CONCEPT EXPLORATION:
SAFETY AS A
QUALITY CONTROL PROCESS

POSSIBLE APPLICATION OF WELL-ESTABLISHED PROCESS CONTROL AND STATISTICAL METHODS TO NAOMS DATA
Acknowledgements

- JIT Software Limited, “Management Theory” (background information on Walter Shewart)
- M. Spiegel and L. Stevens, Statistical Process Control and Process Capability (Schaum’s Outlines) (typology of control charts)
- TK Philips, D. Stein and E. Yashchin, “Monitoring Active Portfolios: The CUSUM Approach” (Paradigm Asset Management) (use of CUMSUM method for early change detection)
### PARALLELS

<table>
<thead>
<tr>
<th>CONTROLLING QUALITY</th>
<th>MAINTAINING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involves managing a process</td>
<td>Involves managing a process</td>
</tr>
<tr>
<td>Strives to minimize defects</td>
<td>Strives to minimize accidents</td>
</tr>
<tr>
<td>Exertion of quality control is a continuous, cyclical process</td>
<td>Maintenance of safety is a continuous, cyclical process</td>
</tr>
<tr>
<td>Ideally, data-driven</td>
<td>Ideally, data-driven</td>
</tr>
<tr>
<td>Excessive attention to quality can be diseconomic</td>
<td>No such thing as too much safety from public vantage point</td>
</tr>
</tbody>
</table>

**IMPLICATION:** Process quality control methods may be usefully applied to safety.
WALTER SHEWART: Plan, Do, Study, Act ….

Profile

Walter Shewart is commonly acknowledged as the father of the “Total Quality” movement. A statistician and mentor of W Edwards Deming his most well known contributions to quality, originated while working at Bell Labs, are the Shewart Cycle and the Process Control chart. According to Shewart:

“Quality improvement is the process of reducing the level of variability in a process so that it can be predicted”.

NAOMS - National Aviation Operations Monitoring Service
Measurement, Metrics, and Statistical Analysis Drive the Cycle

1. Collect Data
   - Analyze, Investigate,
   - Formulate Corrective Strategy

2. Run Small-scale Test of Planned Process Change

3. Analyze Results
   - Tune Strategy

4. Implement on System-wide Basis
• Used to monitor performance
• Characterizes normal performance
• And, variation about the norm
• Depicts performance boundaries
  • Statistical – typical measurement range, or
  • Prescribed – limits specified by rules or SOP
## ABC’s of Control Charts

### Chart Type

<table>
<thead>
<tr>
<th>Chart Type</th>
<th>Statistics Plotted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Variable” Charts</strong></td>
<td></td>
</tr>
<tr>
<td>X-bar and R</td>
<td>Averages and ranges</td>
</tr>
<tr>
<td>X-bar and Sigma</td>
<td>Averages and standard deviations</td>
</tr>
<tr>
<td>Median</td>
<td>Median</td>
</tr>
<tr>
<td>Individual chart</td>
<td>Individual measurements</td>
</tr>
<tr>
<td>CUSUM chart</td>
<td>Cumulative sum of subgroup means minus the nominal</td>
</tr>
<tr>
<td>Zone chart</td>
<td>Zone weights</td>
</tr>
<tr>
<td>UWMA &amp; EWMA</td>
<td>Uniform &amp; exponentially weighted moving averages</td>
</tr>
<tr>
<td><strong>“Attribute” Charts</strong></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Percentage of defective items (i.e., safety incidents) in sample</td>
</tr>
<tr>
<td>NP</td>
<td>Number of defective items (i.e., safety incidents) in sample</td>
</tr>
<tr>
<td>C</td>
<td>Number of defects per item for a constant sample size</td>
</tr>
<tr>
<td>U</td>
<td>Number of defects per item for a varying sample size</td>
</tr>
</tbody>
</table>
CUSUM Plots for Early Change Detection

CUSUM analyzes cumulative deviations from an expected value
- Control limits are embodied in a V-Mask

Strengths
- Rapidly detects systemic change – as much as 10 times faster than other control chart methods with relatively few false positives
- Relatively insensitive to underlying data distributions
- A standard industrial control method
- Also in daily use at a number of large financial institutions – used to monitor over $500 billion in actively traded assets

Known Drawbacks (from NAOMS perspective)
- In its standard form, intended for variable measurements not event counts (mathematical variant for event counts may be possible)
VERY PRELIMINARY!
FOR ILLUSTRATIVE PURPOSES ONLY.

B-AH13-LRG
Unusual Attitude
Large Transport

UWMA Statistic

CUSUM Statistic

Nth Sample of 100 Consecutive Interviews

Avg=0.00325

UCL

LCL

0.000

0.002

0.004

0.006

0.008

0.010

0.000

0.005

0.010

0.015

0.020
B-AC2-LRG
Evasive Action with less than 500 ft Separation
Large Transport

**VERY PRELIMINARY!**
FOR ILLUSTRATIVE PURPOSES ONLY.
B-AD2-MED
Descent Below MSA
Medium Transport

UWMA Statistic

Nth Sample of 100 Consecutive Interviews

CUSUM Statistic

Nth Sample of 100 Consecutive Interviews
Very Preliminary Findings

- There are significant parallels between the processes of quality control and safety maintenance.

- NAOAMS may be able to use the control charts common to manufacturing and financial industries to detect trends:
  - Operationally-oriented
  - Conducive to easy visual interpretation

- Desirable to have a mix of types:
  - Some charts concerned with medium- and long-term secular trends
  - Others focused on leading edge changes

- Some variant on the CUSUM method may be particularly useful as an early change detector.