Quality Management Division
The Global Voice of Quality™

# Paynter Charts: A Form of Predictive Warranty Analysis


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## ASQ General Presentation

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# Learning Objectives

In the next 60 minutes we will…

- Learn about what a Paynter Chart is and…
- Understand how it is tied to Time of Manufacture (**TOM**)
- Construct an example and apply the tool
- Review the Power of the Paynter via risk mitigation
- and…Apply it to Predictive Warranty analysis

Assumptions…

- We know what a Pareto Chart is
- We know what the concept of $Chi^2$ is

**WHAT YOU SHOULD WALK AWAY WITH…**

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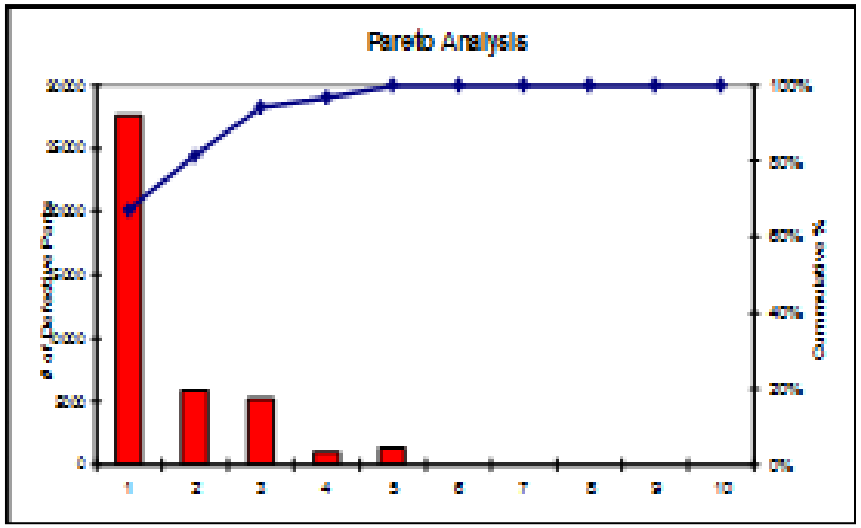
# Assumptions…Pareto & Chi² ($\chi^2$)

Pareto is a bar graph that sorts information in a high to low order. Often called the 80:20 Rule or "worst first"




Chi² ($\chi^2$) is a quick analysis to determine if there is a difference or not between two populations. (*$\chi^2$ tool below is issued to ASQ Statistics Division Members*)

| Catagories | Time 1 | Time 2 | | | | Total |
|---|---|---|---|---|---|---|
| Good | 125 | 142 | | | | 267 |
| Scrap | 4 | 7 | | | | 11 |
| | | | | | | |
| | | | | | | |
| Total | 129 | 149 | | | | 278 |

| Summary Results | | Time 1 | Time 2 |
|---|---|---|---|
| Good | Observed | 125 | 142 |
| | Expected | 123.8957 | 143.1043 |
| Scrap | Observed | 4 | 7 |
| | Expected | 5.104317 | 5.895683 |

| Calculated Values | |
|---|---|
| Number of Rows | 2 |
| Number of Columns | 2 |
| Degrees of Freedom | 1 |
| Chi Square | 0.464132 |
| P Value | 0.4957 |
| Confidence | 0.5043 |

**It is unlikely there is a difference between categories**

## QUICK CONCEPTS

# Define: What's a Paynter?

Developed in the early 1980's by Marvin (Marv) Paynter at Ford Motor Company, a Paynter chart is a graphical tool often used to analyze product failure

- ***Most critically***, Paynter charts rely on **TOM**; the **T**ime **O**f **M**anufacture…ie. By month or week
- Resulting graphics are often a **Matrix of Failures** or **Stack-Bar Charts**; both run over time. Data is usually expressed in percentage or Parts Per Million (PPM)
- Paynters are generally used in tandem with Pareto charts
- Paynters help to verify the effectiveness of Corrective Actions (C/A) over time AND can mitigate business risk

**VERIFIES EFFECTIVE C/A OVER TIME**

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# Define: Matrix-Type Paynter

Paynter variations have multiplied across the past 30 years. However, there are two main types:

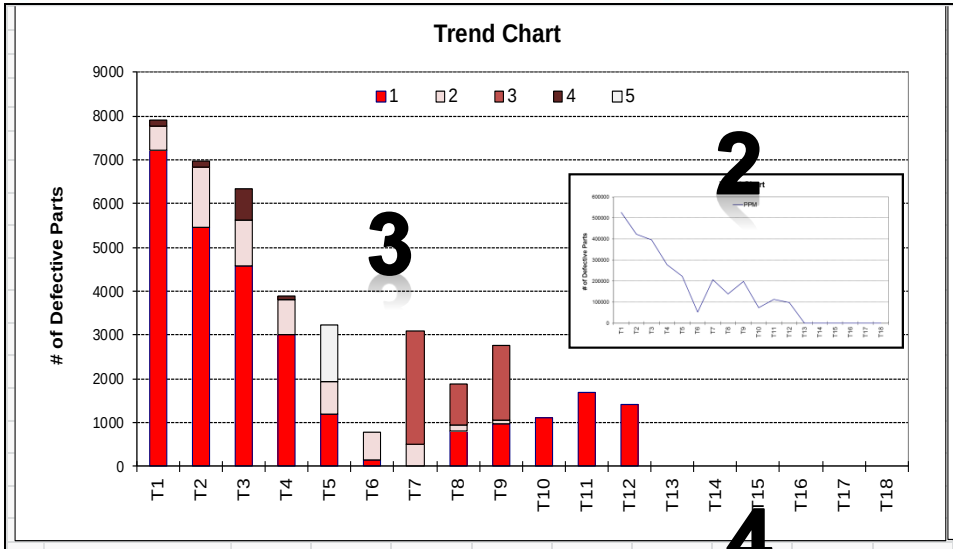
**Matrix Charts** "bucket" the failure data by **TOM** and by type. These charts usually use a Pareto and trend chart. They are often color coded for C/A, spikes and downward trends

