Manufacturing

Industry 4.0 Lean/Six Sigma

& jmp Statistical Discovery.™ From SAS.

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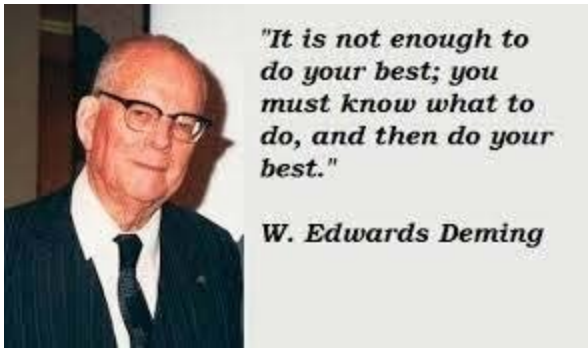


Deming on Data?

"Scientific data are not taken for museum purposes; they are taken as a basis for doing something. If nothing is to be done with the data, then there is no use in collecting any. The ultimate purpose of taking data is to provide a basis for action or a recommendation for action. The step intermediate between the collection of data and the action is prediction."

"An operational definition is a procedure agreed upon for translation of concept into measurement of some kind."

Quotes from Edwards W. Deming

What is Industry 4.0?

Began as initiative of the German government for smart factories; also intelligent manufacturing.

No one agreed upon set of elements that comprise Industry 4.0,

Role of data and analytics in I4.0 (here is our take):

1. Interoperability of equipment (e.g., sensors, machines, networks);
2. Organization and storage of data from many sources and ease of access for stakeholders; **manufacturing and enterprise applications are distinctly different in scale and scope**.
3. Cyber security (especially with Internet of Things);
4. **Analytics**: methods to extract useful information from data;
5. Using information derived from analytics to guide management decisions, customization and continuous improvement;
6. Easy exchange of information across organizations.

What is Industry 4.0?

Industry 4.0 must be interdisciplinary to achieve its full promise, however there is a **BIG** problem (Six Blind Men and the Elephant)

Rime of the Frustrated Data Scientist

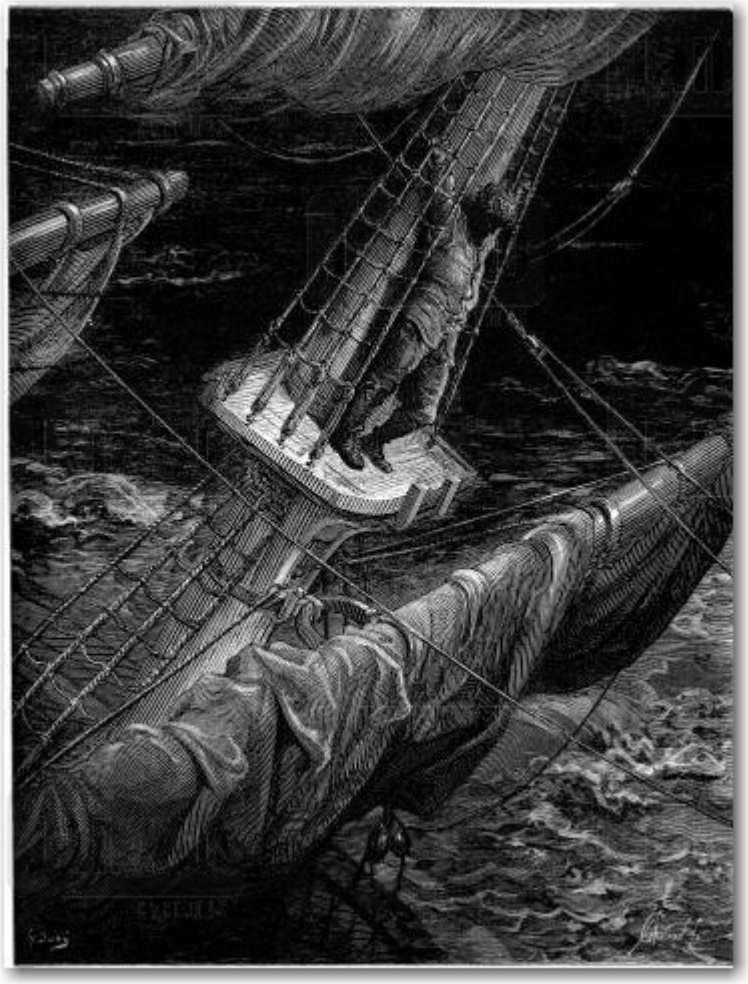
The “Hellish Thing”, Data Data Everywhere .. nor a byte to analyze.

Too often associates spend more time talking about data than analyzing data.

Teams may wait days, weeks, even months for assistance to extract data from various sources.

Once extracted data often is of poor quality and not at all useful.

The impacts of poor data management in organizations on productivity and profits is hard to calculate, but tangible.



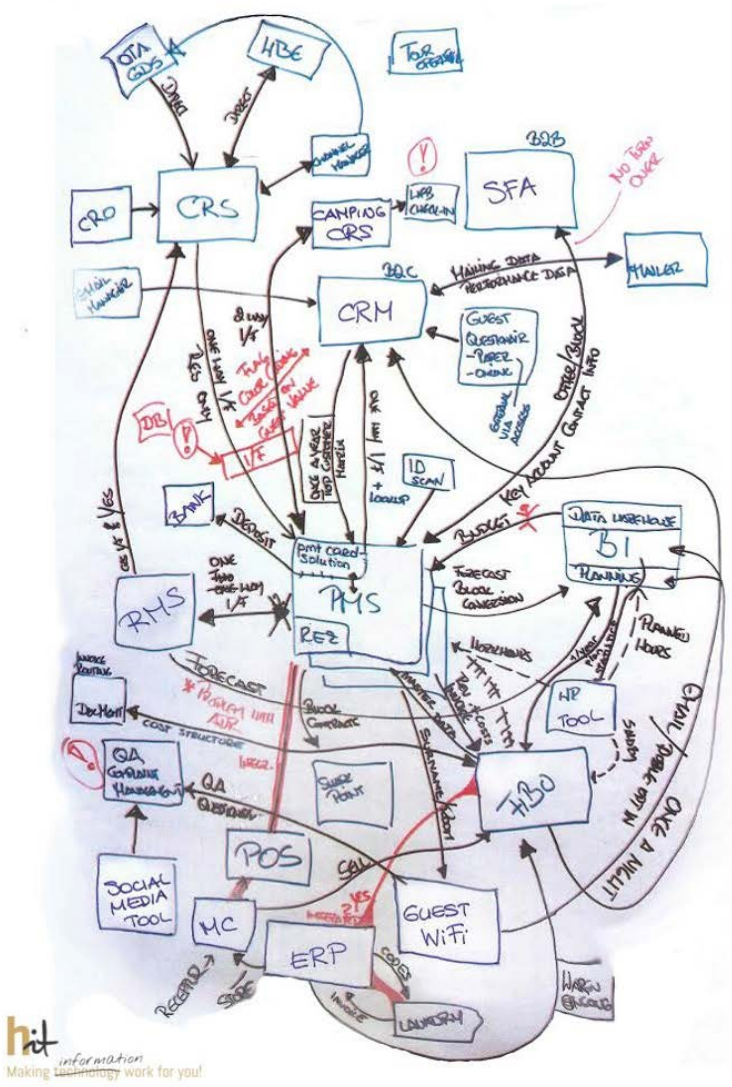
Leaning Out the Data Process

Does your current state process for data acquisition, storage, and distribution resemble the spaghetti diagram to the right. In most cases your data flows are even more disorganized.

Even smaller companies need a digital strategy which includes **governing and managing your data**.

Organizations should apply the same **lean principles** to data flows that they have used successfully for manufacturing.

Hint: this is not an IT project, this is an enterprise project. **You must do this!** Management must lead the way.



The Scourge of Spreadsheets

Although spreadsheet usage is ubiquitous in most organizations, it is the source of error, confusion, and poor productivity related to data.

Once individuals begin putting their data into their personal spreadsheets, the organization has lost control over data.

A recent article in the American Statistician (2018) , “Data Organization in Spreadsheets”, points out the many very bad habits people have in using spreadsheets and the havoc they cause.

There is a European Spreadsheet Risk Interest Group that archives spreadsheet horror stories http://www.eusprig.org/horror-stories.htm

We suggest that use of personal spreadsheets like Excel be very tightly controlled and potential users trained in how to correctly format them.

Also, you need control as to where and how they are archived.

The Evolving Data Ecosystem

Massive data repositories, often unstructured, dynamic, machine and deep learning applied. **Lots of data wrangling required!**

Any useful data from massive data repositories must be extracted and repackaged for engineering and manufacturing uses. Warning! **All process data has a shelf life!**

Smaller, structured (e.g., SQL), static or slowly changing, **where most engineering, manufacturing, and science applications reside**. Data must be easily accessible to be useful. DOE, SPC, MSA, Process Capability, small scale Datamining, Predictive Modeling.

From the Age of Computing to the Age of Data

Forbes Technology Council states that we are now in the Age of Data.

"The workforce is also transforming around data, driven by a new generation of graduates. The job of statistician will be one of the fastest growing categories through 2026, according to the Department of Labor. The workforce is becoming highly data literate. **All of this points to the need for data as a service so that employees have the data they need at their fingertips**."

The article calls for 4 organizational initiatives:

1. Technology Investment
2. Skills Investment (training and skills updating essential)
3. Organizational Changes (embed data analysts everywhere)
4. Compliance and Ethics.

Case Study

Production yields at the beginning of process improvement.

Defining and creating an easy to use SQL database infrastructure.

How to implement standard analytics using JMP Scripting and templates.

Production yields after implementing process improvements.

Identify what is needed to implement a baseline for Industry 4.0 & Analytics.

Introduction of Case Study

Products sell for thousands of dollars.

A defective part can cause loss of life.

