MOTOROLA INC.

Government Electronics Group
Inter-Office Correspondence

Date: October 29, 1985 From: Mike Harry

To: Dick White Phone: 8598

Subject: Statistical Applications

As per your request, the applications of statistics within our organization, as well as other components, is as follows:

1. Retest Program:

   Purpose: Decrease sampling costs and statistically monitor the overall behavior of the final performance test related to Tactical and Secure product.

   Tools: Statistical process control charts (P-chart), Pre-control methodology, tests of significance.

   Design: Probability modeling based on aggregate data.

   Status: Completed

   Results: Identified retest problems which otherwise might have remained undetected.

2. Core Problem:

   Purpose: Determine if significant differences were present between the product supplied by five different vendors.

   Tools: One-way analysis of variance, extension T-tests(Post Hoc comparisons), Cochran's C and Bartlett-Box F tests for homogeneity of variance, and descriptive statistics.

   Design: Single factor configuration and balanced two-group comparisons.

   Status: Completed

   Results: Isolated which vendors did not conform to requirements.

3. Solder Bridging Problem in CMA:

   Purpose: Determine the functional cause-and- effect relationships between component lead length, solder flux density, and wave solder machine chain speed in relation to solder deposition characteristics at the Q2 pin location on PWB No. P22220E001.

   Tools: Three-way analysis of variance, one-way ANOVA, T-tests, and descriptive statistics.

   Design: Three variable, two level full factorial configuration, balanced two-group comparisons, and design collapse techniques.

3. Continued:

   Status: Completed

   Results: Determined relationships among experimental variables, established corrective action, and advanced recommendations for further experimentation.

4. Projectile velocity study for Environmental Test Facility

   Purpose: Derive mathematical equations (second order polynomial) for predicting projectile simulator velocity from known values of the simulator weight and the reverse ballistic air gun tube pressure.

   Tools: Forward/backward entry and stepwise regression procedures.

   Design: Central composit-box rotatable configuration.

   Status: Completed.

   Results: Derived prediction equations and response surfaces. Determined measurement variability was not induced by differences in people.

5. Test Equipment Characterization for KGV-10:

   Purpose: Statistically characteristize hysteresis behavior in relation to loading position during performance testing.

   Tools: Kruskal-Wallis one-way analysis of variance by ranks (nonparametric test), chi-square, and descriptive statistics.

   Design: Balanced two-group configuration

   Status: In progress

   Results: NA

6. Solder cracking problem on Elwell:

   Purpose: Isolate critical process/ product parameters which creates a high propensity for solder joint cracks during thermal and vibration testing.

   Tools: Analysis of variance (Yates' method)

   Design: Replicated 2^{5-1} fractional factorial configuration.

   Status: Completed.

   Results: Isolated a single variable (lead configuration) which accounted for a disproportionate amount of solder cracking. Also isolated a variable interaction which had a significant effect.

7. Component tinning study for CMA:

   Purpose: Determine if the effects of component tinning, orientation, type, and PWB contamination were statistically significant in relation to wetting and solder deposition.

   Tools: Analysis of variance and descriptive statistics.

   Design: Truncated balanced two-group configuration.

   Status: Completed

   Results: Determined that wetting and solder deposition is highly influenced by component type and orientation. Tinning had little effect.

8. Gas Flow Problem at TED:

   Purpose: Statistically determine the influence of seven different variables (each at three levels) on nitrogen gas flow rates related to an infrared soldering operation.

   Tools: Graphical regression

   Design: Random strategy test plan.

   Status: Completed.

   Results: Determined that the major effects were not due to the variables included in the experiment.

9. Wire Bond Problem on System 7:

   Purpose: Statistically determine the effect of four process variables on the structual integrity of gold wire bonds.

   Tools: Analysis of Variance.

   Design: 2^4 Full factorial configuration.

   Status: In Progress.

   Results: NA

10. Ionic contamination problem at Radar:

    Purpose: Determine which of 16 process variables exerts the greatest control in determing the quantity of residual sodium chloride contaminates on printed wiring boards following a wave solder operation.

    Tools: Analysis-of-variance (Yates' method)

    Design: 2^{4-1} fractional factorial group screen configuration (stage wise experimental progression)

    Status: Completed

    Results: Isolated the vital few variables which accounted for a disportionate amount of the variation.

Note: The listed applications are the major efforts. Numerous other applications have occurred; however, due to their basic nature, they are not listed, e.g. calculation of basic descriptive statistics, process capability/control, experiment design, etc.

Mikel J. Harry, Ph.D.
Senior Quantitative Analyst