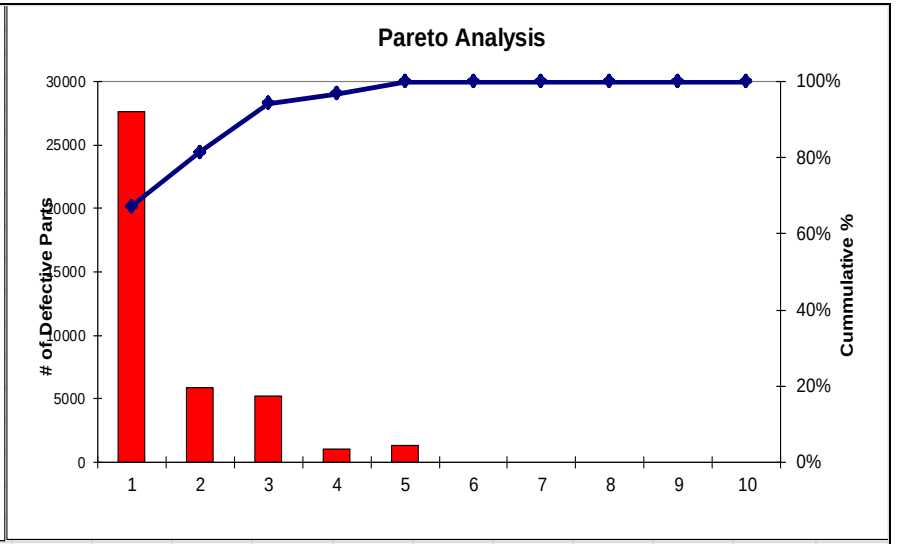
| Concern | Total | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scorch | 27,635 | 48% | 33% | 29% | 22% | 8% | 1% | 0% | 6% | 7% | 7% | 11% | 10% |
| Contamination | 5,867 | 4% | 8% | 6% | 6% | 5% | 4% | 3% | 1% | 0% | 0% | 0% | 0% |
| Raw Material | 5,238 | 0% | 0% | 0% | 0% | 0% | 0% | 17% | 7% | 12% | 0% | 0% | 0% |
| Sticking | 1,068 | 1% | 1% | 5% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Equipment | 1,305 | 0% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | | | | | | | | | | | | | |
| TOTAL MFG'd | | 15,000 | 16,500 | 16,000 | 14,000 | 14,500 | 14,750 | 15,000 | 13,600 | 14,000 | 15,000 | 15,000 | 14,500 |
| TOTAL DEFECTS to date | | 7,899 | 6,979 | 6,339 | 3,893 | 3,241 | 780 | 3,098 | 1,890 | 2,772 | 1,106 | 1,691 | 1,425 |
| TOTAL %DEFECT | | 53% | 42% | 40% | 28% | 22% | 5% | 21% | 14% | 20% | 7% | 11% | 10% |

C/A is implemented

**COLOR CODE TO SEE EFFECT OF C/A**

# Define: Matrix-Type Paynter




**Symptom Matrix**

| # | Symptom | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | T11 | T12 | T13 | T14 | T15 | T16 | T17 | T18 | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Scorch | 7215 | 5464 | 4587 | 3017 | 1184 | 140 | | 818 | 988 | 1106 | 1691 | 1425 | | | | | | | 27635 | 67% |
| 2 | Contamination | 564 | 1367 | 1030 | 798 | 752 | 640 | 516 | 140 | 60 | | | | | | | | | | 5867 | 14% |
| 3 | Raw Matl | | | | | | | 2582 | 932 | 1724 | | | | | | | | | | 5238 | 13% |
| 4 | Sticking | 120 | 148 | 722 | 78 | | | | | | | | | | | | | | | 1068 | 3% |
| 5 | Equipment | | | | | 1305 | | | | | | | | | | | | | | 1305 | 3% |
| 6 | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| 7 | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| 8 | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| | Defective Units | 7899 | 6979 | 6339 | 3893 | 3241 | 780 | | | | | | | | | | | | | | |
| | Production | 15000 | 16500 | 16000 | 14000 | 14500 | 14750 | 15 | | | | | | | | | | | | | |
| | PPM | 526600 | 422970 | 396188 | 278071 | 223517 | 52881 | 206 | | | | | | | | | | | | | |

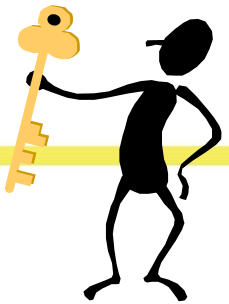
**Corrective Action Tracker**

| | |
|---|---|
| 2 | T4…PM change |
| 4 | T4…New lubricant |
| 1 | T5…DOE on heat settings |
| 5 | T5…Changed fixture. New PM |
| 3 | T9…Supplier repaired equipment |
| 1 | T12…Repair TCs |

