The Quality Solutions Provided by an Automated Statistical Process Control System at Northrop Grumman Corporation

Lorraine Schacht, Northrop Grumman Corporation, Perry, GA
Donna Fulenwider, Meridian Software, Inc., Raleigh, NC
Bradley W. Klenz, Meridian Software, Inc., Raleigh, NC

ABSTRACT

The Georgia Production Site of the Northrop Grumman Corporation produces aircraft assemblies. The manufacturing facility, located in Perry, Georgia, produces frames, doors, and subassemblies for the 747 fuselage as a supplier to The Boeing Commercial Airplane Group. Boeing identified a quality problem with the aircraft frames in early 1992. As a result, Northrop Grumman implemented Statistical Process Control (SPC) techniques on 232 unique aircraft frames. Aircraft mechanics collected measurement data manually and a computer operator input the data into the SAS System® running on a mainframe computer. Analysts performed the SPC analysis off-line and provided the mechanics with the results, often after the frames had been shipped to the customer.

Due to many insufficiencies with the manual SPC data collection and analysis system, Northrop Grumman decided to automate the effort using radio-frequency technology and the SAS System. This paper focuses on the efforts required to provide a real-time automated data collection and analysis system for large aircraft assemblies and the benefits provided by such automation.

INTRODUCTION

The Northrop Grumman Corporation has been producing parts and assemblies for the 747 aircraft under contract with The Boeing Commercial Airplane Group since 1967. In support of this contract, the Georgia Production Site, located in Perry, GA, began producing frame assemblies, doors, and subassemblies in the fall of 1991.

In early 1992, Boeing contacted Northrop Grumman about a quality problem with the frame assemblies. Defective frame assemblies were being delivered to the customer from the Perry facility. In response to the customer complaint, Northrop Grumman implemented a manual SPC data collection and analysis system. The primary goal of the system was to ensure that no defective parts were delivered to the customer.

After collecting data manually for a year, Northrop Grumman decided to automate the system to increase efficiency and lower costs. Northrop Grumman conducted a product search of available software and hardware vendors and decided to use radio-frequency technology. This solution would provide real-time data collection and analysis on the manufacturing floor. Northrop Grumman selected the SAS System to perform data management and analysis and Telxon Corporation's radio-frequency devices to transmit data from the manufacturing floor to the SAS System. Additionally, Northrop Grumman selected Meridian Software, Inc. to provide system development and integration services.

THE PROBLEM

Frames are aircraft assemblies that form the ribs of the aircraft. A number of frames are used to build a panel, or section of the aircraft. Panels are connected to form the fuselage of the aircraft. Figure 1 shows the relationship of the frames to the aircraft fuselage.

In early 1992, Boeing identified a quality problem with the aircraft frames produced by Northrop Grumman. Parts of the fuselage did not join together correctly, and Boeing was spending a great deal of time reworking the assemblies to make them fit the fuselage. One problem was the fact that variability in the sizes of the frames that mated together often prevented an acceptable mating condition. At the points where the frames join together, the ends of the frames should be the same width. If one frame is larger than the nominal measurement and the mating frame is smaller than the nominal measurement, the frames will not join correctly. This condition is called "frame mismatch" and is shown in Figure 2.

THE MANUAL SYSTEM

Upon being notified of the quality problem with the frames, Northrop Grumman implemented SPC techniques on each of the 232 different frame assemblies built at the Perry site.

Northrop Grumman set up a SAS database on the mainframe to store the frame measurement data, engineers defined tolerances for each of the frames, and mechanics began measuring each frame built. The mechanics submitted the measurements to a computer operator who entered the measurement data into the SAS database.

The computer operator checked the measurements against the defined tolerances to determine if the frame was good or defective. Next, the operator generated SPC charts to determine if the frame production process was in-control or out-of-control. Finally, the operator distributed the results of these tests to the mechanics. If

