A REVIEW ABOUT THE „QUALITY TOOL" INDUSTRIAL STATISTICAL SERVICE SOFTWARE

László Lugosi[1], Balázs Merkl[2], Róbert Salk[3], Árpád Jankó[4]
[1]Software Developer Engineering-Physicist
[2]Software Development Engineering Team Leader
[3]Production Support Engineering Assistant
[4]Engineering Service Center Manager
Elcoteq SE, Engineering Service Center (ESC), New Product Introduction (NPI), Experimental Development Center

ABSTRACT

In this paper a recently developed statistical service software by the Elcoteq NPI Test Engineering Group is introduced, which can be applied widely to various measurement system analysies as well as statistical process control that are important methods in the product quality assurance. The typical output numerical and graphical results on tables and control charts, respectively are also presented as illustrative examples for understanding the functioning and using of the program. The authors would like to note that: this application is used in several countries for validation and qualification of many test stations, are belonging to such product lines of the Elcoteq multinational company, on that products are made to acclaimed customers (e.g. Nokia, Ericsson, Philips, Thomson, Research In Motion - RIM).

INTRODUCTION

The data analysis today is an expensive and time-consuming activity. Many companies must purchase robust database oriented or statistical spreadsheet programs and even develop utility applications and other additional routines, macros for those to obtain the necessary ability to analyze measured data. The main reason for this is that most test data analysis softwares are expensive, slow, difficult to use and can not be adapted to an uniform investigations of substantially differing test systems. On the other hand, the measured data are commonly aggregated in tester log files which have several type of formats (txt, csv, xml, html, xls, etc.). The preparing of the input data from these documents is a source of potential error, mainly if it is made by manually. In order to offer a possible way to solve the above problems, the Elcoteq ESC NPI Test Engineering Group decided to develop a new program called as *Quality Tool* for the critical test data estimation tasks.
The *Quality Tool* program is a comprehensive and dedicated industrial statistical service software for Measurement System Analysis (MSA) conforming to the Third Edition of AIAG MSA reference manual [1] (see, also: http://www.aiag.org/). The purpose of this application is to give a statistical tool for the practicing test engineers in industrial mass production environment, who needed to make Gage Repeatability and Reproducibility (GR&R) studies as well as Statistical Process Control (SPC) for complex test systems which are built from many test stations and their testing process contains numerous measurement sequence steps.

In the program the ANOVA GR&R quality control method that uses *ANalysis Of VAriance* and the Process Capability & Performance Analysis (PCA, PPA) [2] are implemented, which important tools within the *Six Sigma* (6σ) methodology [3] (see, also: http://www.motorola.com/) and frequently applied MSA techniques to the quantitative assess of a test measurement system.
The application allows users to perform fast, easy and practical test data analysis with customizable and add-in input file converters, filtering options and extensive mathematical functions, furthermore it stores the measurements in well defined and structured XML files as well as makes convenient and user-friendly text or table and graphical reporting in Excel worksheets.

APPLICATIONS OF THE PROGRAM

The *Quality Tool* program has an ergonomic windows graphical user interface (GUI) (see fig. 1.) permitting of access to all functions by using dedicated buttons on the main toolbar. On the next page the sctructogram of the main program can be