**Discussion**:

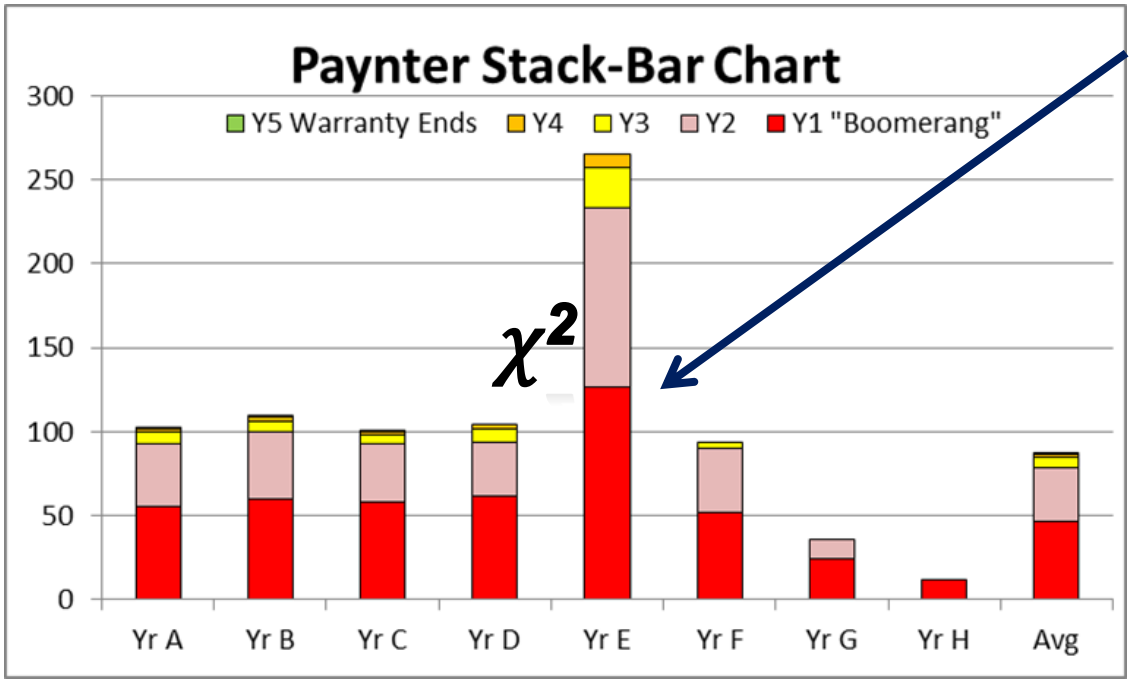
1. **MUST have accurate measurement system**
2. Trend Chart may be a stack bar or line chart
3. With a bar, can see items turn on/off
4. What might have happened at 1:T7?
5. Data can either be percentages or quantity

# Define: Stack-Bar Paynter



TOM is the Key!

**Stack-Bar Charts** show return data "bucketed" by **TOM** when items are received. Extensive Pareto work is typically conducted behind the scenes




A change in supplier caused this effect… The penny saved cost a bundle…for years! If a Paynter had been in use, the issue may have been identified via $\chi^2$ within a few months of release

**APPLY ALL RETURNS TO TOM; QUICKLY!**

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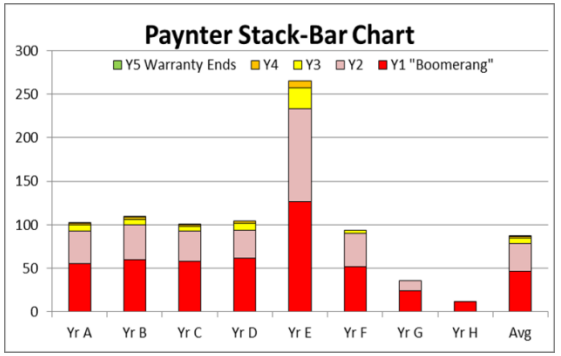
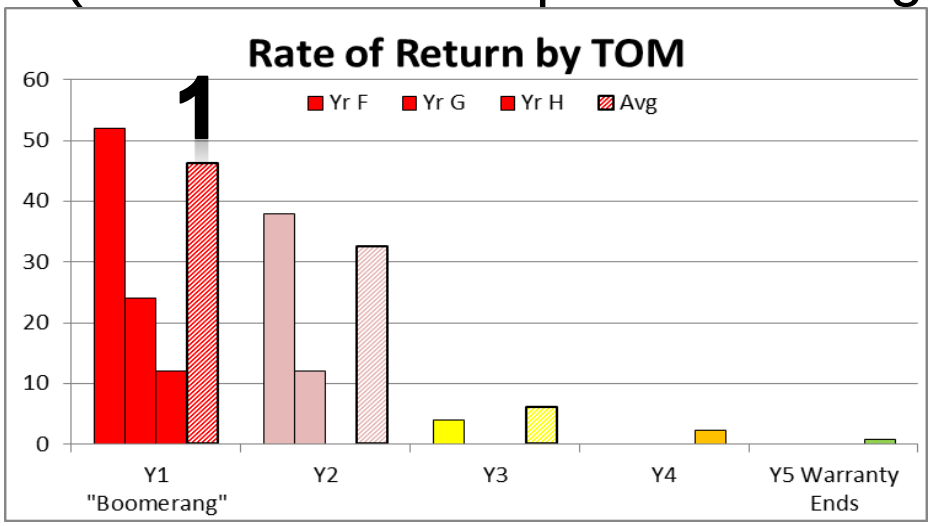
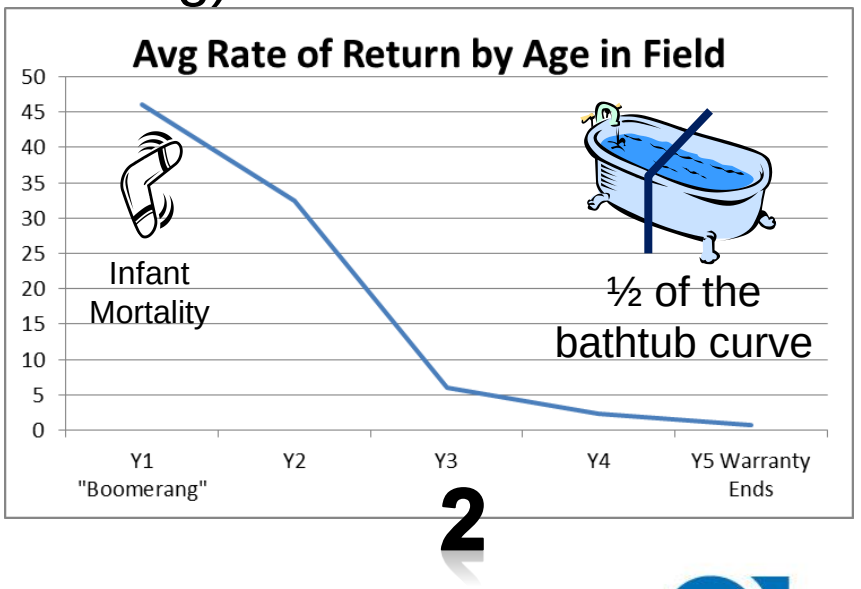
# Define: Stack-Bar Paynter