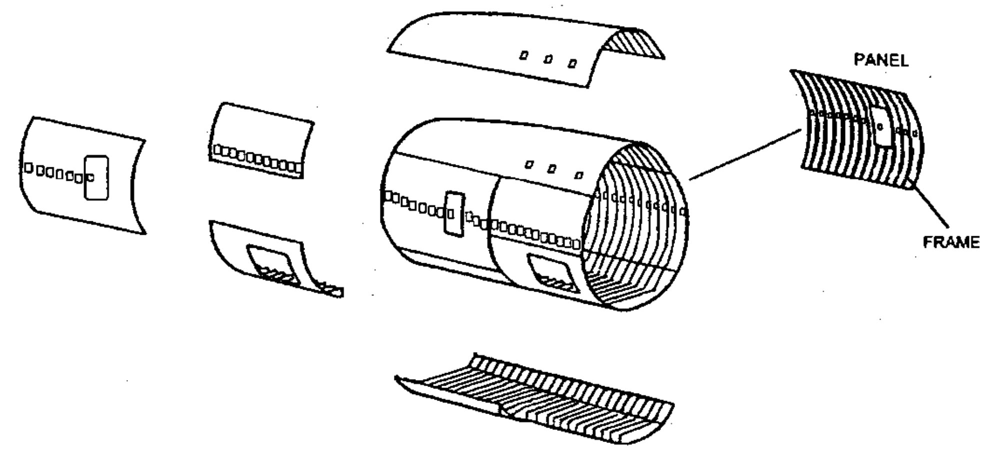

Figure 1 *Relationship of the Frames to the 747 Fuselage*

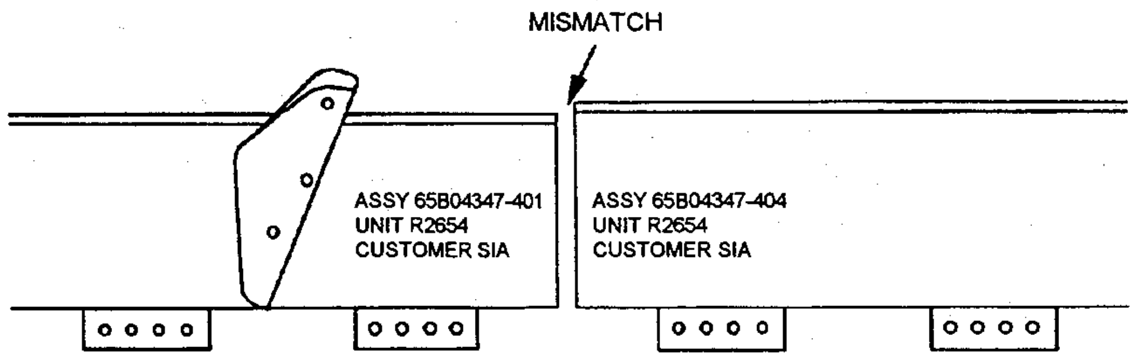

Figure 2 *Frame Mismatch*

the frame was defective, the mechanic reworked the frame to meet specifications. Many times, however, the frame had already been shipped by the time the mechanic received the results of the frame measurement data analysis. In this case, it was impossible to rework the frame. Thus, even with the data collection and analysis system in place, Northrop Grumman still had a problem with defective parts being shipped.

It was clear that the manual data collection and analysis system had unacceptable problems. The primary problem was the time it took to complete the process. Because of the lengthy cycle time, the process did not solve the problem of shipping defective parts. The delay that resulted from the time the measurements were taken to the time feedback was received caused many of the frames to be shipped before anyone discovered that the frames were defective. In addition, the nature of manual data collection provided a greater chance for error - both in recording data on measurement sheets and in keying data into the SAS database.

To meet the goal of shipping only quality parts, Northrop Grumman decided to automate the measurement analysis system. It was critical that the mechanic receive immediate feedback regarding the quality of each frame built.

THE AUTOMATED SYSTEM

Northrop Grumman defined the following requirements for the automated data collection and analysis system:

- Provide real-time analysis and feedback to the mechanic

- Eliminate manual recording of data
- Perform SPC analysis and generate appropriate charts
- Provide a direct gage interface
- Provide an integrated bar code laser scanner
- Provide mobile analysis capabilities
- Provide real-time update of the measurement database

The intent was to provide a system that automated the entire data collection and analysis process with minimal disruption of the flow of work. A mechanic would be able to build a frame, measure the frame, and immediately determine if the frame was good or not without leaving his work area. The direct gage interface and integrated bar code laser scanner requirements were designed to eliminate the manual recording of data. The system had to be mobile because aircraft frames are large and not easily transported.

Northrop Grumman investigated three automation options:

- Hard-wired stations
- Batch systems
- Radio-frequency systems.