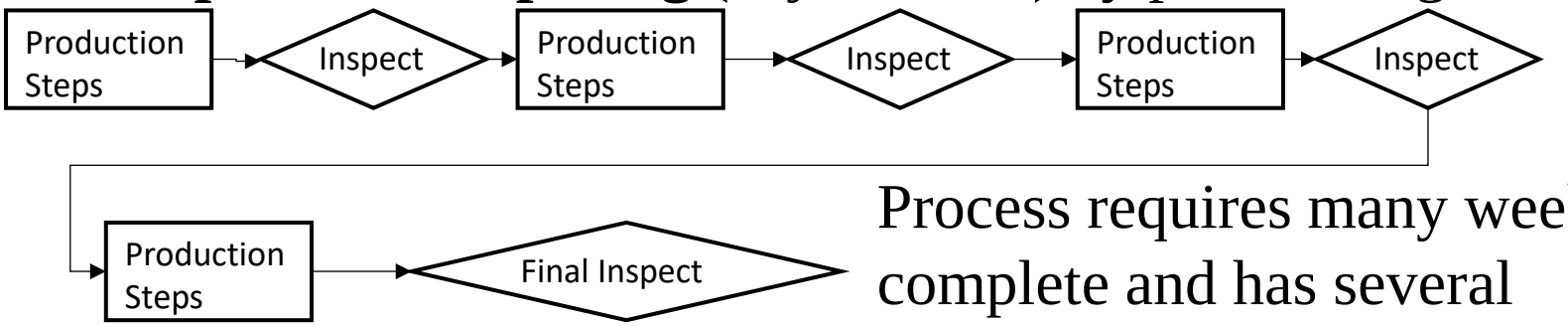
Final Inspection yields are 0 to 20% with a program needing greater than 90% yields.

Each part must meet between 1,800 to over 7,000 characteristics.

Engineers can only view data for one process and one part at a time.

Excessive rework with constant rework loops is the normal production.

Constant **process tampering** (adjustments) by process engineers.



Process requires many weeks to complete and has several outside processes.

Use JMP & Industry 4.0
For Breakthrough Improvements

Create an easy to use and responsive integrated SQL database.

Create JMP scripts and tables for use by process owners.

Use external and internal training for associates.

Methods to deploy JMP to Process Owners that consist of Engineers, Technicians, and Management.

Implement standard analytics using JMP Scripting and query.

Integrate Industry 4.0 and Lean/ Six Sigma tools for current and New Product Introduction process.

Use Standard Metrics reviewed at Technical Interchange Meetings to drive continuous improvement.

Research Studies

McKinsey Digital 2016 research states:

Most German players (67 percent) and Japanese players (74 percent) are as optimistic about the potential of Industry 4.0 as they were a year ago while 44 percent of US companies say they have become even more optimistic.

Companies are seeking a solution and road map to Industry 4.0

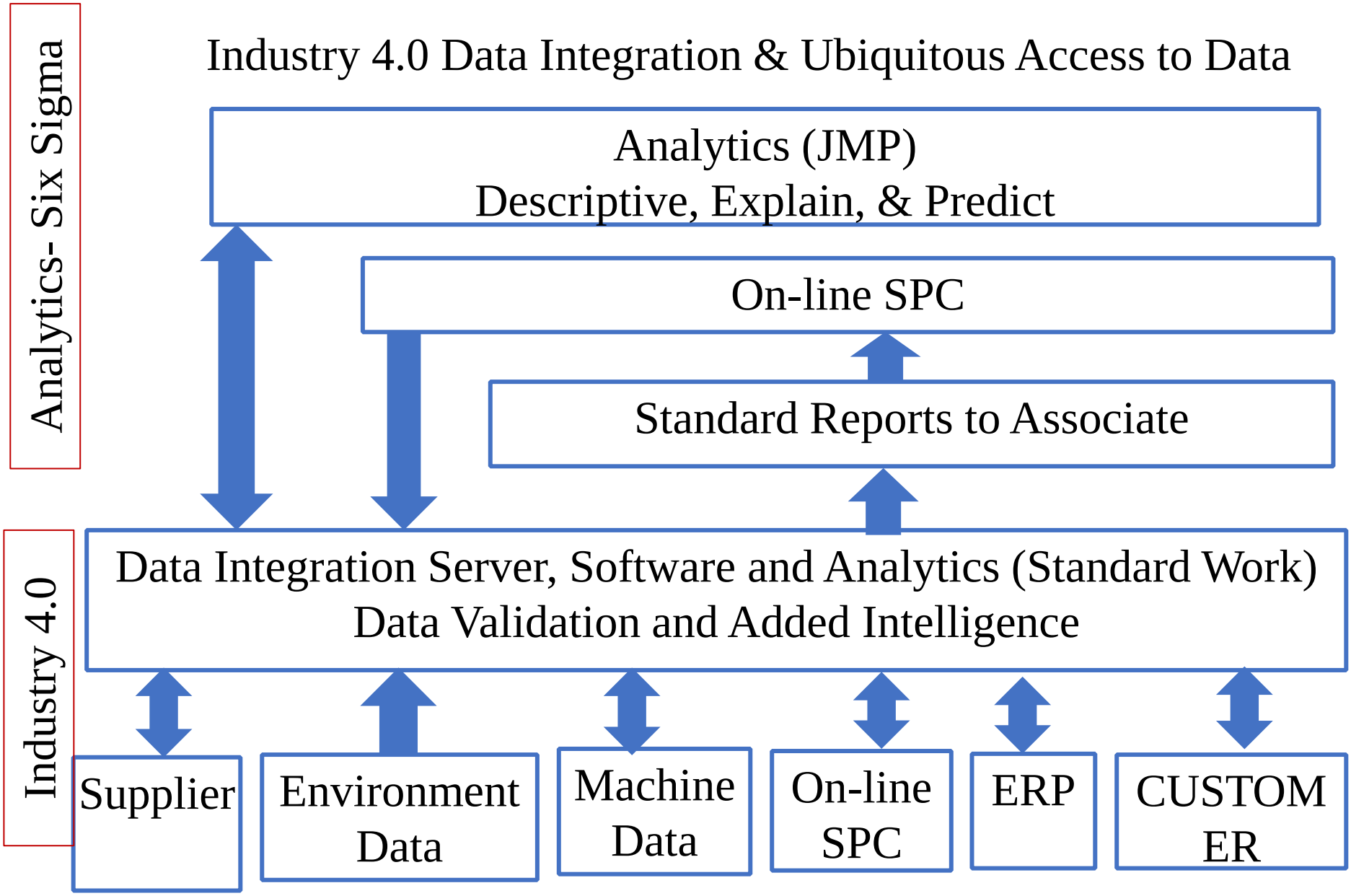
There is a difference between Consumer and Production data.

Data has a shelf life for predicating the future.

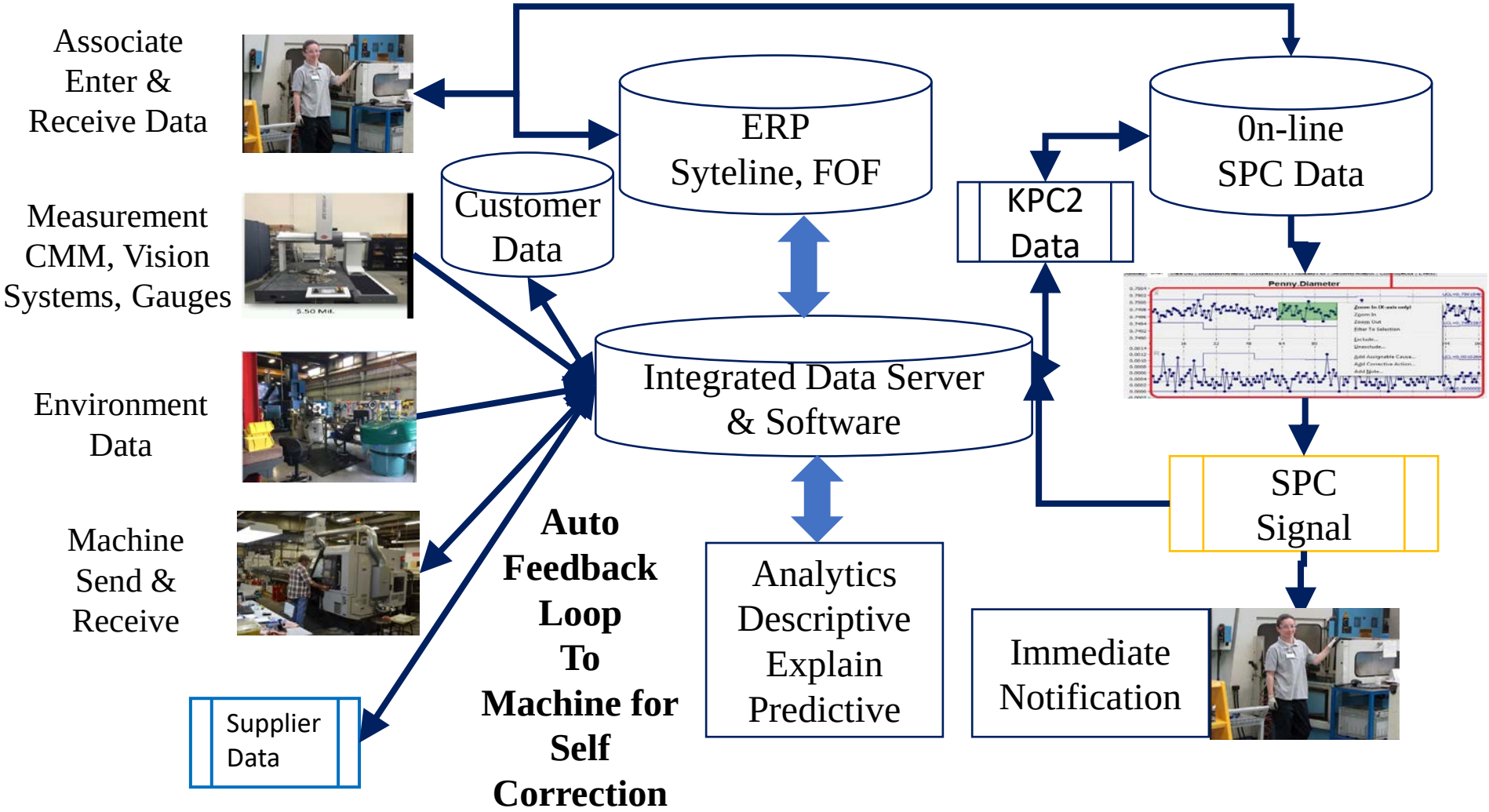
2017 Cisco study reports 74% of companies that begin an IoT initiative fail.