1. Once developed, use the average stack-bar to identify changes in return rates
2. The average of each return window can be used to create an “empirical” bathtub curve (can then be compared to design testing)



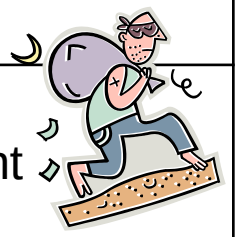




## USE $\chi^2$ TO TRIGGER C/A ANALYSIS

# Measure: Why TOM vs ROB?

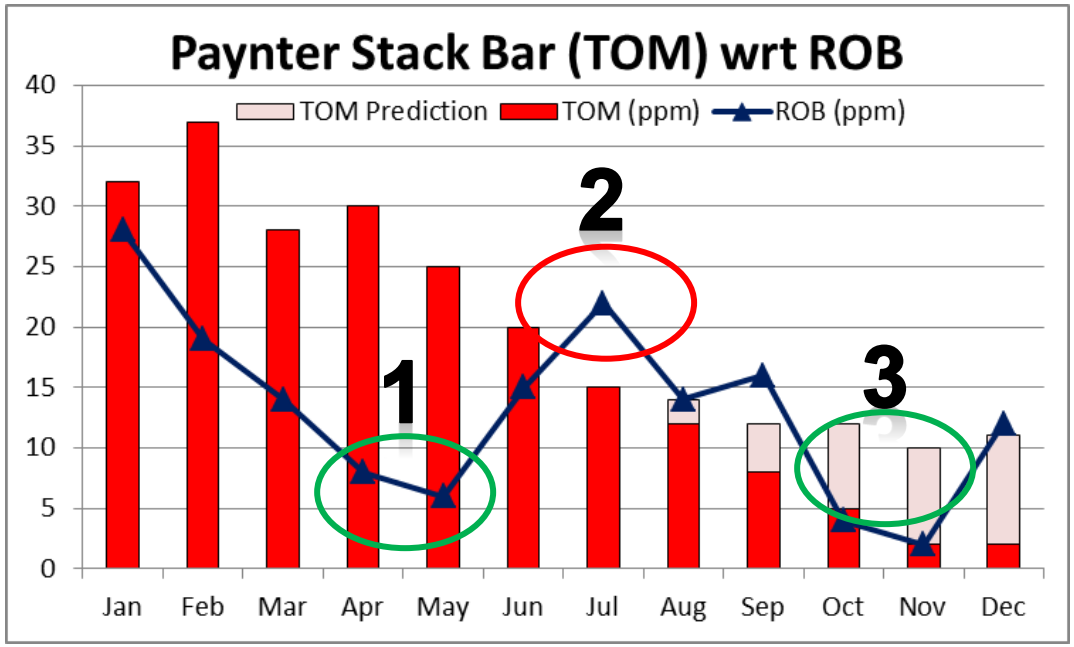
Time Of Manufacture (**TOM**) is used to manage business risk. Tracking by the day it **R**eturns to **O**ur **B**ackyard (**ROB**) does not enable predictive nor preventive planning

| TOM | ROB |
|---|---|
| • Can use "iterative" Chi-Square analysis to predictively check for difference in rate of returns<br>• Can make a decision on how far into the value stream you need to go to contain an identified issue<br>• Can more effectively plan for reserves and/or margin impact<br>• Able to quickly see impact of C/A from future returns |  <br>"Return" pattern holds no meaning causing inconsistent over and under reaction to "results"<br><br>May be inversely tied to sales volume:<br>• Smaller percent of return with recent high sales.<br>• Larger percent of return with recent low sales |

**FOCUS ON PREDICTIVE CONTROL**

# Measure: ROB Reactiveness

Traditional financial accounting compares the return data to sales (**ROB**). The “incoming” goods does not reflect either the quality nor financial risk inherent  in the “outgoing” goods




1. Ops looks like a hero because prior low sales volume reduced the ROB return rate “x” months later
2. Ops is struggling to explain why the ppm went up when, in fact, the process is the best it has ever been
3. Prediction data is based on past return performance

**TOM DATA HELPS WITH FUTURE VISIBILITY**

# Session Worksheet

| Age | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | %Ret |
|---|---|---|---|---|---|---|---|---|---|---|
| Mo 1 | Jan 10 | Feb 20 | Mar 30 | Apr 20 | May 10 | Jun 2 | | | | 5.8% |
| | | | | | | | | | | |
| Mo 2 | Feb 10 | Mar 20 | Apr 30 | May 10 | Jun 10 | | | | | 5.0% |
| | | | | | | | | | | |
| Mo 3 | Mar 5 | Apr 10 | May 15 | Jun 5 | | | | | | 2.2% |
| | | | | | | | | | | |
| Mo 4 | Apr 5 | May 10 | Jun 15 | | | | | | | 1.9% |
| | | | | | | | | | | |
| Mo 5 | May 3 | Jun 6 | | | | | | | | 0.6% |
| | | | | | | | | | | |
| Mo 6 | Jun 2 | | | | | | | | | 0.1% |
| | | | | | | | | | | |
| Cum | 35 | 66 | 90 | 35 | 20 | 2 | 0 | 0 | 0 | 248 |
| Mfg | 100 | 200 | 300 | 400 | 500 | 100 | | | | 1600 |
| YTD % | 35% | 33% | 30% | 9% | 4% | 2% | | | | 15.5% |
| Apr | C/A #1 implemented. Reduce infant mortality (boomerang) failures | | | | | | | | | |
| May | C/A #2 implemented. Reduce premature product fatique failures | | | | | | | | | |

| Returned in the month of… | | | |
|---|---|---|---|
| TOM | Jul | Aug | Sep |
| Sep | | | Mo 1 **3** |
| Aug | | Mo 1 **2** | Mo 2 **1** |
| Jul | Mo 1 **2** | Mo 2 **2** | Mo 3 **1** |
| Jun | Mo 2 | Mo 3 | Mo 4 |
| May | Mo 3 **2** | Mo 4 **1** | Mo 5 **2** |
| Apr | Mo 4 | Mo 5 **1** | Mo 6 |
| Mar | Mo 5 **4** | Mo 6 **1** | |
| Feb | Mo 6 **2** | | |
| Total | 10 | 7 | 7 |