Hard-wired stations consist of computers physically located on the manufacturing floor. SPC analysis software is resident on the computers. The mechanic takes the part to a computer, measures the characteristics of the part, enters the measurement data into the SPC program, and receives instant feedback. Hard-wired stations were not acceptable because they are not mobile. Aircraft assemblies are not easily portable. The measurement system must be taken to the assembly rather than the assembly taken to the measurement system.

Batch systems consist of portable units running an SPC program. The mechanic takes a portable unit to the part, measures the characteristics of the part, enters the measurement data into the SPC program, and receives instant feedback. At the end of the day, the data collected on the portable units is downloaded onto a computer for permanent storage. Batch systems provide mobile analysis, but they were not acceptable because they do not provide real-time update of the measurement database.

Radio-frequency systems consist of portable, hand-held units that communicate using radio waves to a centrally located server running an SPC program. The mechanic takes a portable radio-frequency device to the part, measures the characteristics of the part, enters the measurement data into the SPC program on the server using the portable radio-frequency device, and receives instant feedback. Radio-frequency systems are mobile, provide real-time analysis and feedback to the mechanic, and provide real-time update of the measurement database. Thus, a radio-frequency system was chosen as the automation solution.

After examining four radio frequency devices and 24 SPC software packages, Northrop Grumman decided to combine the SAS System with Telxon Corporation's radio frequency equipment. During the course of the vendor evaluation, SAS Institute, Inc. and Telxon Corporation established a working relationship and generated a working demonstration of SAS® software and Telxon hardware.

Northrop Grumman decided to run the automated data collection and analysis system on an OS/2® platform. We chose OS/2 as the server operating system because of the ease with which it integrated with the Telxon hardware.

To run on the system server, Northrop Grumman selected the SAS System for OS/2 with the following components of the SAS System:

- Base SAS
- SAS/AF®
- SAS/FSP®
- SAS/QC®

Additionally, Northrop Grumman selected the SAS System for Windows for development and analysis stations. We made this choice because of the existing Novell network at the Perry facility. The following components of the SAS System were selected for applications development and data analysis purposes:

- Base SAS
- SAS/AF
- SAS/FSP
- SAS/GRAPH®
- SAS/QC
- SAS/STAT®

Thus, applications could be developed under the SAS System for Windows and executed in a real-time production environment under the SAS System for OS/2. Further reporting and analysis could then be performed using the SAS System for Windows.

The radio-frequency data communications hardware and software required consisted of:

- 1 radio-frequency base station controller
- 15 radio-frequency handheld devices (PTC 960 Portable Tele-Transaction Computer)
- 15 TRIPS (Telxon RF Interpretive Prompting System) software
- 1 RFXpress software

TRIPS is the radio-frequency software that runs on and controls the operation of the hand-held devices. RFXpress software is the radio-frequency software that runs on the OS/2 server and controls the data communications.

The PTC-960 communicates via spread-spectrum radio frequency data communications with the base station. The base station is hard-wired through the network controller to the OS/2 server running the application program. The OS/2 server is connected via the Netware network to the PCs running Windows throughout the facility.

The start-up cost of the system was $106,000 and the annual cost is $16,000. Figure 3 shows the system configuration.

The radio-frequency unit uses an integrated bar code laser scanner and has a direct link for the gage. The integrated bar code laser scanner is used to scan in all identifying information (such as date, time, assembly number, and employee number). The gage is directly connected to the unit, so the gage reading is automatically read into the system Thus, all manual data entry is eliminated. This significantly reduces the possibility of data entry error.