A Master Lean Six Sigma professional with process knowledge, extensive analytics and database knowledge provides the best skills to lead Industry 4.0

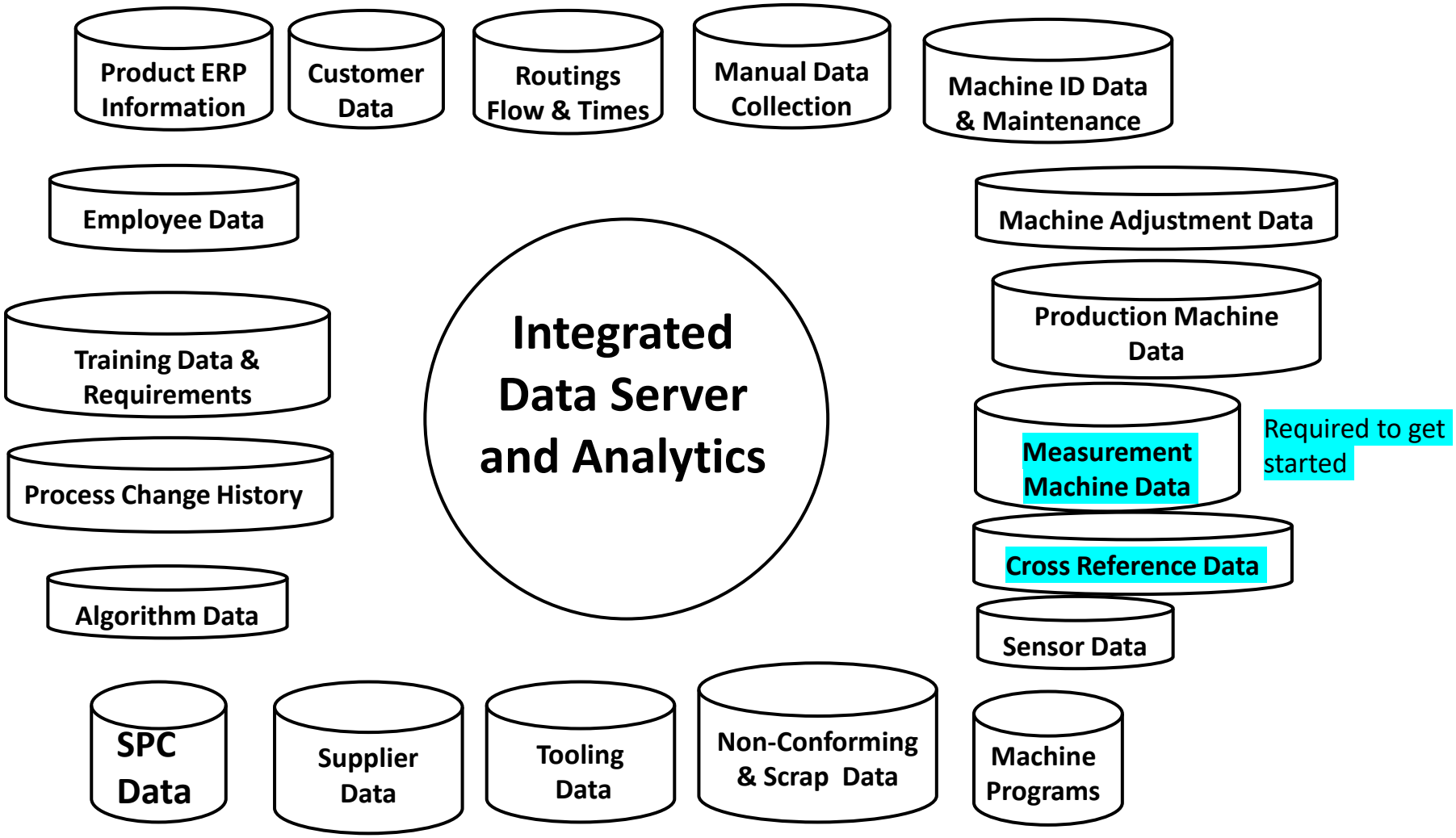
Integrated SQL Server



Manufacturing Industry 4.0 and Machine Learning



Industry 4.0 Data Server Content



SQL Server Database Design

Create Industry 4.0 SQL integrated server using Six Sigma Tools and available data.

Identify all available data from machine controllers and method to provide feedback to machine controller.

- FMEA(s)
- Control Plan
- PPAP
- Previous process improvements
- Machine Controllers (Out/IN)
- Sensors

- **Data Gaps (data sources)**
- Database Dictionary
- Database Schema
- Program Specifications
- Define people, machines and database interactions
- Machine interaction
- Importing Data & Validation
- **Mistake-Proofing Data Collection**
- Linking intelligent data to product & process data

SQL View
SQL View
Dictionary
Intranet Report
Dictionary

JMP
Analytics
&
Machine
Learning

Note:
You will discover the need for additional data collection as you analyze the process.

Add Database Intelligence!

Add Product/Process information when data is imported to SQL.

Identify records “As Built” (1st record) and “As Shipped” (Last Record).

Collect all possible process information for SQL server such as machines, tooling, molds, batch data, associates, environment, etc..

Link inspection/test data to process information.

Link previous analytics to product information.

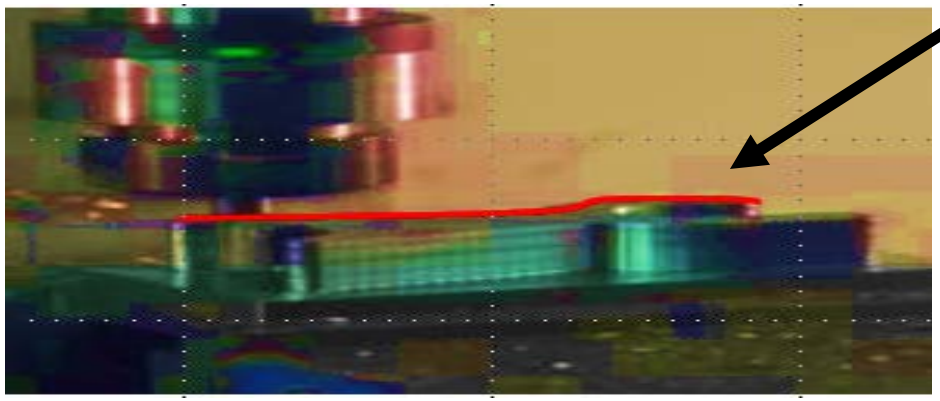
Identify machine tool paths used for machining parts.

Identify any other product/process data points unique to part/process.

Mistake-proof data collection: **Typically 90% of analytical time is just formatting and correcting data.**

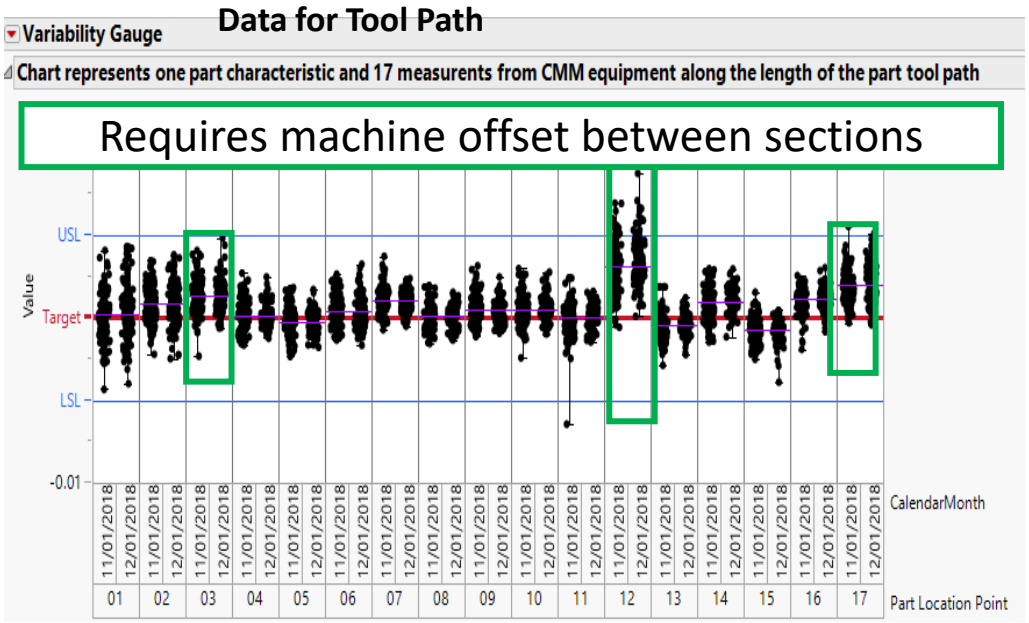
Evaluating CNC Machine Tool Path Capability

Use Variability Attribute Gauge platform to measure the ability of a CNC machine to meet part specification within a tool path.



There are 17 points measured along the tool path, and data reports deviation from the CAD model. Y axis of 0 means the part is the same as the CAD model.

