PROJECT TITLE:
Travan TR7 Dynamic Electrical Test Failure Reduction

TEAM : Elite Sigma

MEMBERS:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joel Amil</td>
<td>Process Eng’g. Manager</td>
<td>Team Leader</td>
</tr>
<tr>
<td>Johnny Ledesma</td>
<td>Process Engineer</td>
<td>Mechanical Issues (FA/CA)</td>
</tr>
<tr>
<td>Ernesto Manuel</td>
<td>Process Engineer</td>
<td>Electrical Test Issues (FA/CA)</td>
</tr>
<tr>
<td>Eric Maligaya</td>
<td>Customer Interface</td>
<td>Mechanical Issues (FA/CA)</td>
</tr>
<tr>
<td>Lito Suba</td>
<td>Test-Section Manager</td>
<td>Electrical Test (Equipment and Setup)</td>
</tr>
<tr>
<td>Marvin Marte</td>
<td>QA Manager</td>
<td>Customer Interface</td>
</tr>
</tbody>
</table>

MEETING TIME / VENUE:

<table>
<thead>
<tr>
<th>Place</th>
<th>Joel Amil’s room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule</td>
<td>Monday’s through Fridays</td>
</tr>
<tr>
<td>Time</td>
<td>1245H to 1400H</td>
</tr>
<tr>
<td>Attendance</td>
<td>88.7%</td>
</tr>
<tr>
<td>Start Date</td>
<td>Dec. 2002</td>
</tr>
<tr>
<td>End Date</td>
<td>Feb. 2003</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION:

Read-Rite Philippines is the manufacturing site for Tape Head Business Unit, and the core competency is assembly and test. Read-Rite (Tape Head Business Unit) manufactures magneto-resistive (MR) tape heads to the entry level through mid-range tape drive markets, with products such as Travan, DLT (Digital Linear Tape), SLR (Scalable Linear Recording) and SDLT (Super DLT).

In order to become competitive in the market, QUALITY, COST and DELIVERY performance must be world-class. This case study describes the low first pass yield problem at Final Test station (Travan TR7), which is one of the major sources of high-cost-manufacturing, and how it was solved.

1.1 Yield

TR7 tape heads are used for Travan 40 tape drives which offer up to 20 Gbytes native storage capacity (40 Gbytes compressed). Seagate Line, Travan TR7 product First Pass Yield at Dynamic Electrical Test (DET) shows a stable but low trend at an average of 61% as shown in the graph below.
1.2 Pareto of Defect

Pareto chart shows the dominant failures are Low Output (f_out and r_out), Fwd_rev ratio (f_r ratio) and Forward Resolution (fwd_res). These three defects comprise the vital few equivalent to 85% of the problem.
1.3 Defect Rate

- Chart below shows the hierarchy per defect (Average defect rate from May to Dec).

1. low output = 22% failure rate
2. f_r ratio = 9% failure rate
3. fwd_res = 5% failure rate
4. Others = 3% failure rate
1.4 Definition:

Output Voltage is defined as the quotient between the High Frequency measurement output by the gain of the test pre-amp and filter circuit.

Forward/Reverse ratio mismatch is calculated from the signal output in the forward and reverse direction.

\[
\text{Fwd/Rev Ratio (\%)} = \frac{(\text{MAX Output} - \text{MIN Output}) \times 100}{\text{MAX Output}}
\]

Resolution shall be measured as the ratio of the Fd signal amplitude, divided by the write-equalized Fd/8 signal amplitude.

Physical manifestations and engineering attributes:

Output is a measure of the output voltage at the head's highest Recording Density. Output depends on the ability of the head to read a very small (weak) signal that was written to and stored on the magnetic tape. The closer the tape is to the head or the better the contact between the tape and the head, the stronger (large) the signal is and the higher the output.