**Mfg Qtys**: Jul: 200, Aug: 300, Sep: 400

1. Take the returns information above and calculate TOM%
2. Review the rates vs the C/As implemented
3. Calculate the last 3 mos of the %Return rate

# Session Worksheet

| Age | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | %Ret |
|---|---|---|---|---|---|---|---|---|---|---|
| Mo 1 | Jan 10 | Feb 20 | Mar 30 | Apr 20 | May 10 | Jun 2 | Jul 2 | Aug 2 | Sep 3 | 5.8% |
| | 10% | 10% | 10% | 5% | 2% | 2% | 1% | 0.7% | 0.8% | 0.8% |

| Returned in the month of… | | | |
|---|---|---|---|
| TOM | Jul | Aug | Sep |
| Sep | | | Mo 1 **3** |
| Aug | | Mo 1 **2** | Mo 2 **1** |
| Jul | Mo 1 **2** | Mo 2 **2** | Mo 3 **1** |
| Jun | Mo 2 | Mo 3 | Mo 4 |
| May | Mo 3 **2** | Mo 4 **1** | Mo 5 **2** |
| Apr | Mo 4 | Mo 5 **1** | Mo 6 |
| Mar | Mo 5 **4** | Mo 6 **1** | |
| Feb | Mo 6 **2** | | |
| Total | 10 | 7 | 7 |

**Mfg Qtys**: Jul: 200, Aug: 300, Sep: 400

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mfg | 100 | 200 | 300 | 400 | 500 | 100 | 200 | 300 | 400 | 1600 |
| YTD % | 35% | 33% | 30% | 9% | 4% | 2% | 0.04% | 0.01% | 0.01% | 15.5% |
| Apr | C/A #1 implemented. Reduce infant mortality (boomerang) failures | | | | | | | | | |
| May | C/A #2 implemented. Reduce premature product fatique failures | | | | | | | | | |

1. Take the return information from each month and “allocate” it into the TOM
2. Evaluate if the return rates “hold up” based on the C/As implemented

# Analyze: Stack-Bar Before

| Age | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | %Ret |
|---|---|---|---|---|---|---|---|---|---|---|
| Mo 1 | Jan 10 | Feb 20 | Mar 30 | Apr 20 | May 10 | Jun 2 | | | | 5.8% |
| Mo 2 | Feb 10 | Mar 20 | Apr 30 | May 10 | Jun 10 | | | | | 5.0% |
| Mo 3 | Mar 5 | Apr 10 | May 15 | Jun 5 | | | | | | 2.2% |
| Mo 4 | Apr 5 | May 10 | Jun 15 | | | | | | | 1.9% |
| Mo 5 | May 3 | Jun 6 | | | | | | | | 0.6% |
| Mo 6 | Jun 2 | | | | | | | | | 0.1% |
| Cum | 35 | 66 | 90 | 35 | 20 | 2 | 0 | 0 | 0 | 248 |
| Mfg | 100 | 200 | 300 | 400 | 500 | 100 | | | | 1600 |
| YTD % | 35% | 33% | 30% | 9% | 4% | 2% | | | | 15.5% |

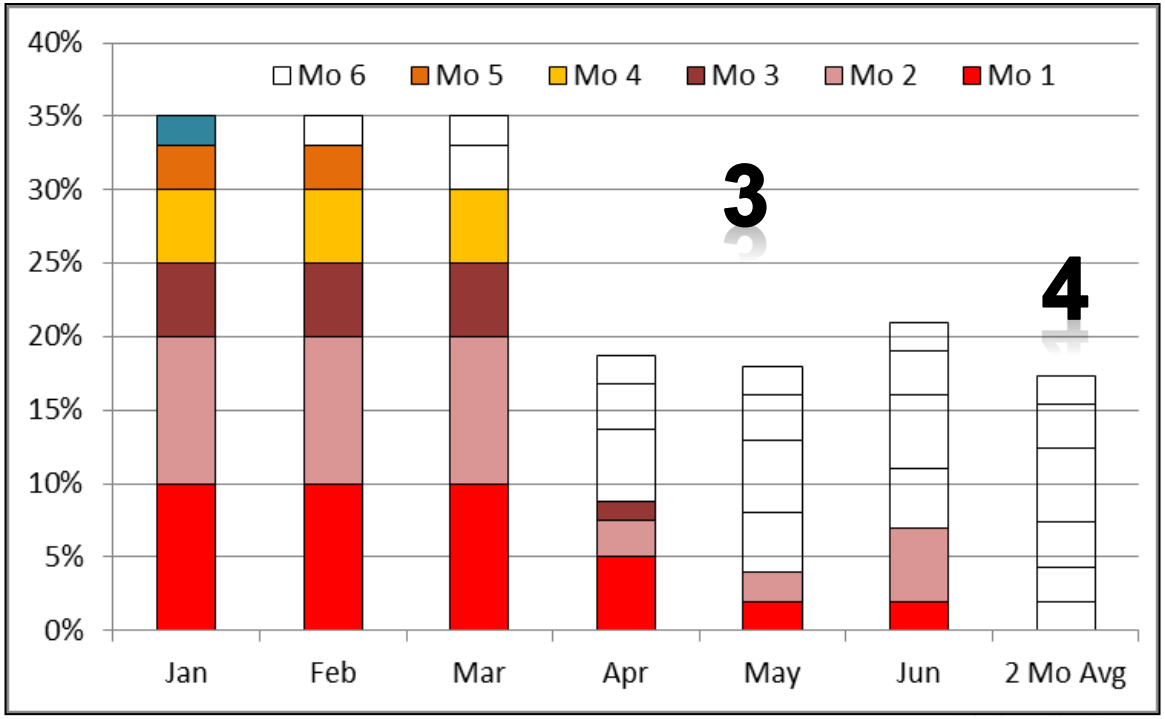
1

2

Percent Return Rate by TOM

| | Jan | Feb | Mar | Apr | May | Jun | 2 Mo Avg |
|---|---|---|---|---|---|---|---|
| Mo 1 | 10% | 10% | 10% | 5% | 2% | 2% | 2% |
| Mo 2 | 10% | 10% | 10% | 3% | 2% | | 2% |
| Mo 3 | 5% | 5% | 5% | 1% | | | 3% |
| Mo 4 | 5% | 5% | 5% | | | | 5% |
| Mo 5 | 3% | 3% | | | | | 3% |
| Mo 6 | 2% | | | | | | 2% |