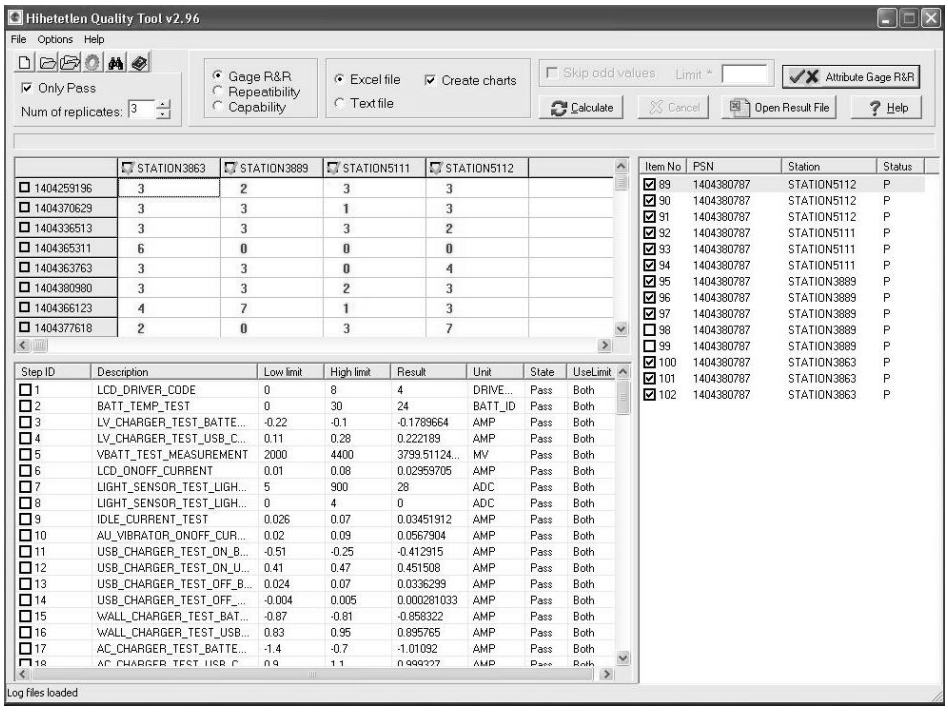
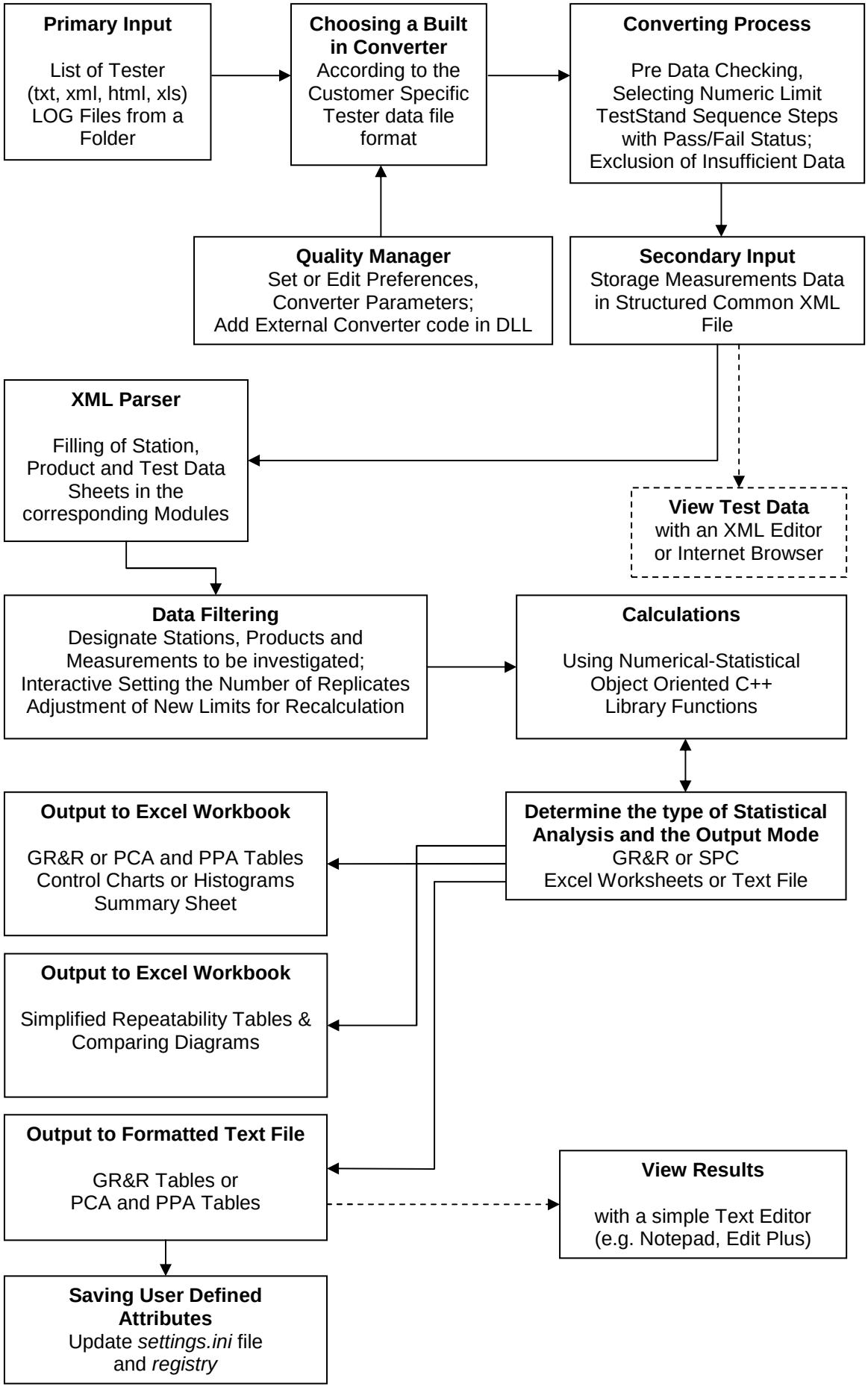


