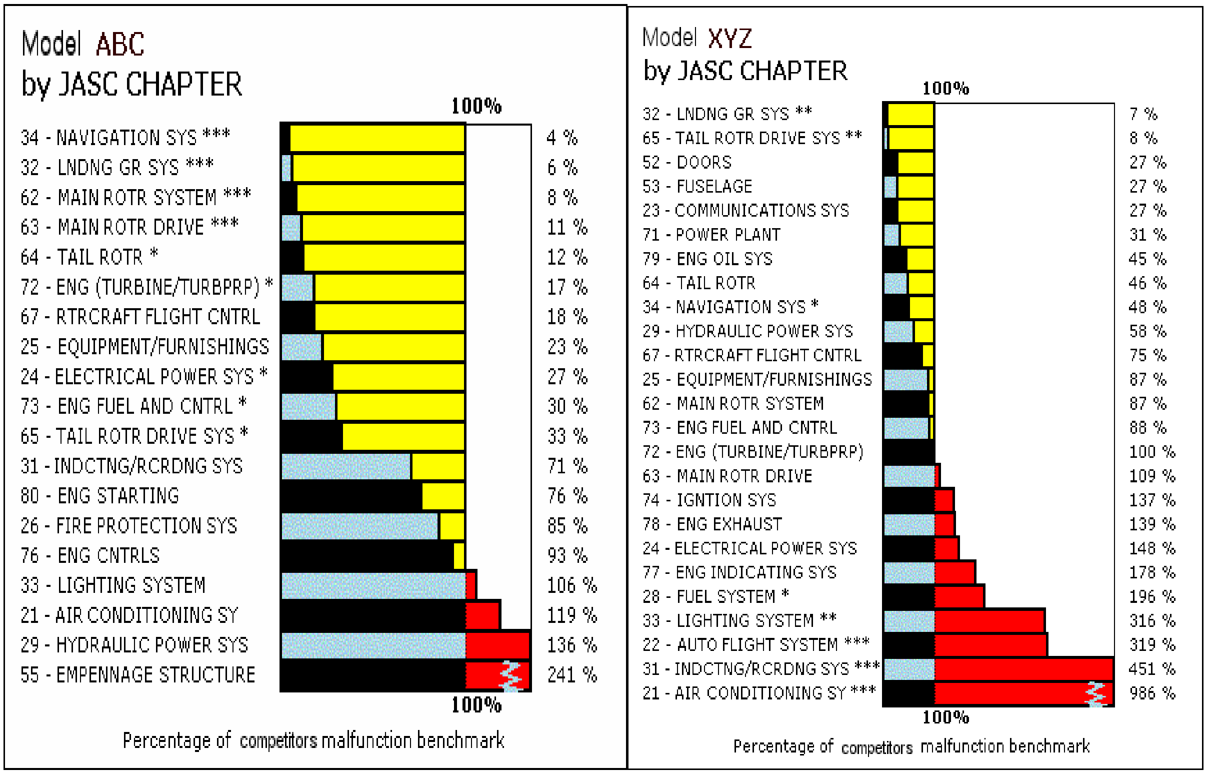

Figure 4 **Two Different Models Showing Malfunction Ratios by Mechanical System**

The left-hand graph in figure 4, model ABC, has a predominance of yellow, indicating mechanical systems with malfunction ratios below the competitors' norm. The systems for navigation, landing gear, main rotor and main rotor drive at the top of the graph are all below 12% of the competitors' norm. At the bottom of the Model ABC graph, the three mechanical systems with red bars indicate malfunction ratios above the competitors' norm. For model ABC, the graph shows quite clearly that the majority of systems have malfunction ratios less than the competitors' experience.

The right-hand graph in figure 4, model XYZ, has a predominance of red, indicating mechanical systems that have malfunction ratios above the competitors' norm. At the bottom of the model XYZ graph there are 11 mechanical systems with red bars indicating malfunction ratios above the competitors' norm.

The graph shows quite clearly that there are a substantial number of mechanical malfunction ratios above the competitors' experience.