1. Establish a percent and/or ppm table
2. Determine an approxi-mate and meaningful "historical" average (ie. Most recent 2 mos)
3. Create the stack-bar with "ghost bars" to estimate potential future returns
4. Is this the desired level?

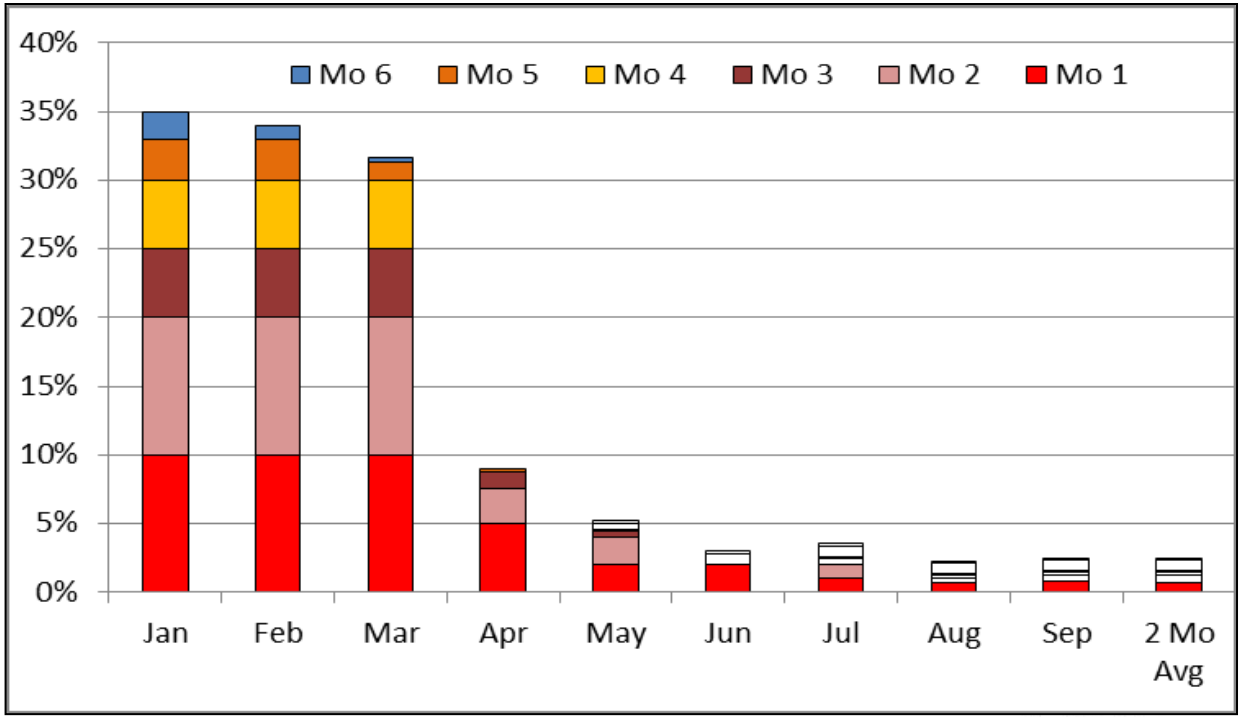


# Analyze: Stack-Bar…3 Mos Later

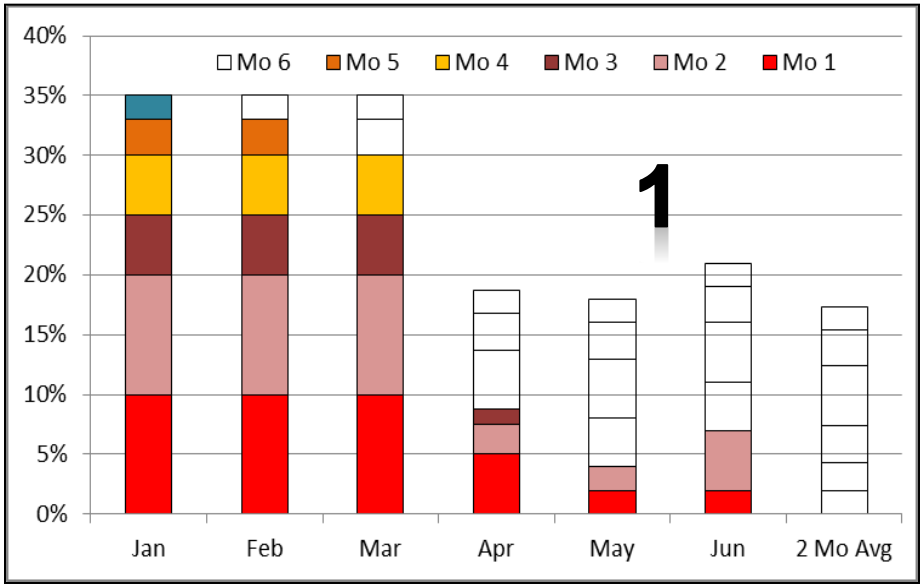
| Age | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | %Ret |
|---|---|---|---|---|---|---|---|---|---|---|
| Mo 1 | 10 | 20 | 30 | 20 | 10 | 2 | 2 | 2 | 3 | 4.0% |
| | | | | | | | | | | |
| Mo 2 | 10 | 20 | 30 | 10 | 10 | | 2 | 1 | | 3.3% |
| | | | | | | | | | | |
| Mo 3 | 5 | 10 | 15 | 5 | 2 | | 1 | | | 1.5% |
| | | | | | | | | | | |
| Mo 4 | 5 | 10 | 15 | | 1 | | | | | 1.2% |
| | | | | | | | | | | |
| Mo 5 | 3 | 6 | 4 | 1 | 2 | | | | | 0.6% |
| | | | | | | | | | | |
| Mo 6 | 2 | 2 | 1 | | | | | | | 0.2% |
| | | | | | | | | | | |
| Cum | 35 | 68 | 95 | 36 | 25 | 2 | 5 | 3 | 3 | 272 |
| Mfg | 100 | 200 | 300 | 400 | 500 | 100 | 200 | 300 | 400 | 2500 |
| YTD % | 35% | 34% | 32% | 9% | 5% | 2% | 3% | 1% | 1% | 10.9% |