Figure 1. Screenshot from the main window of *Quality Tool* program

seen. The application rapidly and directly parses the tester log files as input data by running special built-in file format converters. External converter can also to be added to the application with the help of a *Quality Manager* dialog box in dynamic link library (DLL) code. All those test step can be selected for what analysis will be carried out. Since, test data files are often „not perfect” the program provides powerful filtering options that help the user easily identify and eliminate unwanted data (*pass/fail*, *parts*, *test steps*, *stations*). The comprehensive *Station*, *Product* and *Test Data* modules even allow one to ignore the most common mismatches among datasets (*part count*, *test count*, *test numbers*, *test limits*).


Primary Input
List of Tester (txt, xml, html, xls) LOG Files from a Folder
Choosing a Built in Converter
According to the Customer Specific Tester data file format
Converting Process
Pre Data Checking, Selecting Numeric Limit TestStand Sequence Steps with Pass/Fail Status; Exclusion of Insufficient Data
Quality Manager
Set or Edit Preferences, Converter Parameters; Add External Converter code in DLL
Secondary Input
Storage Measurements Data in Structured Common XML File
XML Parser
Filling of Station, Product and Test Data Sheets in the corresponding Modules
View Test Data
with an XML Editor or Internet Browser
Data Filtering
Designate Stations, Products and Measurements to be investigated; Interactive Setting the Number of Replicates Adjustment of New Limits for Recalculation
Calculations
Using Numerical-Statistical Object Oriented C++ Library Functions
Output to Excel Workbook
GR&R or PCA and PPA Tables Control Charts or Histograms Summary Sheet
Determine the type of Statistical Analysis and the Output Mode
GR&R or SPC
Excel Worksheets or Text File
Output to Excel Workbook
Simplified Repeatability Tables & Comparing Diagrams
Output to Formatted Text File
GR&R Tables or PCA and PPA Tables
View Results
with a simple Text Editor (e.g. Notepad, Edit Plus)
Saving User Defined Attributes
Update settings.ini file and registry

The program supports up to 128 test stations (operators), 64 products (parts) and 32 replicates (trials) for GR&R study as well as 4096 samples for SPC calculations, respectively. It processes measured data up to 1500 numeric limit test steps per sequence and stores these in XML files. The numerical and graphical results of the analysis for all selected steps are displayed in separated and high quality Excel tables and color charts. The graphs (control charts and histograms) give useful and quick information about the characteristic of measurement process. There is possibility of many level preference settings which are belonging to the application environment variables and the parameters of statistical methods. The user defined attributes are saved to *registry* or *settings.ini* file, so those will be available next time.