The second set of charts in figure 5 show within a specific mechanical system the malfunction ratios for different models. In the left-hand graph, most of the models have fewer malfunctions in the landing gear system than competitor manufacturers.

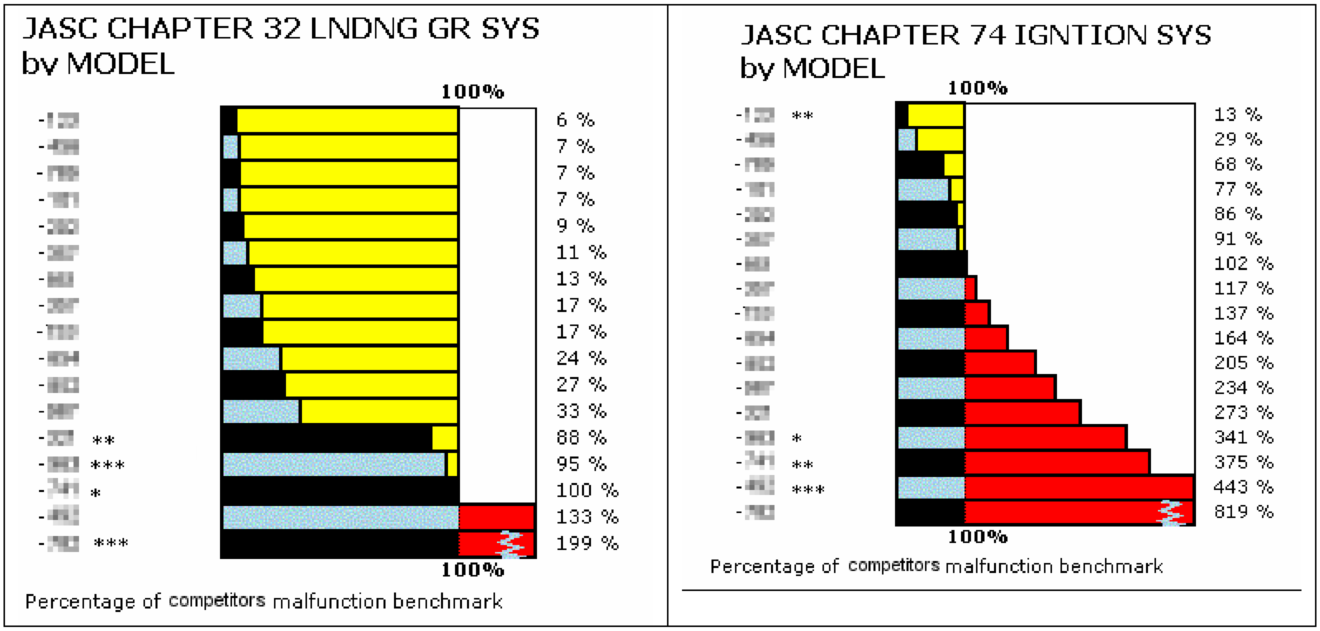

Figure 5 **Two Different Mechanical Systems Showing Malfunction Ratios by Model**

In the right-hand graph for ignition system, most of the models have higher malfunction ratios reported than competing manufacturers. This ignition system graph identifies one model (with 13% of the average competitors malfunction rate) from which lessons might be learned and applied to other models.

5 Application of the Results of the Analysis

JetStat provides an economic and effective way for manufacturers, operations and regulators to identify high priority anomalies and trends in malfunction reports, and thereby provide everyone with a "heads-up" to potential problems before they become significant events. In short, JetStat addresses five key questions every time it is operated:

1. What model(s) and/or part(s) are demonstrating anomalies?
2. How unusual is the occurrence?
3. How serious is the problem?
4. Is the problem getting worse over time?
5. What is the priority for further assessment?

JetStat then provides this information in an easily understood report helping the reader quickly continue with Safety Management System analyses:

1. Is there a problem with particular equipment?
2. Do other operators have this problem with a specific model?
3. Do other models have this problem
4. What lessons have been learned by other operators experiencing the problem?
5. What potential problems should be anticipated with this model?

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