| Percent Return Rate by TOM | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 2 Mo Avg |
| Mo 1 | 10% | 10% | 10% | 5% | 2% | 2% | 1% | 1% | 1% | 1% |
| Mo 2 | 10% | 10% | 10% | 3% | 2% | 0% | 1% | 0% | | 1% |
| Mo 3 | 5% | 5% | 5% | 1% | 0% | 0% | 1% | | | 0% |
| Mo 4 | 5% | 5% | 5% | 0% | 0% | 0% | | | | 0% |
| Mo 5 | 3% | 3% | 1% | 0% | 0% | | | | | 1% |
| Mo 6 | 2% | 1% | 0% | 0% | | | | | | 0% |

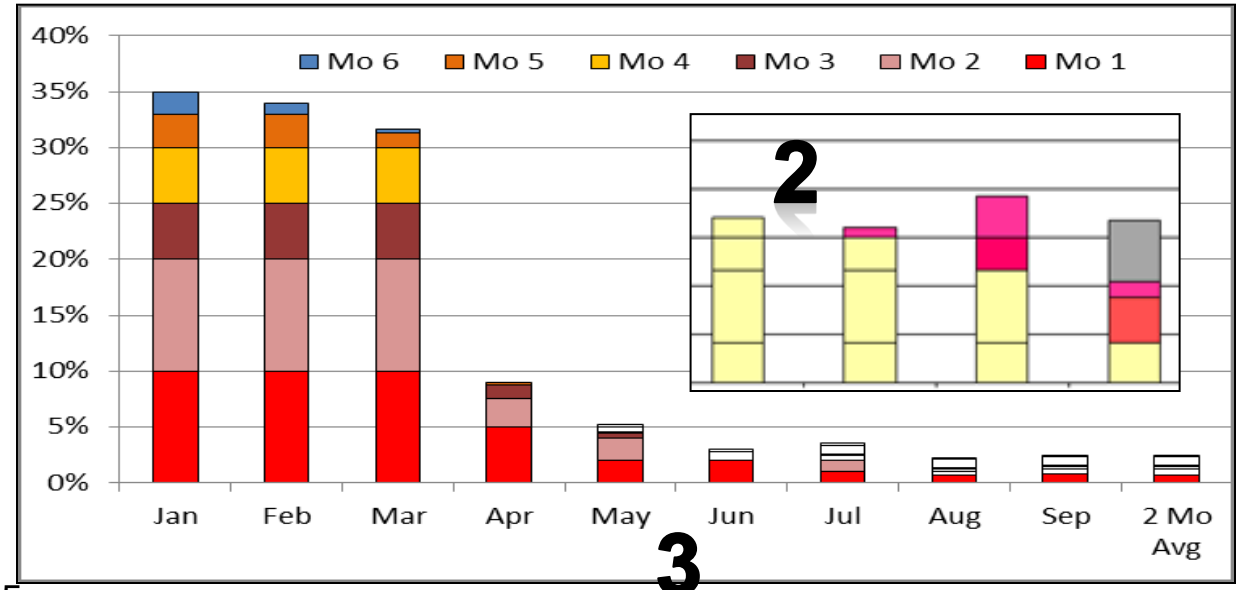
1. Note the dramatic expected reduction in “future” returns
2. Based on $\chi^2$ analysis, just a few units can trigger an alert for corrective action review and/or containment
3. Are the CA/PAs working?



# Analyze: Side by Side




1. "Ghost" bars help to visualize potential risk. They help to see the future cost/business risk *potential*
2. "Ghost" bars can be used for previous timing when you are "starting a Paynter in the middle"
3. Return data needs to be analyzed and "bucketed" quickly to get Paynter cost benefits by "pre-sponding" to an issue; or to share improvement results