Data for Tool Path



Graph reports deviation from part design (model) for each part location and each part location has two months of data.

Action:
Adjust process mean at sections 03, 12, and 17, highlighted with green boxes, to be within 95% CI of mean target of 0.

Review

We have:

- Analyzed the process.
- Identified all available and missing data.
- Identified methods to import data into an SQL server.
- Identified missing data.
- Linked all data in an SQL server with millions of records.

Now we will extract and analyze data using JMP.

Formatting JMP File Names

Create a format for naming JMP tables and scripts to make it easy to repeat analysis.

JMP file name convention

XX_YY Name

XX - is a major category or analysis.

YY_YY – is a sequence within the XX major category.

Example for creating several JMP tables for data analysis

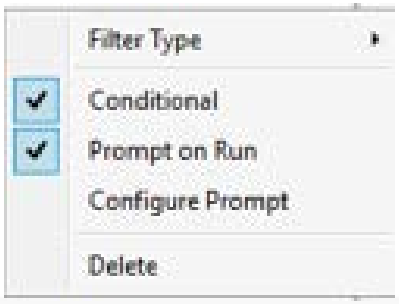
- 00_00 First table Data extract from SQL database
- 00_01 Specification from 00_00
- 00_02 Split table from 00_00
- 00_03 Split table with specifications and analytical scripts

Associate will use JMP tables from 00_00 through 00_03 and use session scripts to complete data analysis.

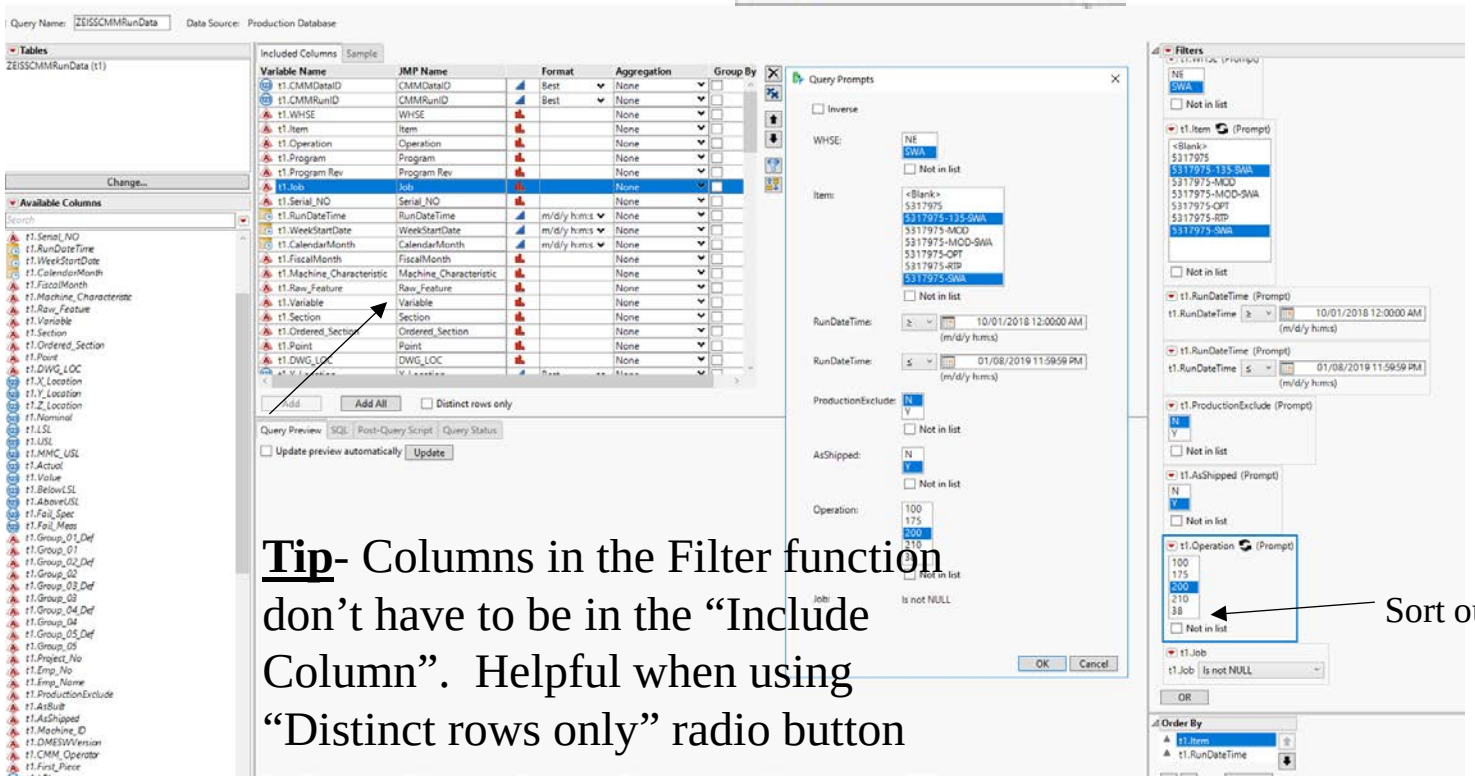
Obtain Data For Analytics

Create JMP Database QRYs

- Make Sure you use:
- Filter Type
- Conditional
- Prompt on Run & Configure Prompt



Tip- Ensure all columns used to filter data are indexed in the SQL database.

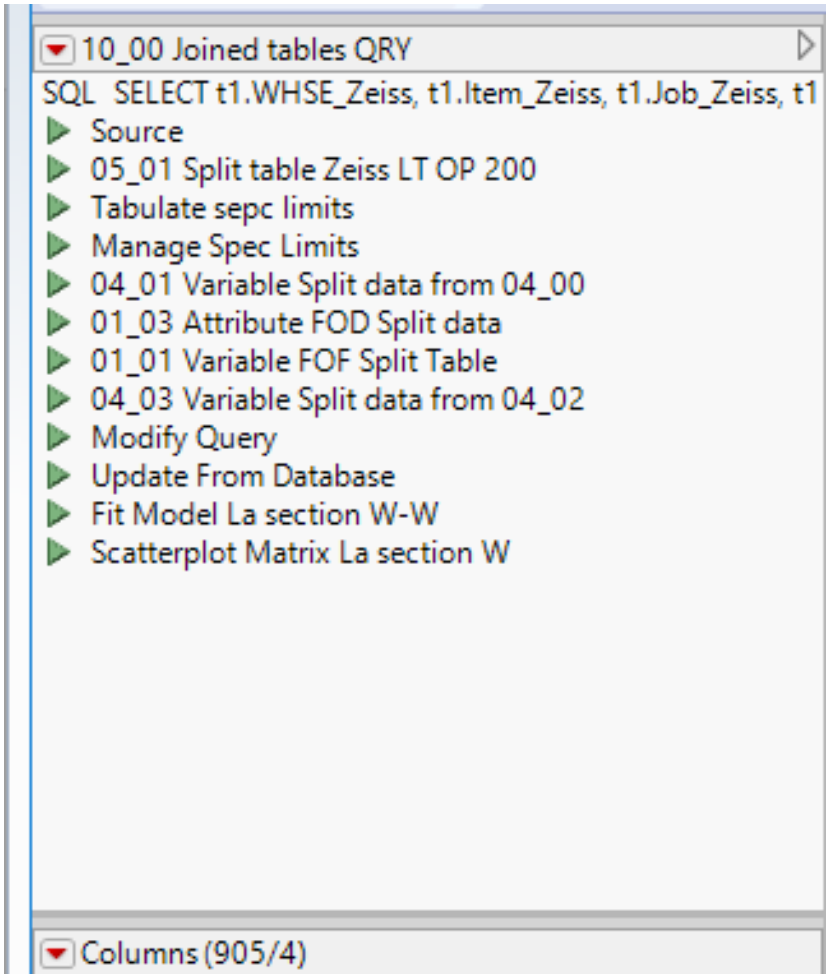


Tip- Columns in the Filter function don't have to be in the "Include Column". Helpful when using "Distinct rows only" radio button

Ensure the use of standard field names across multiple data sources.

Join Tables to View Entire Process

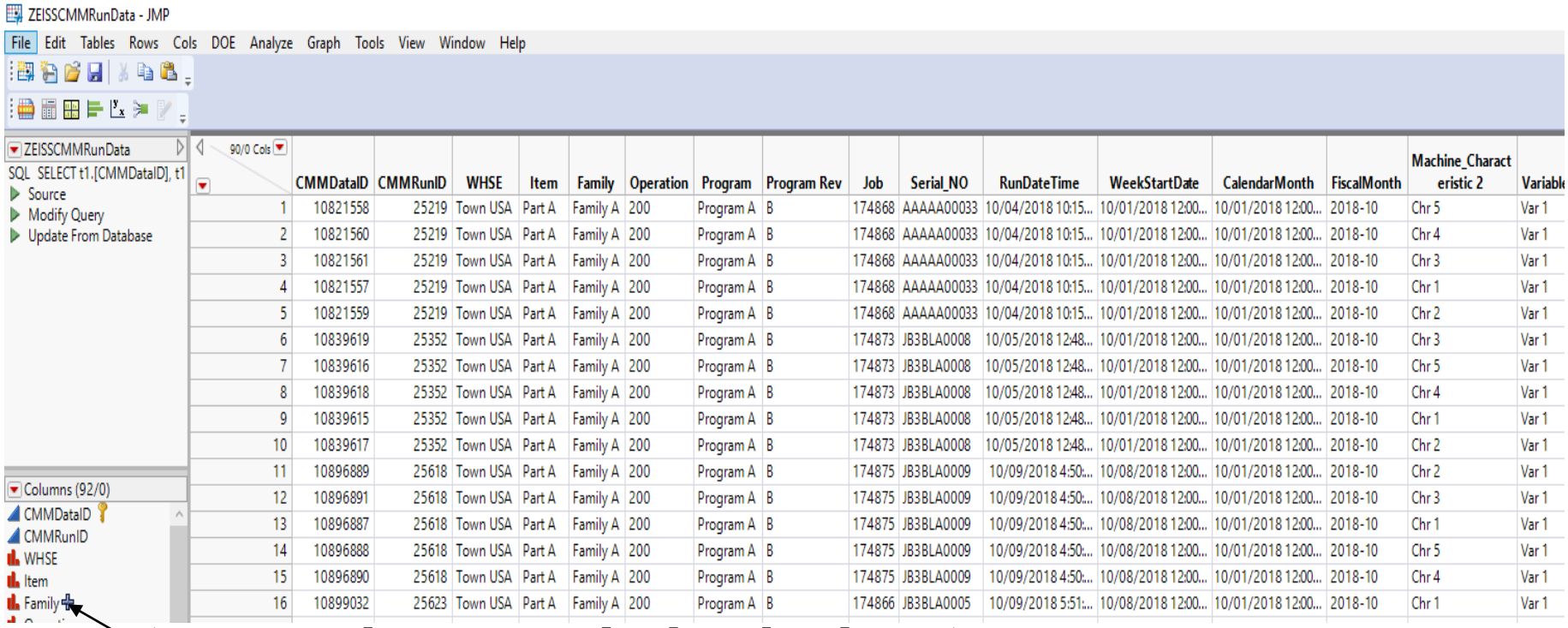
Use JMP Table QRY Builder or Link function to view/combine several JMP tables.



