THE KODAK QUALITY PACKAGE

James L. Bossert, Eastman Kodak Company
Julie A. LaBarr, Eastman Kodak Company

INTRODUCTION

We are here today to talk about a statistical quality control package which we developed on our IBM mainframe utilizing SAS(R) as our foundation. We are proud of this package because:

1. It shows the adaptability of SAS(R) to the needs of its users.
2. It was the first IBM mainframe quality package ever developed at Kodak Park.
3. It met the growing needs of Eastman Kodak as it searched for ways for improved quality in its products.

The development of this package was anything but smooth. There were times when XP (as we affectionately call our package) seemed like a millstone around our necks. This presentation is to provide a roadway for others in how to bring a quality computer package into existence. The talk is broken into four segments: Background, Development, Implementation, and Future Developments.

BACKGROUND

Eastman Kodak has a number of manufacturing units, the largest of which is Kodak Park located in Rochester, NY. At Kodak Park, there is a steering committee of upper management which tracks quality activities having multiple user input. In June of 1984, the Quality Technology Unit approached the Quality Advisory Committee for the support and funding of a statistical quality control computer package. This was given with the contingency that a preliminary package would be ready for field testing by February 14, 1985. This meant that the team formation, planning, and debugging had to be accomplished in approximately seven months. Before any programming could take place, four items had to happen:

1. A project team had to be formed;
2. The “fitness-for-use” criteria had to be determined;
3. What type of computer system was to be utilized -- mainframe, PC, both;
4. What type of programs should be in the initial product.

It was decided that the start-up team would consist of four members: the team leader, the programming and hardware coordinator, a quality consultant who would determine the fitness-for-use criteria, and a person who would develop a “strawman” based on the fitness-for-use criteria. Each person had some role to play which, when combined, would form a comprehensive data base to proceed from. The team leader was responsible for the overall coordination of the project. He would also be responsible for obtaining information on all types of quality systems and software. He would be the liaison to the Quality Advisory Committee and other organizations at Kodak. The programming and hardware coordinator would coordinate the activities of the programmers and provide information on hardware and software availability, accessibility, and compatibility. The quality consultant would be responsible for determining what programs were needed, the priority of the programs, what hardware was preferred, and user interest. The consultant who developed the strawman was responsible for the format of the package: how the package is developed -- modular? integrated? user-friendly? menu-driven? command activated? -- these types of things. Then he would present what he felt was the most appropriate based on the fitness-for-use criteria.

So the team was picked; I was in the role of the quality consultant who would determine the fitness-for-use. Julie was the programming and hardware coordinator.

What were the needs of the potential users? Many people at Eastman Kodak were enhancing their knowledge on statistical process control. What were the types of processes which would be attempted to be controlled, and what type of techniques would be utilized? Kodak Park manufactures many products; the processes vary as much as the products; there are continuous processes, batch processes, specialty products, and routine products. The initial task was to find the right combination of techniques for the initial package which would fit the needs of the majority of people.

Kodak Park had embarked on a training program where individuals within the various manufacturing divisions were trained to teach their divisions how to broaden their use of statistical process control techniques. It was decided that these individuals would provide a good sample of what was needed. Some things were obvious: X bar and Range control charts, histograms, and some attribute control charts. There was one surprise, many people expressed an interest in statistical inference. So the team did a Pareto analysis to come up with the three initial programs -- X bar and Range control charts, histogram, and statistical inference. It was decided that after these were developed, other parts would be included.

Now the question remains: what system should this package be developed on? Much time and energy focused on the PC vs. mainframe question. PCs were easier to program, but slow and not readily available. Mainframe packages were looked upon as user vicious, and having slow response during peak usage, but they were accessible throughout Kodak Park. The final decision was to develop first on the mainframe, and then downstream to consider PC applications. The mainframe was chosen as the most efficient use of resources. All the statistical programmers were well versed on the mainframe, a majority of the PC's had communication links to the mainframe, and we could utilize SAS(R) as the foundation for all data handling and graphic capabilities.