Resolution and output are quite related. The process induced parameters that will affect them are: PTR (Pole Tip Recession), stripe height, spacing (contour affecting tape/head interface). PTR will affect both the output and resolution (resolution is ratio of HF output to LF output) while, contour in particular how the gap is centered will affect relative response in FWD or REV direction.
2.0 OBJECTIVE:

2.1 To improve First Pass Test Yield from ~61% to 90% (29% improvement) by January 2003.

<table>
<thead>
<tr>
<th>DET Parameters</th>
<th>From</th>
<th>To</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>low output</td>
<td>22%</td>
<td>7%</td>
<td>15%</td>
</tr>
<tr>
<td>f_r ratio</td>
<td>9%</td>
<td>1%</td>
<td>8%</td>
</tr>
<tr>
<td>fwd_res</td>
<td>5%</td>
<td>1.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>others</td>
<td>3%</td>
<td>0.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>39%</strong></td>
<td><strong>10%</strong></td>
<td><strong>29%</strong></td>
</tr>
</tbody>
</table>
3.0 EXPERIMENTAL SECTION:

3.1 SIPOC (Supplier-In-Process-Out-Customer)

<table>
<thead>
<tr>
<th>Tester</th>
<th>G\textsubscript{RnR}</th>
<th>Control</th>
<th>Tester</th>
<th>G\textsubscript{RnR}</th>
<th>Control</th>
<th>Tester</th>
<th>G\textsubscript{RnR}</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>WYKO MHT III</td>
<td>9.09% 6.67% 14.53%</td>
<td>X-bar and R</td>
<td>Heighmatic</td>
<td>19.93%</td>
<td>100% test</td>
<td>HTU 528</td>
<td>18.95% 16.15% 19.70%</td>
<td>100% test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HTU 566</td>
<td>10.56% 13.28% 16.27%</td>
<td>100% test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HTU 583</td>
<td>10.50% 12.31% 19.67%</td>
<td>100% test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HTU 573</td>
<td>10.83% 10.96% 18.93%</td>
<td>100% test</td>
</tr>
</tbody>
</table>

Tape Polish $\Rightarrow$ Carriage Bond $\Rightarrow$ Electrical Test
3.2 Root Cause Analysis

*Design of Experiment (Paired Comparison/Tukey Test) Methodology* was used to analyze the problem. Wherein 7 good heads and 7 bad heads were simultaneously collected at Final Test station. The samples were arranged in ascending order with respect to the mechanical independent variables. As indicated in the table below, PTR shows as the RED-X (Red X refers to the root cause of the problem) at 98% confidence level.

Radius and Apex Offset are showing slight significance at about 70% confidence, factorial design is necessary.
3.3 Full Factorial Design

3.3.1 To test if radius and apex offset are important factors on DET parameter responses, while blocking the PTR as one of the factors.

3.3.3 Design (2 levels, 2 factors, 4 responses, 1 middle)

3.3.4 Result:
3.3.5 Analysis of results:

3.3.5.1 Jump software was used to analyze data.
3.3.5.2 Both radius and apex offset are active factors on all selected responses.
3.3.5.3 Radius being the active factors for both f_out and r_out while Apex offset for both f_ratio and fwd resolution.
3.3.5.4 Most desirable grid setting based on prediction profiler showed that:
   Radius : High
   Apex : High

3.3.6 Validate Result:
- Confirm through B Vs. C (B = Better, C = Current).
  
<table>
<thead>
<tr>
<th>Radius</th>
<th>Apex Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set B</td>
<td>Hi</td>
</tr>
<tr>
<td>Set C</td>
<td>Mid</td>
</tr>
</tbody>
</table>

- Sample size = 12 at 95% confidence level

<table>
<thead>
<tr>
<th>Set</th>
<th>Ave</th>
<th>r_out</th>
<th>fr</th>
<th>fwdRes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>2.19</td>
<td>2.38</td>
<td>7.76</td>
<td>77.53</td>
</tr>
<tr>
<td>C</td>
<td>2.07</td>
<td>2.19</td>
<td>5.96</td>
<td>68.60</td>
</tr>
</tbody>
</table>

Insignificant
4.0 RESULTS AND DISCUSSION:

Paired comparison (Good vs. Bad) Tukey analysis revealed that PTR is the Red X. Blocking the PTR as a factor, Full Factorial Design showed that Radius and Apex Offset are significant factors (Radius = High; Apex Offset = High). However, validation run using B vs. C and two tailed hypothesis test shows that B process can give the same result as of C or current process.

Step by step investigation is shown in the Solution Tree below.
5.0 IMPROVEMENT ACTION:

5.1 Change PTR spec from -2.5 μ" minimum to -1.5 μ" minimum spec.
   Who: Ernie M.
   When: ww16
   Status: Implemented

6.0 CONTROL PLAN:

6.1 Perform 100% PTR check at the source (Tape Polish).
   Who: Wyko operator
   When: ww16
   Status: Implemented

6.2 Incoming diamond tape dressing.
   Who: Tape Polish Operator
   When: ww17
   Status: Implemented

6.3 SPC - X bar and R chart.
Diamond Tape Preparation Dressing Flow

Begin

Lap 1 dummy head

Measure PTR

PTR =/= -1.0u”

No

Yes

Forward to next segment

Lap 1 dummy head

Dress the tape using any TR7 headflex assy (done flat lap) dummy head for 20 minutes.