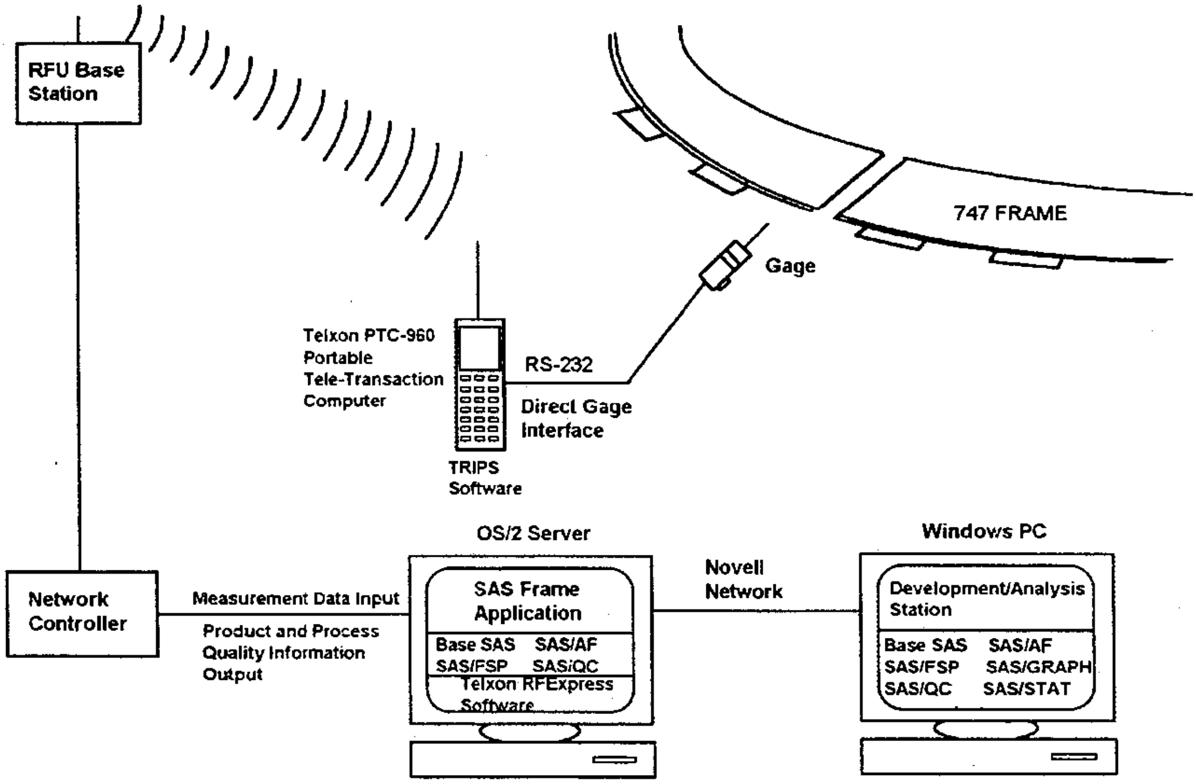

Figure 3 *Automated Data Collection and Analysis System Configuration*

Using the new automated data collection and analysis system, the mechanic takes the measurement with the gage connected directly to the radio-frequency device. The mechanic receives real-time measurement verification and process information, and the measurement database is automatically updated. If the frame is defective, the mechanic can correct the problem before the frame is shipped to the customer.

THE BENEFITS

The automated data collection and analysis system has been very successful. Since its introduction in 1993, it has eliminated the manual data collection process and has helped Northrop Grumman attain its quality goals.

The system provides mobile data collection and analysis capabilities for the mechanics that allow them to take complete ownership of the quality of the assemblies in their work area. The use of the integrated bar code laser scanner and the direct gage input eliminate all manual data entry. There are no non-value added steps in the data collection and analysis process.

The cost savings of the automated process over the manual process are substantial. The streamlining of the process through automation allows Northrop Grumman to save $54,000 in labor costs annually.

The greatest benefits realized from the automated data collection and analysis system are manufacturing benefits. The system provides a real-time system for analyzing and reporting the data for management and for our customer. Defective parts are immediately identified and reworked. The shipment of defective parts is eliminated. The mechanics have more control of the measurement process and are more knowledgeable about the parts that they build. The system reduces costly rework by providing a means of improving processes used to build the frames.

SUMMARY

The automated data collection and analysis system was first implemented in 1993 and has proven to be a great success. It has increased customer satisfaction to the point that Boeing no longer has any complaints about the frames produced in Perry. Also, Northrop Grumman has been able to gain control over the frame manufacturing process and ensure that the company does not build bad parts and does not ship bad parts.

THE AUTHORS

Lorraine Schacht
Northrop Grumman Corporation
Georgia Production Site
1 Northrop Place
Perry, Georgia 31069

Donna Fulenwider
Meridian Software, Inc.
4308 Oak Park Road
Raleigh, NC 27612

Bradley W. Klenz
Meridian Software, Inc.
4308 Oak Park Road
Raleigh, NC 27612

REFERENCES

Telxon Corporation
3330 West Market Street
P.O. Box 5582
Akron, Ohio 55445