Members of the Quality Technology Unit then developed the specifications necessary for the programmers to work from. At the same time, our strawman was developed. Our package was designed to be modular in format; this way it would be
easy to add new parts to the package. Secondly, it would be menu driven so that anyone could use the package regardless of how much computer knowledge they had. This concept was called the "PC in the mainframe."

DEVELOPMENT

At Kodak Park, we use SAS (R) as a decision support tool. At the time of development of this package, SAS did not have any statistical process control procedures available. We chose SAS/GRAPH (R)2 to generate the graphics in this package because of its ability to "replay" plots. Replay capability gave us better control over directing plots to various graphics devices.

Our initial intent was to provide some basic SPC tools -- no frills attached. Our users have varied computer backgrounds. Many of the people attending our training program had never before worked at a computer terminal. It became obvious that a menu driven front end to our SAS SPC tools was required. An interface to direct plots and printouts to graphics and printing devices was necessary as well.

To give you an idea of our menu structure, let's look at a couple of package menus. When users first enter the package, they receive the main menu:

--- Kodak Quality Package ---

1. Histogram
2. Control Charts
3. Statistical Inference
4. Utilities

--- Kodak Quality Package Main Menu ---

From here, they select an application; for example, control charts. They then receive a menu that allows them to select which type of control chart they want; for example, a chart of individuals:

--- KQP Control Charts ---

1. Xbar and Range/Sigma Chart
2. Individuals and Moving Range Chart
3. CUSUM Chart

--- KQP Control Chart Menu ---

Once their selection is made, they receive the menu specific to the chart type requested. In Figure 3, the details required to perform the individuals/moving range charts are requested:

--- KQP Chart of Individuals ---

SAS dataset name: DEMO
Response variable: [Upper Limit]
Sigma limits: [2]
Calculations limits: [Upper Limit]

--- KQP Utilities ---

1. Create a new SAS dataset
2. Edit a SAS dataset
3. Interactive SAS
4. Browse a SAS dataset
5. Browse Variable list of a SAS dataset
6. Browse current listing file
7. Print current listing file
8. Replay plots in KQP PLOTS
9. (filename filetype filemode)

--- KQP Utilities Menu ---

Our first release of the package included histograms, X bar and Range/Sigma control charts, and statistical inference. We decided to place these tools in the hands of the users -- we wanted feedback on their likes and dislikes of the package and what other tools were needed. KQP was a "prototype" system. Before releasing the package to the general public, we selected 15-20 people who expressed an interest in testing the package. These were people from all sections of Kodak Park. They had varying levels of computer experience, but none were computer novices.

They tested our product for approximately six weeks. Any bugs detected were fixed. We received feedback on likes and dislikes of the package. For example, concern was expressed over:

- The automatic plotting of the normal distribution on the histogram, and
- The selected pattern style for the control limits on control charts with unequal subgroup sizes.

One need became apparent -- a data entry/modification feature. Some of our testers were SAS users, some were not. Those unfamiliar with SAS needed help getting their data into a format KQP understood. Another need also was identified -- a feature allowing users to store and replay plots and associated statistical output at the screen and then replay to hardcopy devices. An ideal way for users to run KQP is to display the plots and associated statistical output at the screen and then replay to hardcopy devices.

Our first attempt at data entry was unrefined, but answered the immediate need. From the UTILITIES section, users select data entry and specify a dataset name:
They then receive a screen where they define their dataset variables:

They then receive a screen where they define their dataset variables:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>(Char var)</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISC</td>
<td>N</td>
<td></td>
<td>VISCOSITY</td>
</tr>
<tr>
<td>DENSITY</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BATCH</td>
<td>C</td>
<td>6</td>
<td>MANUFACTURING BATCH NUMBER</td>
</tr>
</tbody>
</table>

Once their variables are defined, they enter data, one observation at a time:

SAS's full-screen editor (SAS/FSP) provides this data entry capability.