Example links five JMP Tables that resulted in 905 columns in one view for a complete view of the process.

Add Formulas To JMP Tables

- Create formula columns that will help analyze data like “Family”.
- Have associates use the “Update From Database” to refresh data to analyze the most current data.



	CMMDataID	CMMRunID	WHSE	Item	Family	Operation	Program	Program Rev	Job	Serial_NO	RunDateTime	WeekStartDate	CalendarMonth	FiscalMonth	Machine_Characteristic 2	Variable
1	10821558	25219	Town USA	Part A	Family A	200	Program A	B	174868	AAAAA00033	10/04/2018 10:15...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 5	Var 1
2	10821560	25219	Town USA	Part A	Family A	200	Program A	B	174868	AAAAA00033	10/04/2018 10:15...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 4	Var 1
3	10821561	25219	Town USA	Part A	Family A	200	Program A	B	174868	AAAAA00033	10/04/2018 10:15...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 3	Var 1
4	10821557	25219	Town USA	Part A	Family A	200	Program A	B	174868	AAAAA00033	10/04/2018 10:15...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 1	Var 1
5	10821559	25219	Town USA	Part A	Family A	200	Program A	B	174868	AAAAA00033	10/04/2018 10:15...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 2	Var 1
6	10839619	25352	Town USA	Part A	Family A	200	Program A	B	174873	JB3BLA0008	10/05/2018 12:48...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 3	Var 1
7	10839616	25352	Town USA	Part A	Family A	200	Program A	B	174873	JB3BLA0008	10/05/2018 12:48...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 5	Var 1
8	10839618	25352	Town USA	Part A	Family A	200	Program A	B	174873	JB3BLA0008	10/05/2018 12:48...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 4	Var 1
9	10839615	25352	Town USA	Part A	Family A	200	Program A	B	174873	JB3BLA0008	10/05/2018 12:48...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 1	Var 1
10	10839617	25352	Town USA	Part A	Family A	200	Program A	B	174873	JB3BLA0008	10/05/2018 12:48...	10/01/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 2	Var 1
11	10896889	25618	Town USA	Part A	Family A	200	Program A	B	174875	JB3BLA0009	10/09/2018 4:50:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 2	Var 1
12	10896891	25618	Town USA	Part A	Family A	200	Program A	B	174875	JB3BLA0009	10/09/2018 4:50:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 3	Var 1
13	10896887	25618	Town USA	Part A	Family A	200	Program A	B	174875	JB3BLA0009	10/09/2018 4:50:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 1	Var 1
14	10896888	25618	Town USA	Part A	Family A	200	Program A	B	174875	JB3BLA0009	10/09/2018 4:50:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 5	Var 1
15	10896890	25618	Town USA	Part A	Family A	200	Program A	B	174875	JB3BLA0009	10/09/2018 4:50:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 4	Var 1
16	10899032	25623	Town USA	Part A	Family A	200	Program A	B	174866	JB3BLA0005	10/09/2018 5:51:...	10/08/2018 12:00...	10/01/2018 12:00...	2018-10	Chr 1	Var 1

(+ sign indicates a calculated column)

Warning: The associate creating the formulas should understand process and product.

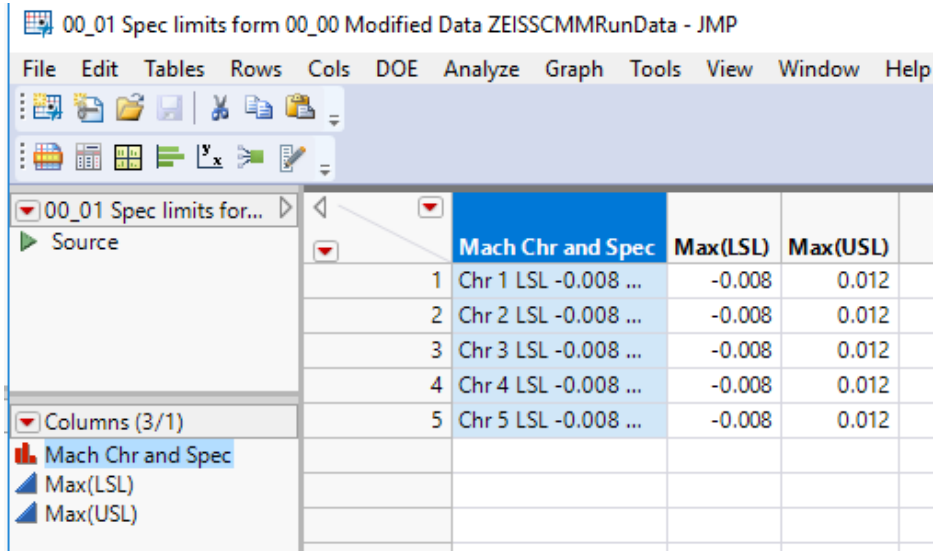
Create Specification Limit Table

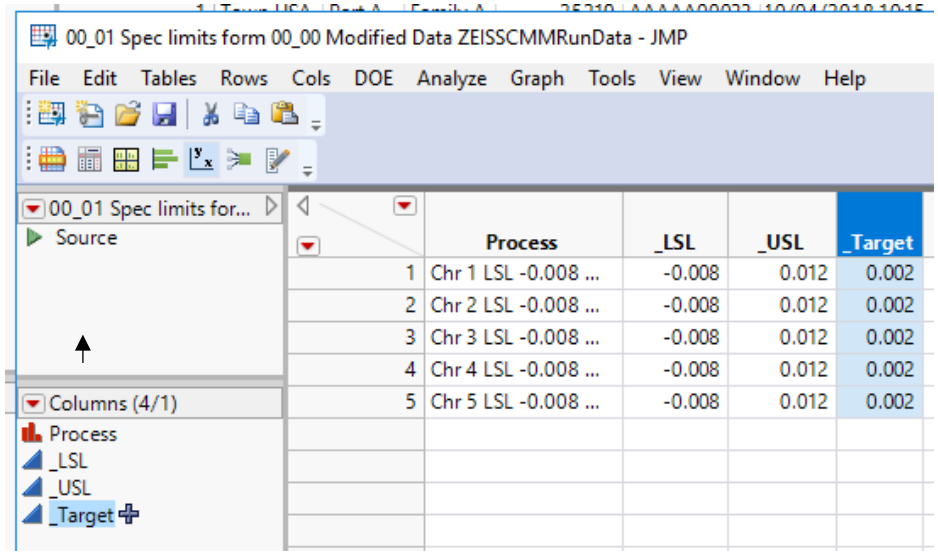
Create a script to summarize or tabulate specification limits.

Warning: Having a "_Target" column can cause problems with CUSUM charts when process mean is off target.

Use Tabulate or Split function to create specification table.

Rename columns for importing data.