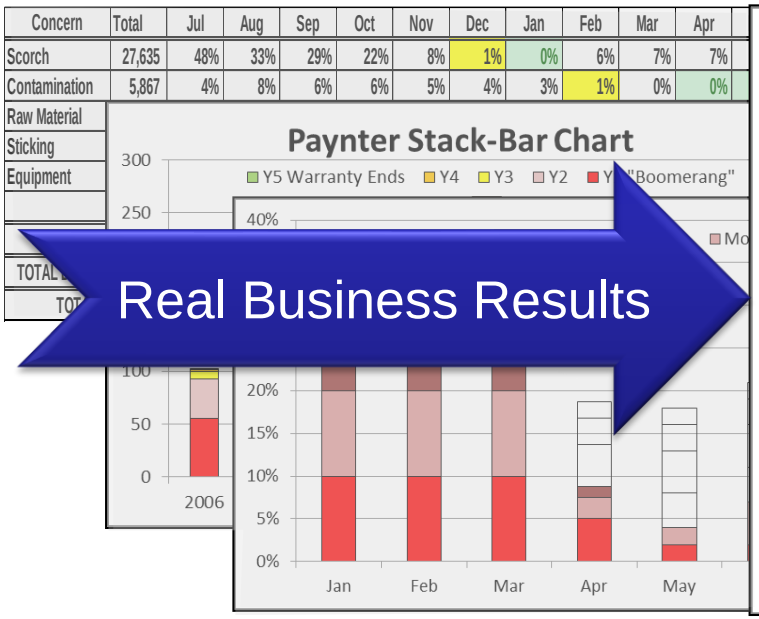

**As effective CA/PA is taken at the front end (DFM/DFSS/DFA) external results are impacted**

# Improve: Paynters with a Purpose

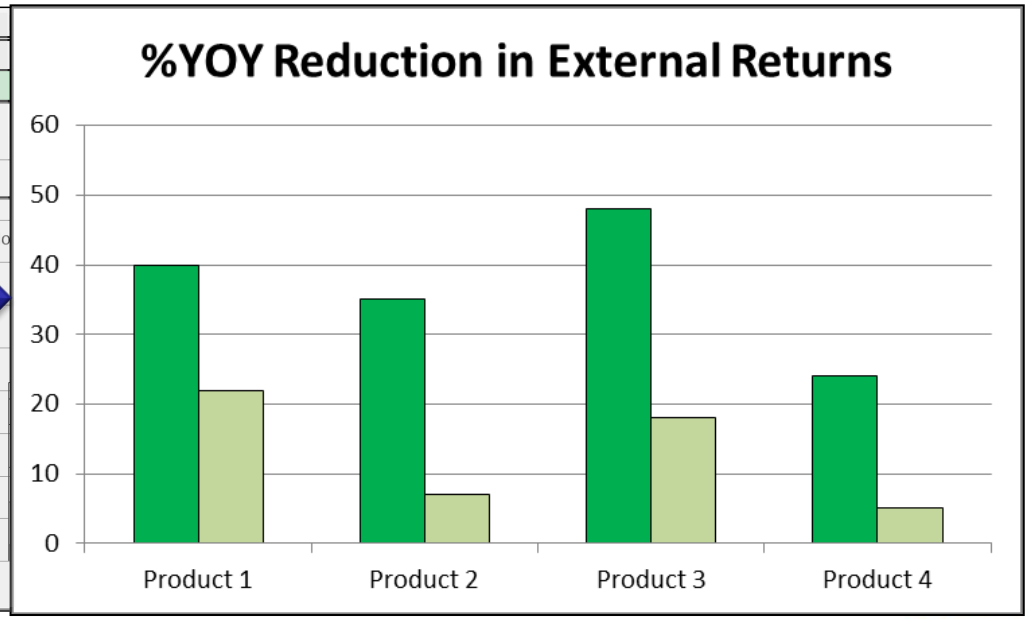
Use the Paynters to proactively

- Identify if C/A is effective
- Plan for business risk/reserves
- Build empirical results to improve design testing processes

| Concern | Total | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Scorch | 27,635 | 48% | 33% | 29% | 22% | 8% | 1% | 0% | 6% | 7% | 7% |
| Contamination | 5,867 | 4% | 8% | 6% | 6% | 5% | 4% | 3% | 1% | 0% | 0% |
| Raw Material | | | | | | | | | | | |
| Sticking | | | | | | | | | | | |
| Equipment | | | | | | | | | | | |




Real Business Results




**USUALLY HIGH IMPACT IN YR 1 & YR 2**

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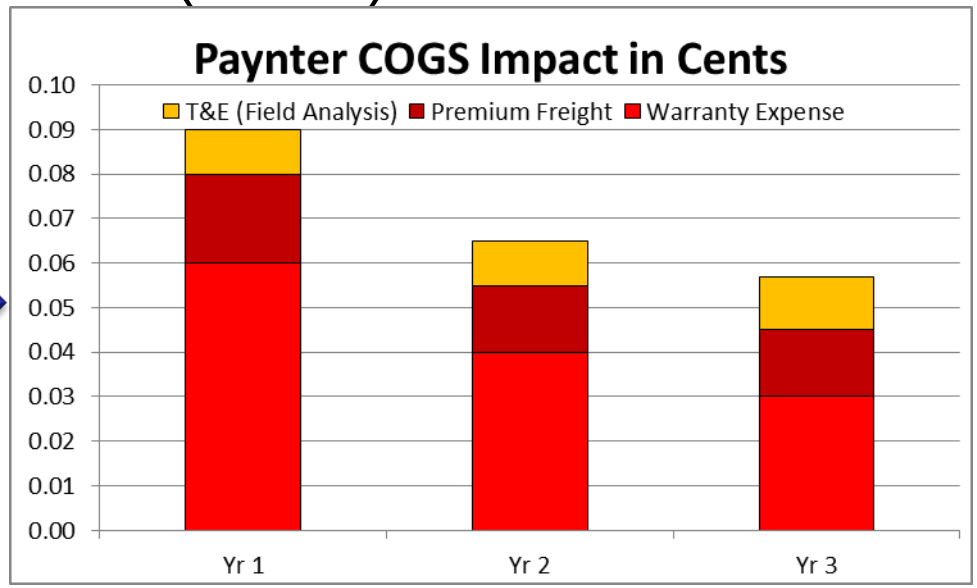
# Control

Paynter Pointers…

- Use Paynters for verification, containment on your terms (mitigate cost) and to understand product performance
- Once you have a working data system…*automate it*
- Paynters require thought; Use $\chi^2$ to assess for change
- Ensure system fixes are sustainable; or they'll show up again
- Tie results to Cost of Goods Sold (COGS)
- **Color code**!

Real Business Results




**37% REDUCTION IN WARRANTY EXPENSE**

# Learning Objectives

In this time we have…

- Learned about what a Paynter Chart is and…
- Determined how it is tied to Time of Manufacture
- Constructed an example and applied the tool
- Reviewed the Power of the Paynter's ability to mitigate business risk
- and…We applied it to Predictive Warranty analysis

**WHEN WE DO, WE UNDERSTAND…**

# Thank You

# Questions?

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