**IMPLEMENTATION**

After testing was completed and the data entry features added, KQP was released to the general public. It remained a prototype system. We wanted our users to tell us what more was needed. At Kodak, areas working with chemicals cannot always test in logical subgroups. The need for charts of individuals was critical — hence our control chart option started to expand. Specifications for P/NP charts, C charts, U charts, and Pareto analysis were also written. One area expressed an interest in multivariate control charting — specifications were drawn up. We went from a three-application package in Spring 1985 to eight applications by the Fall. Modifications to the current modules were also made:

- Control over cell size in the histogram module was added.
- The overlay of the normal distribution on histograms became optional.
- The limit calculations in the X bar and Range/ Sigma charts were changed from table look-up to algorithms. This provided us with more flexibility.

The need for plot and listing output consistency among modules became apparent. Specifications for line patterns, colors, and symbol types were written.

We had no written documentation for KQP — instead we included an on-line tutorial. The tutorial is available from either the main menu:

**Kodak Quality Package**

**OPTION => T**

1. Histogram
2. Control Charts
3. Statistical Inference
4. Utilities
5. CMS Commands or Execs
6. Tutorial
7. Exit

Figure 7. Sample quality package main menu.

**Figure 8. Sample quality package statistical inference menu.**

and they are placed into the tutorial for statistical inference:

**TUTORIAL</code>**

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User ID: 123456</td>
</tr>
<tr>
<td>2</td>
<td>Time: 02:01</td>
</tr>
<tr>
<td>3</td>
<td>TERMINAL: 3078</td>
</tr>
<tr>
<td>4</td>
<td>PP KEYS: 24</td>
</tr>
<tr>
<td>5</td>
<td>CONTROL CHARTS</td>
</tr>
<tr>
<td>6</td>
<td>STATISTICAL INFERENCE</td>
</tr>
<tr>
<td>7</td>
<td>UTILITY</td>
</tr>
<tr>
<td>8</td>
<td>CMS COMMANDS</td>
</tr>
<tr>
<td>9</td>
<td>EXEC</td>
</tr>
<tr>
<td>10</td>
<td>TUTORIAL</td>
</tr>
</tbody>
</table>

**Figure 9. Sample quality package statistical inference tutorial.**
Our tutorial was not enough. First-time users requested demonstrations of the package. Many of our users had used our computer facilities previously only for electronic mail -- or not at all. At our on-line demonstrations, we walked through each of the applications function in KQP, and how to enter data. The demonstrations and tutorials provided users with enough information to get started. Computer and SPC consulting for the package is also available. A user manual is provided with the Fall release of our product. This manual contains a walk-through of the package. Making the entries shown and using datasets we provide on our system disk, users can get a feel for how KQP functions.

Let's go through an application in KQP from start to finish as a real user would.

To enter the package, enter "KQP". You receive the KQP main menu. You have an existing database that you want to add this week's data to, so you enter the UTILITIES section. You enter the appropriate option and dataset name (refer to Figures 4 and 6). From there you are placed into SAS's full-screen editor and you start adding observations to the dataset. After adding this week's data, you would like a histogram. From the main menu, you enter the HISTOGRAM section:

```
Figure 10. Sample quality package main menu.
```

You receive the HISTOGRAM application menu and make the following specifications:

- The variable you want a histogram of,
- The subgroup variable,
- Historical specification limits, and
- Titles.

```
KQP100 -- Kodak Quality Package
COMMAND -->

SAS dataset name --> DEMO , KQPDATA (library) [dataset]

Response variable --> DENSITY
Subgroup variable --> BATCH
Start subgroup number -->
End subgroup number -->
Upper Spec --> 140
Lower Spec --> 110
Cell Maximum -->
Cell Minimum -->
Cell Size -->
Normal Curve Overlay --> NO

Title --> KQP WALKTHROUGH
Subtitle --> [SIMULATED DATA]
Graphics output: DISPLAY - IBM3279
Listing output: DISPLAY
Do you want to change these selections --> NO

Figure 11. Sample quality package histogram menu.
```