Gage Repeatability and Reproducibility Study

Choosing the GR&R industrial standard MSA method [1-3], *Quality Tool* will compute and report the components of variation like (*AV*, *EV*, *PV*, *I*, *R&R* and *TV*), the percentage contributions and tolerances, together with the *F-ratios* and *p-values* on Excel tables (see fig. 2.). This quantities are derived from the ANOVA table.

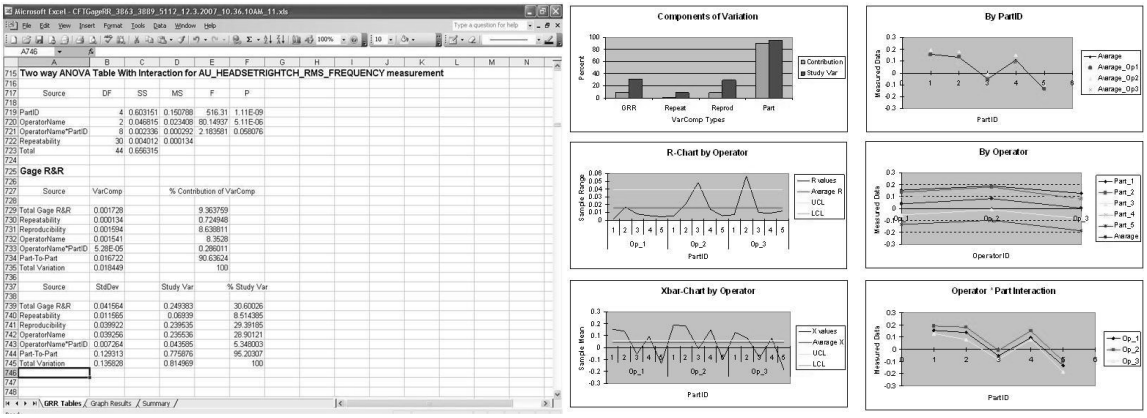


Figure 2. Excel table and graphical GR&R report of *Quality Tool* for a given test step

On the graphical report sheet the regular control charts will be displayed, such as *Contribution chart*, *R-chart*, *Xbar-chart*, *Interaction-plot*, and run charts of *Measurement by operator* and *Measurement by part* (for details see refs. [1-3]). The interpreting equation for the used two way ANOVA model [2] can be written as:

$$y_{ijk} = \mu + \alpha_i + \beta_i + (\alpha\beta)_{ij} + \varepsilon_{ijk} . \qquad (1)$$

In equation (1), indices *i* and *j* denote the *i*-th and the *j*-th level of factor F_1 (part) and F_2 (operator), whereas index *k* corresponds to the *k*-th repetition of the occurrence (*i*, *j*) (k=1,...,n) and n the total number of observations, y_{ijk} is a special matrix of observations, μ is a constant of the overall mean. Moreover, parameters α_i and β_j quantify the mean differential effects of the *i*-th level of factor F_1 and the *j*-th level of factor F_2 with respect to the first levels of F_1 and F_2, respectively. The

interaction effect between level i of F_1 and level j of F_2 is then isolated and measured with elements of the matrix $(\alpha\beta)_{ij}$. The model assumes that $\varepsilon_{ijk} \sim \mathcal{N}(0, \sigma^2)$ is the stochastic measurement error (independent random variables, identically distributed with normal law, zero mean and equal variance).

Statistical Process Control

In the case of SPC investigation [1-3], the program calculates the process means, standard deviations, defects per million opportunities (DPMO) as well as the process capability (*Cpk*) and performance (*Ppk*) indexes that can be defined as [2]:

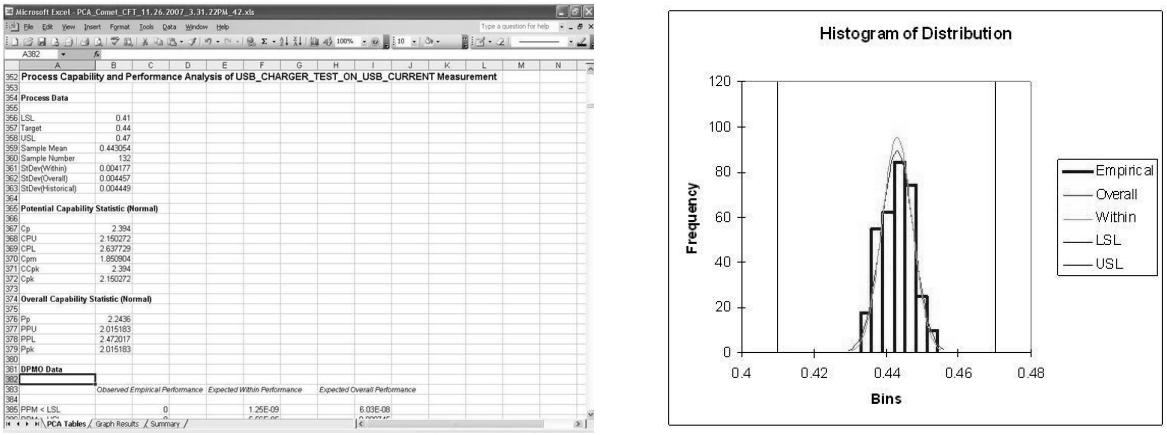


Figure 3. Excel table and graphical SPC report of *Quality Tool* for a given test step

$$Cpk = \min\left[\frac{USL-\mu}{\frac{\nu_{\text{StudyVar}}}{2}\sigma_{\text{Within}}}, \frac{\mu-LSL}{\frac{\nu_{\text{StudyVar}}}{2}\sigma_{\text{Within}}}\right], \quad Ppk = \min\left[\frac{USL-\mu}{\frac{\nu_{\text{StudyVar}}}{2}\sigma_{\text{Overall}}}, \frac{\mu-LSL}{\frac{\nu_{\text{StudyVar}}}{2}\sigma_{\text{Overall}}}\right]. \quad (2)$$

In equation (2) *USL* and *LSL* are the upper and lower specification limits, σ_{Overall} and σ_{Within} are the long and short term standard deviations, and the default value of ν_{StudyVar} study variation is 6 according to the expected $\pm 3\sigma$ coverage level, because this width of the interval is needed to capture the 99.73% spread of a given process measurement. The above data are displayed on Excel tables, in addition on the graphical report sheet (see fig. 3.) the histogram of the empirical relative frequency density just as the overall and within Gaussian distribution curves are shown.

VALIDATING THE SOFTWARE

Quality Tool has been tested, validated and deemed suitable for release. Numerous results of test calculations were compared with well known values and published data in the literature. As a further test, check comparisons for our computed data have also been made with the results were obtained by using the MatLab® version 7.1 Release 14 Mathematical- and MiniTab® Release 14.1 Statistical Software Systems.

TECHNICAL DETAILS

The Object Oriented source code components of program had been developed in Borland C++Builder 5.0 (Enterprise Suite, Build 12.34, Update Pack 1) and Borland Delphi 5.0 (Enterprise, Build 6.18, Update Pack 1) programming systems under Microsoft Windows XP Professional (Version 5.1.2600, Service Pack 2). The functioning of program partionally built on ActiveX technology and the using of Object Linking and Embedding (OLE) Component Object Model, respectively.

SUMMARY

We have made and reviewed an industrial statistical service software which conforms to the 3rd edition of AIAG MSA Reference Manual [1] and it can be used for general test measurement system qualification and design of experiments (DOE) methods [3]. This program was developed from the engineering point of view instead of a theoretical software package. Due to the applied state-of-art numerical algorithms, the modern application development technologies and the tracking of the sophisticated Six Sigma methodology [3], this work should be an example of a successful innovation via applied informatics.

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NOTES

Permanent address: Elcoteq Hungary Ltd., Engineering Service Center, H-7632 Pécs, Szilva str. 1-3., Hungary.
Telephone: +36-72-509-100 Telefax: +36-72-509-855
Website address: http://www.elcoteq.com/ E-mail: laszlo.lugosi@elcoteq.com

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