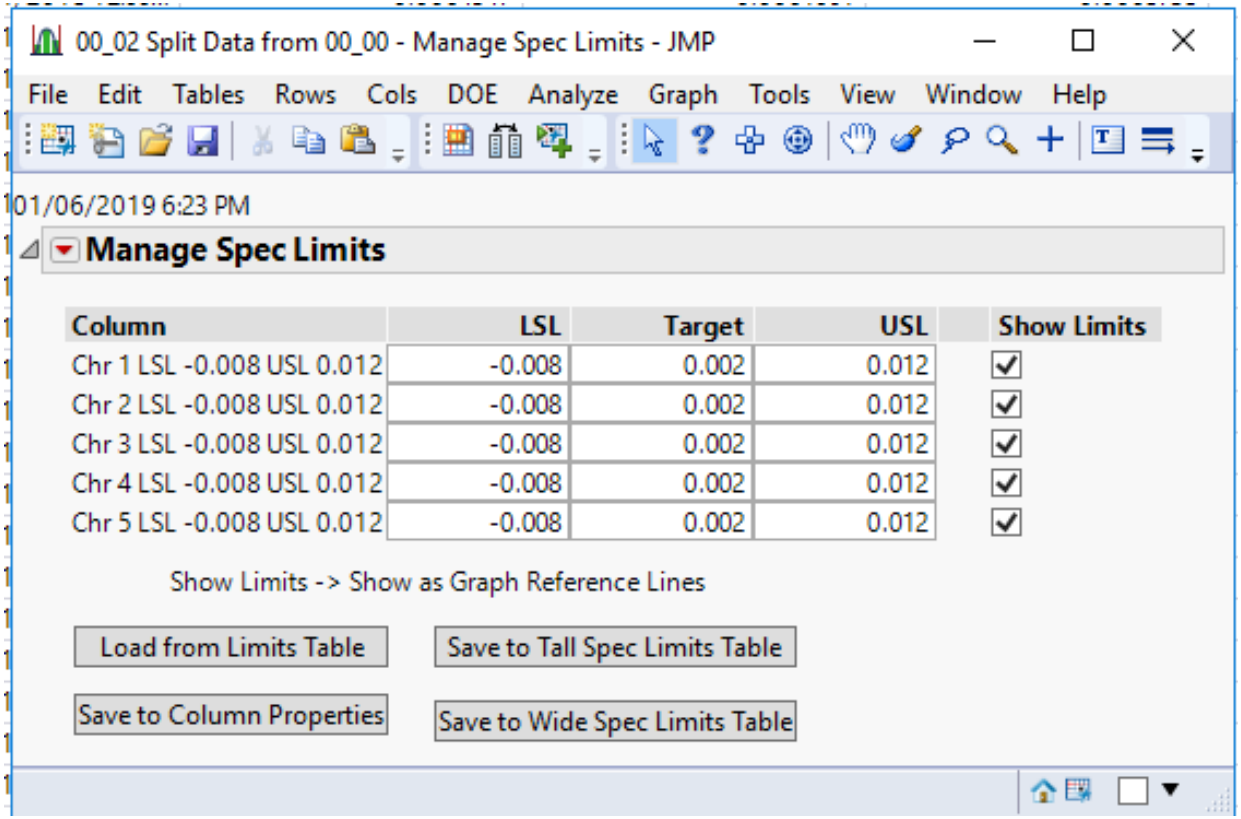


_Target (Added a Calculated Column)

Import Specification Limits

Use JMP Manage Spec Limit platform to import specifications.

Import as many specification limits as you need for the JMP table. Even over 8,000 specification limits at one time.



Use red triangle to show limits on all graphs and color out of spec.

Warning: Placing values in the "Target" column can cause problems with CUSUM charts when process mean is off target.

Improve Production Process

(Next step after retrieving data)

Identify and resolve over 80% of production issues using the following simple actions/tools:

- Modify JMP Platform defaults to meet Standard Work.
- Create JMP scripting for associates to retrieve data.
- Create JMP table scripts for associates to analyze data in the Standard Work format.

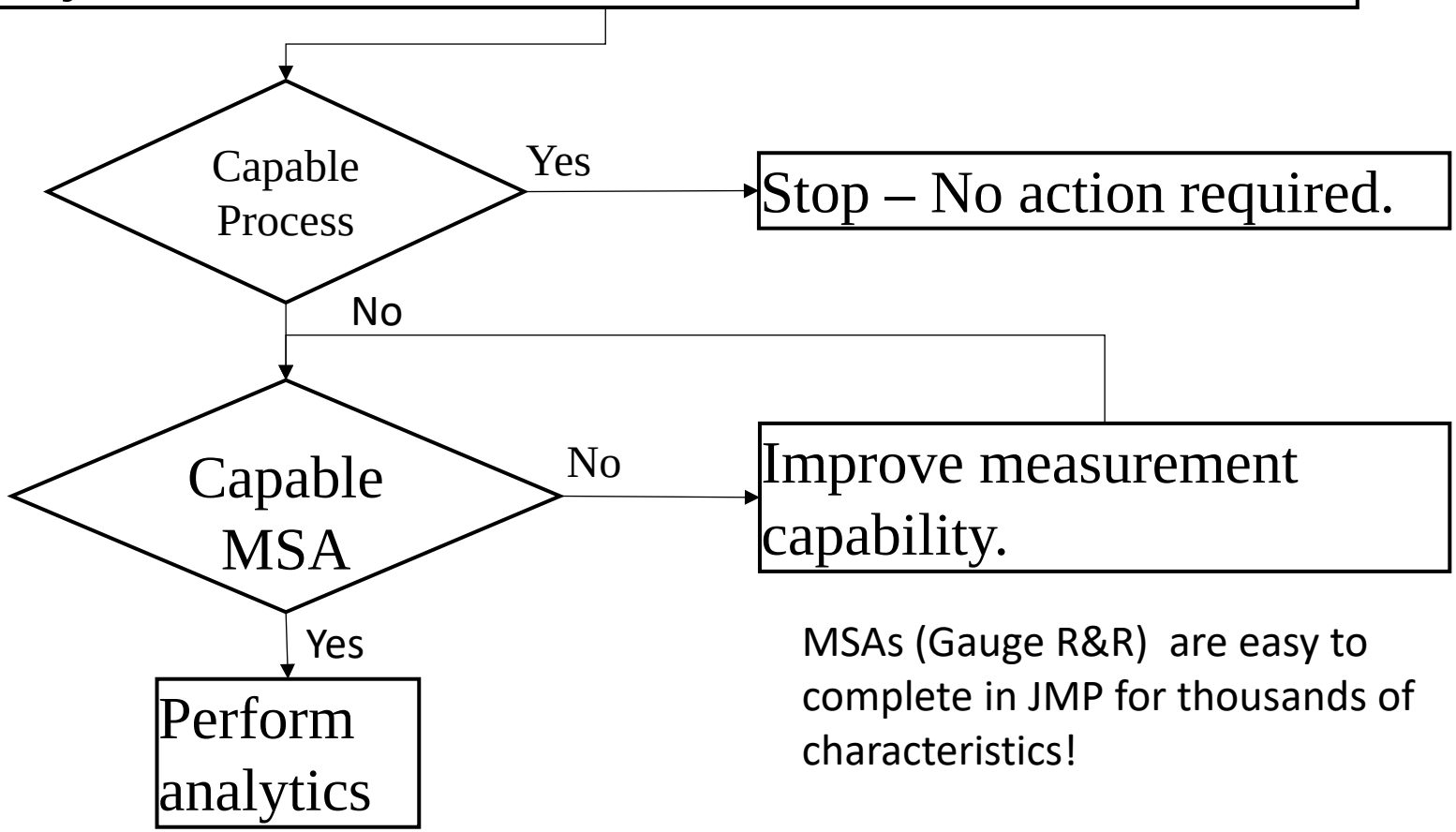
Improve Production Process

Use the following JMP platforms to improve process:

- **Process Screening (Goal Plot, Process Performance Graph, Defect Count, Drill Down)**
- Scatter Plot
- Chart builder
- CUSUM Chart
- Multivariate, Partition Platform, Scatter Plot Matrix
- Variability / Attribute Gauge Chart
- Chart Builder IR – Phase (Based on Partition Platform results)
- Response Screening
- Multivariate Methods
- Fit Model
- Profiler
- Prediction profiler

Standard Analytics

Use JMP "Process Screening" to measure the process capability for each characteristic.



MSAs (Gauge R&R) are easy to complete in JMP for thousands of characteristics!

Machine Learning won't identify inadequate measurement process and can provide misleading information.

TIM (Technical Interchange Meeting)

Use weekly TIM meetings that review standard metrics with data from Intranet reports and JMP.

Color codes for status of metric

	A	B	C	D		
1	**Product TIM Review**					
2	Note: This worksheet reports status of Agenda results for each week at a high level. It provides a sense is the process improving, stable, or deteriorating.					
3	Frequency	Color Scheme:		Improving	Stable	Statistically out of Control
4	Frequency	Week being Evaluated/Summary	Objective	Week 1	Week 2	Week 3
5	Weekly	Process Changes or machine settings changes?				
6	Weekly	Improve Project List		On-schedule		
7	Weekly	Action Item		Stable	Need More Effort	Stable
8	Weekly	Program Summary Product A		Stable	Stable	Stable
9	Weekly	Program Summary Product B		Stable	Stable	Statistically out of Control
10	Weekly	OP XX Product A Final CMM		Stable	Stable	Stable
11	Weekly	OP XX Product A Second CMM		Stable	Stable	Stable
12	Weekly	OP XX product B Final CMM		Stable	Statistically out of Control	Stable
13	Weekly	NC Tag Freq Dist Table Product A		No Outlier	No Outlier	No Outlier
14	Weekly	NC Tag Freq Dist Table Product B		No Outlier	Outlier	Outlier
15	Weekly	NC Inventory		On Target	Off Target	On Target
16	Weekly	Scrap (Percent of parts to Finish Goods)		On Target	Off Target	Off Target
17	Weekly	Submit Concession Request		Met Plan	Missed Plan	Met Plan
18	Weekly	Maintain Cross ref and data history		Met Plan	Met Plan	Missed Plan
19	Weekly	CMM Load Errors		3	2	2
20	Weekly	Product A 12 Week Defect Freq Distribution Table		No New Issue	No New Issue	No New Issue
21	Weekly	Product B 12 Week Defect Freq Distribution Table		No New Issue	New Issue	New Issue
22	Weekly	Concession Metric Control Chart YTD		Stable	Stable	Stable
23	Weekly	Issue Log		On Target	Off Target	On Target
24	Monthly	Characteristics with KPC2 Process Screening		Improving	Improving	Improving
25	Monthly	Characteristics Process Screening (Non KPC2)		Improving	Missed Plan	Improving
26	Monthly	Escape Metric		No Escapes	No Escapes	No Escapes

Metrics are compared to plan objectives and determine if they are in statistical control.

Each metric is hyperlinked to an Excel aworksheet with approved (Standard Work) analytics.

Identify Top Issues

Use JMP Process screening platform to identify the top issues across thousands of characteristics, and perform a quick drill down.

The chart below is a copy of the top 7 variables with the highest number of defects across the entire process.