You will note at the bottom of the screen that the listing and graphics options are set for DISPLAY. You submit this request and view the histogram:

```
Figure 12. Sample quality package histogram.
```

and associated statistical listing output.

```
KQP WALKTHROUGH
(ANALYZED DATA)

STATISTICS OF PLOT - DENSITY

N = 120
MIN = 108
MAX = 137
MEAN = 127.6
STDEV = 0.719584
%CV = 5.257898
MEAN + 3 STDEV = 147.9588
MEAN - 3 STDEV = 107.6412
LSL = 110
USL = 140
% BELOW LSL = 0.4036879
% ABOVE USL = 3.471696
TOTAL % OUTSIDE SPEC = 3.875384
P.C.I. = 0.6051953

Figure 13. Sample histogram listing output.
```

You now want an X bar/Range control chart of the data. Again from the main menu, you indicate the CONTROL CHARTS section:

```
Figure 14. Sample quality package main menu.
```

You next select the X bar and Range/Sigma chart from the CONTROL CHARTS selection menu:
You receive the X-bar and Range/Sigma chart application menu, and make the following specifications:

- the variable you want a control chart of,
- the subgroup variable,
- historical control limits, and
- titles.

You submit this request and view the control chart:

![Sample quality package Xbar/range chart](image1)

and associated statistical listing output.

How that you have done these analyses, you would like a hard copy of the control chart. You reenter the UTILITIES section of KQP again from the main menu and select the REPLAY PLOTS option:

![Sample quality package utilities menu](image2)

A screen appears requesting where you would like the plots sent:

![Sample quality package output options menu](image3)

After selecting a device, you select which plots you want a hard copy of:
Graphics Replay Procedure

Command ===>

Note: For help, press PF 1 or PF 10

- PROC G PLOT OUTPUT 15AUG85 00:12
- PLOT OF YYX
- PROC G PLOT OUTPUT 15AUG85 00:17
  X PLOT OF S*SUBGROUP

Figure 21. Sample quality package graphics replay menu.

The plots are directed to the selected graphics location. You also want a hard copy of the statistical listing output. From the UTILITIES menu you enter the appropriate option and again select the output destination. The statistical listing output is directed to the selected location. You have concluded the analysis you want to perform, so you exit KQP:

------------------------------------------ Kodak Quality Package ------------------------------------------

OPTION ===> X

1 Histogram USERID  -  120456
2 Control Charts TIME  -  09:20
3 Statistical Inference TERMINAL - 3278
4 Utilities PF KEYS - 24

C CMS Commands or Execs
T Tutorial
X Exit

Figure 22. Sample quality package main menu.

The package prompts you for a filename for storing your plots and returns you to the host operating system:

Enter a new name for the KQP plot file:
ASQC

Plots from this session have been saved in ASQC PLOTS A R;

Figure 23. Exitting the KQP package.

FUTURE DEVELOPMENTS

Based on input from our users, many specifications are being developed for future inclusion into KQP. A sampling of these specifications are: median control charts, CUMSUM control charts, normal probability tests, power curves for sampling plans, a sampling module, and bivariate control ellipses. The user community submits requests in writing, and we act on them based on input from the Quality Technology Unit at Kodak Park.

FOOTNOTES

(1) SAS is a registered trademark of SAS Institute, Inc., Cary, NC 27511-8000, USA. No endorsement is implied by Eastman Kodak Company.

(2) SAS/GRAPH is a registered trademark of SAS Institute, Inc., Cary, NC 27511-8000, USA. No endorsement is implied by Eastman Kodak Company.

(3) SAS/PS is a registered trademark of SAS Institute, Inc., Cary, NC 27511-8000, USA. No endorsement is implied by Eastman Kodak Company.