End of segment

Yes

No

Begin

End
7.0 VERIFICATION

7.1 DET First Pass Yield:

Electrical Test First Pass Yield Trend

Process Control Implementation

No Build

FPY

<table>
<thead>
<tr>
<th>Month</th>
<th>May 02</th>
<th>Jun 02</th>
<th>Jul 02</th>
<th>Aug 02</th>
<th>Sep 02</th>
<th>Oct 02</th>
<th>Nov 02</th>
<th>Dec 02</th>
<th>WW 16 '03</th>
<th>WW 17 '03</th>
<th>WW 18 '03</th>
<th>WW 19 '03</th>
<th>WW 20 '03</th>
<th>WW 21 '03</th>
<th>WW 22 '03</th>
<th>WW 23 '03</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>65.42%</td>
<td>62.99%</td>
<td>62.27%</td>
<td>63.67%</td>
<td>56.31%</td>
<td>57.49%</td>
<td>81.51%</td>
<td>67.64%</td>
<td>90.04%</td>
<td>90.81%</td>
<td>90.05%</td>
<td>90.39%</td>
<td>91.05%</td>
<td>91.74%</td>
<td>91.17%</td>
<td>90.81%</td>
</tr>
</tbody>
</table>

FPY: First Pass Yield
7.2 Comparison of Means Before and After Implementation:

<table>
<thead>
<tr>
<th></th>
<th>BEFORE</th>
<th>AFTER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave</td>
<td>Ave</td>
</tr>
<tr>
<td>t0</td>
<td>1.74</td>
<td>2.10</td>
</tr>
<tr>
<td>Stdev</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>6.12</td>
<td>5.50</td>
</tr>
</tbody>
</table>

Critical Region: 1.98
\( \beta \) = 0.05

Significant Change
7.3 Customer Yield:

Seagate Drive Yield

Before After

Calibration FCT 2

<table>
<thead>
<tr>
<th>WW 18</th>
<th>WW 19</th>
<th>WW 20</th>
<th>WW 21</th>
<th>WW 22</th>
<th>WW 23</th>
<th>WW 24</th>
<th>WW 25</th>
<th>WW 26</th>
<th>WW 31</th>
<th>WW 32</th>
<th>WW 33</th>
<th>WW 34</th>
<th>WW 35</th>
<th>WW 36</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.86%</td>
<td>96.31%</td>
<td>92.18%</td>
<td>94.55%</td>
<td>93.82%</td>
<td>94.47%</td>
<td>94.69%</td>
<td>94.89%</td>
<td>94.64%</td>
<td>97.19%</td>
<td>91.15%</td>
<td>94.23%</td>
<td>96.32%</td>
<td>91.78%</td>
<td>100.00%</td>
</tr>
<tr>
<td>75.80%</td>
<td>83.78%</td>
<td>85.59%</td>
<td>92.61%</td>
<td>88.12%</td>
<td>92.20%</td>
<td>91.54%</td>
<td>87.87%</td>
<td>85.97%</td>
<td>90.64%</td>
<td>89.39%</td>
<td>89.31%</td>
<td>85.61%</td>
<td>82.47%</td>
<td>85.42%</td>
</tr>
</tbody>
</table>

Calibration 86.59% 94.50%
FCT 2 79.79% 81.17%
8.0 CONCLUSION:

8.1 Controlling the PTR (Pole Tip Recession) from the source (Tape Polish) has been proven to provide beneficial impact to:

- Improved First Pass Yield (FPY) by 29%.
- Average output voltage increased from 1.7mV TO 2.1mV.

9.0 RECOMMENDATION:

9.1 Fan out improvement action and control plans to Travan 5 Program.

10.0 BUSINESS AND FINANCIAL IMPACT:

Cost Savings of $ 0.41 Per Unit.
Quarterly Savings of $20.5K.
$0.41/Unit x 50K order = $20.5K

11.0 DELIVERABLES:

11.1 Increased DET First Pass Yield by 33X.
11.2 Predictable test result will enable the factory to consistently provide Seagate an average output of above 2.0 mV.
11.3 Increased in capacity in DET provides flexibility to convert from one program to another.