Process Screening

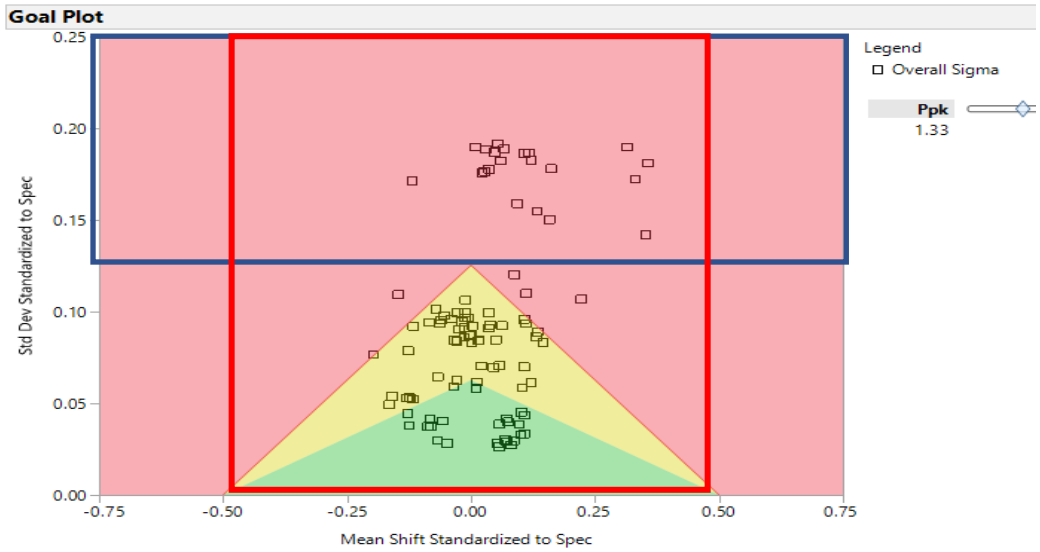
Indiv and MR

	Variability			Summary		Control Chart Alarms						Capability						
Column	Stability Index	Within Sigma	Overall Sigma	Mean	Count	Alarm Rate	Any Alarm	Test1	Test2	Test3	Latest Alarm	Ppk	Cpk	Cp	Target Index	Out of Spec Count	Out of Spec Rate	Latest Out of Spec
Variable 1	1.32	0.00975	0.01291	0.01712	206	0.05204	14	13	0	1	51	-0.055	-0.072	0.513	1.756	150	0.7282	6
Variable 2	1.30	0.01111	0.01445	0.01412	206	0.04461	12	11	0	1	51	0.020	0.026	0.450	1.271	91	0.4417	7
Variable 3	1.21	0.01045	0.0126	-0.0301	203	0.01859	5	5	0	0	21	0.129	0.156	1.116	2.882	85	0.4187	6
Variable 4	1.15	0.01162	0.01331	-0.0127	206	0.01487	4	3	0	1	148	0.057	0.065	0.430	1.096	75	0.3641	14
Variable 5	1.12	0.00347	0.00387	-0.0073	268	0.00743	2	1	1	0	2	0.231	0.259	0.961	2.109	60	0.2239	3
Variable 6	1.24	0.01193	0.01484	-0.0279	203	0.02230	6	6	0	0	21	0.159	0.198	0.978	2.340	56	0.2759	6
Variable 7	1.11	0.00349	0.00387	-0.0062	268	0.00372	1	1	0	0	2	0.324	0.359	0.956	1.790	46	0.1716	3

Use the red triangle to view the associated control charts of each selected row(s).

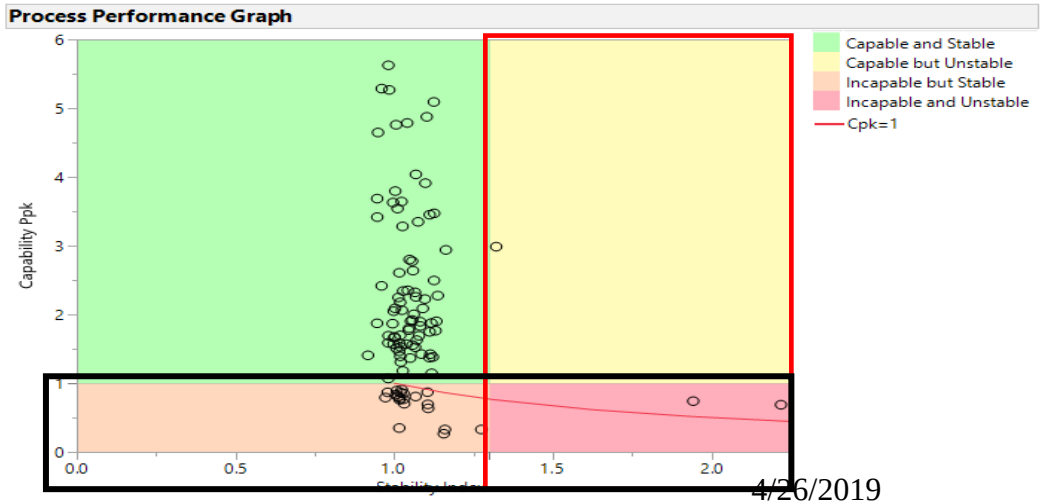
JMP Process Screening (Continued)

Evaluate thousands of characteristics using two graphs



Points within blue box reports process have too much variation to meet desired PPK.

X axis reports how far off the characteristic is from target (0.00). Reference Deming and Taguhci loss function information.

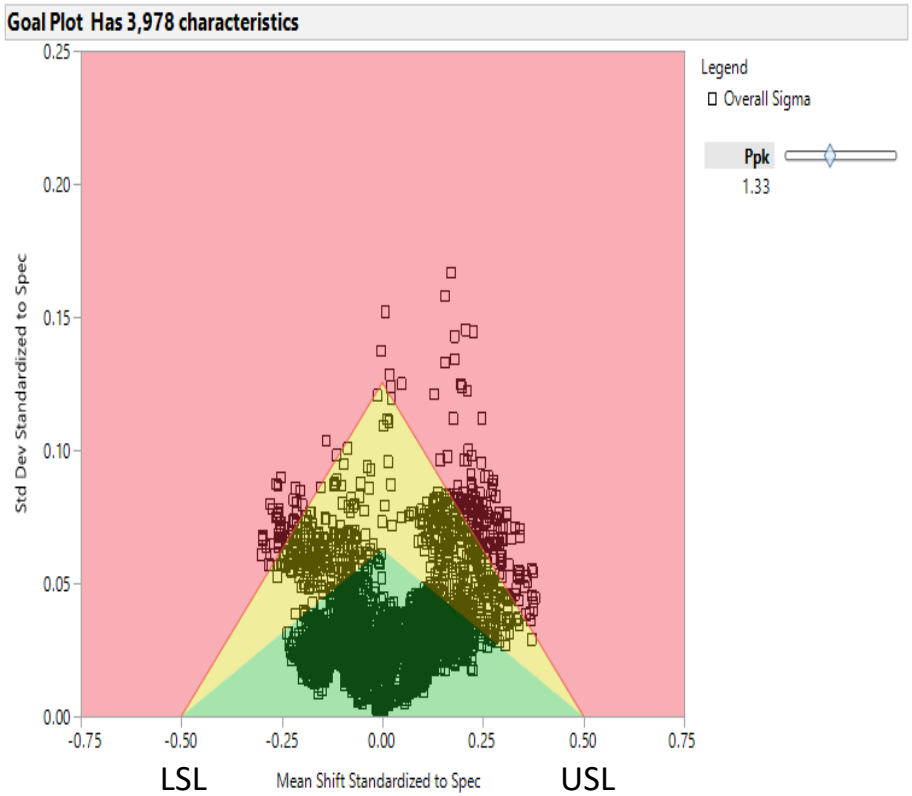


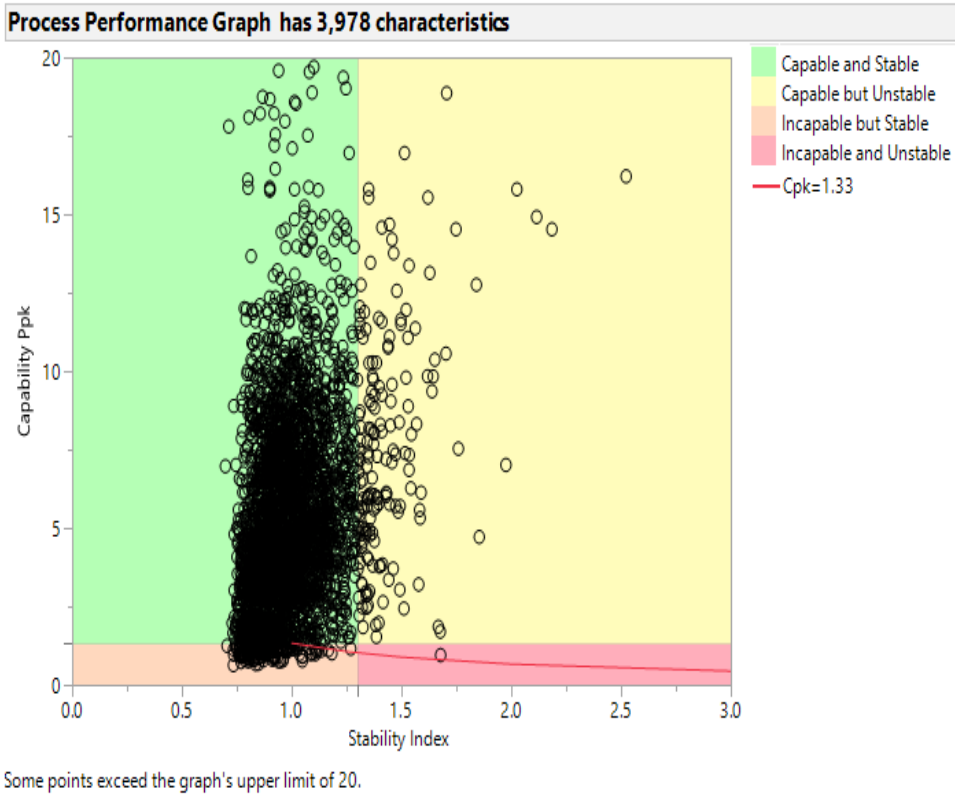
Points in red and black box may lead to more variation when process is managed by specification, and not SPC. Google Deming Funnel effect for details.

Identify Top Issues

JMP easily monitors 4K Characteristics and establish priorities for improvement.

JMP has quick, fast and efficient drill down to control charts for top issues that are biggest contributors to defects.





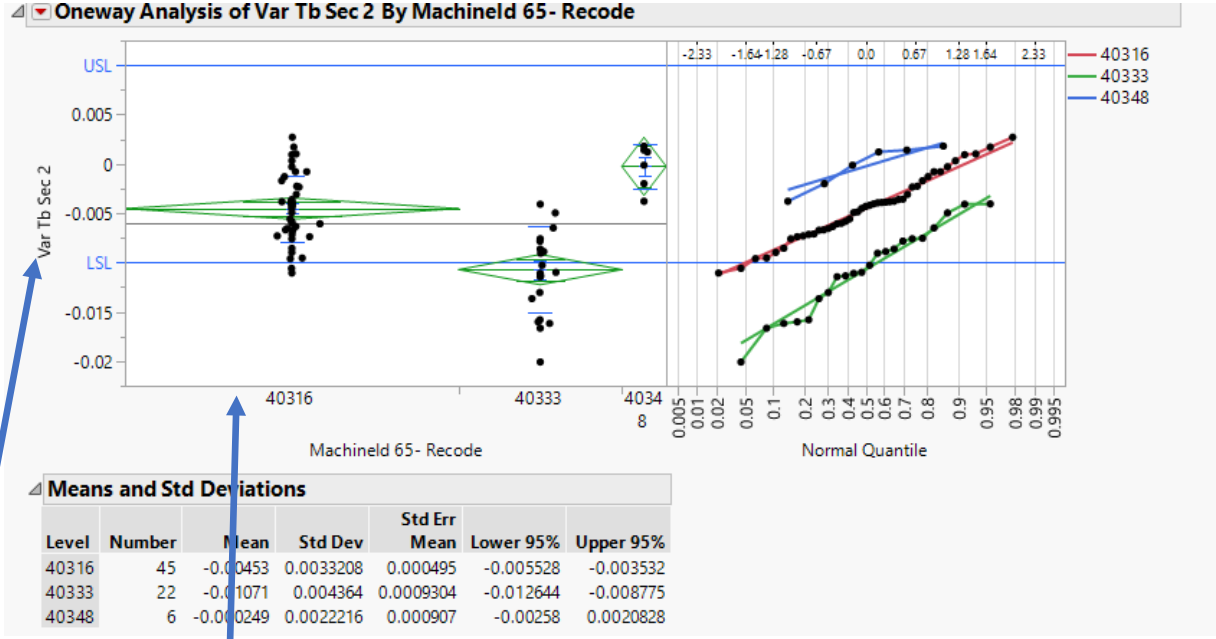
-0.50 represent Lower Specification Limit.

0.50 represents Upper Specification Limit.

Combine Data From Multiple Processes

The data in this chart uses the Final Inspection data (Y axis) and production machines (X axis) used to make parts in production.

Parts manufactured many weeks before Final Inspection measured parts.



Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
40316	45	-0.00453	0.0033208	0.000495	-0.005528	-0.003532
40333	22	-0.01071	0.004364	0.0009304	-0.012644	-0.008775
40348	6	-0.00249	0.0022216	0.000907	-0.00258	0.0020828

X axis contains the machine number that manufactured the part **several weeks** prior to Final Inspection.

Y axis has measurement data from Final Inspection.

The use of a control chart to qualify the new machine and setup would have reduced the number off target parts from 50 to 2.

Process Analysis Capability and Correlation

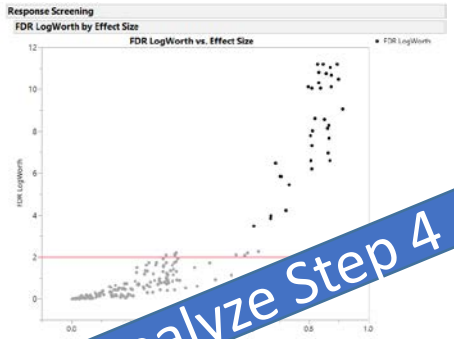
Analyze
Step 1

Process Screening
Identifies Top Issue

Column	Variability: Stability Index	Variability: Within Sigma	Variability: Overall Sigma	Summary: Mean	Summary: Count	Control Chart Alarms: Alarm Rate	Control Chart Alarms: Any Alarm	Control Chart Alarms: Test1	Control Chart Alarms: Test2	Control Chart Alarms: Test3	Control Chart Alarms: Latest Alarm	Capability: Ppk	Capability: Cpk	Capability: Out of Spec Count	Capability: Out of Spec Rate	Capability: Latest Out of Spec
Var Tb Sec 2	1.59	0.00304	0.00482	-0.006	74	0.01553	5	5	0	0	254	0.274	0.435	14	0.1892	241
Var Ta Sec 2	1.57	0.00307	0.00481	-0.0051	74	0.01553	5	5	0	0	254	0.338	0.529	12	0.1622	241
Var Tb Sec 1	1.48	0.00295	0.00435	-0.0028	74	0.00621	2	2	0	0	242	0.551	0.813	6	0.0811	255
Var Ta Sec 4	2.15	0.00136	0.00293	0.0031	74	0.03416	11	10	1	0	143	0.786	1.691	1	0.0135	167
Var Tb Sec 3	1.49	0.00234	0.0035	-0.0017	74	0.01242	4	2	2	0	205	0.789	1.178	1	0.0135	275
Var Tb Sec 4	1.92	0.00157	0.00302	0.00249	74	0.04037	13	9	4	0	143	0.828	1.594	0	0	.
Var Ta Sec 3	1.52	0.00214	0.00324	-0.0007	74	0.00932	3	2	1	0	205	0.959	1.454	0	0	.
Var Ta Sec 1	1.43	0.0031	0.00444	-0.0012	74	0.00000	0	0	0	0	.	0.663	0.948	0	0	.

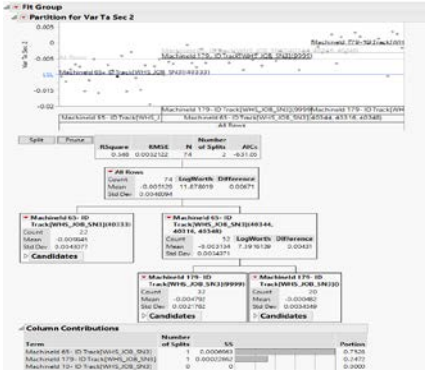
Analyze
Step 2

Response Screening
Identifies Special Causes



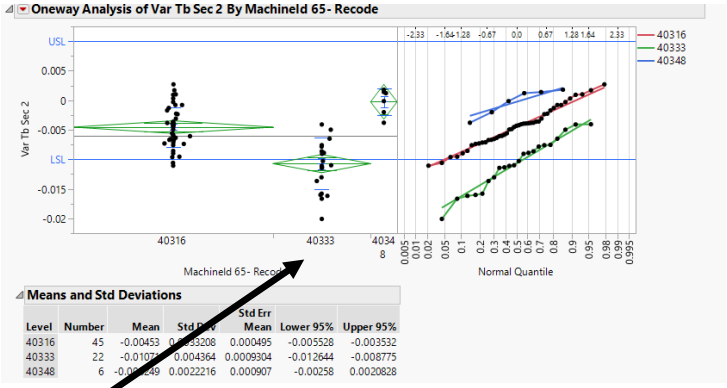
Analyze
Step 3

Partition Model
Identifies Major Source



Analyze Step 4

Graph Reports Significant Correlation to Machine ID



Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
40316	45	-0.00453	[illegible]	0.000495	-0.005528	-0.003532
40333	22	-0.01075	0.004364	0.0009304	-0.012644	-0.008775
40348	6	[illegible]	0.0022216	0.000907	-0.00258	0.0020828

The new machine manufactured 53 parts off target. Using a SPC chart would have reduced the number of parts being machined off target to 2 parts.

New Machine off target. Mean Below LSL

Use Historical Performance To Your Advantage

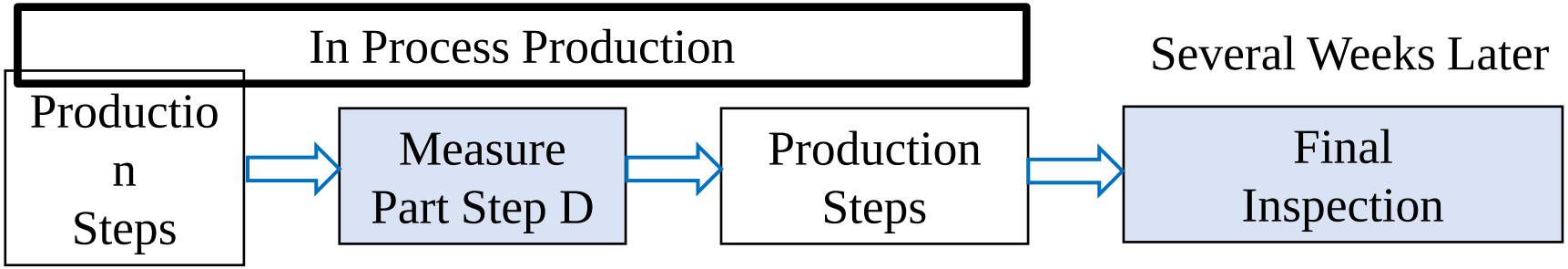
Use the following process to qualify a new machine or setup when the population mean and variance is known.

1. Create a control chart using the 95% CI of the mean and standard deviation of a known process.

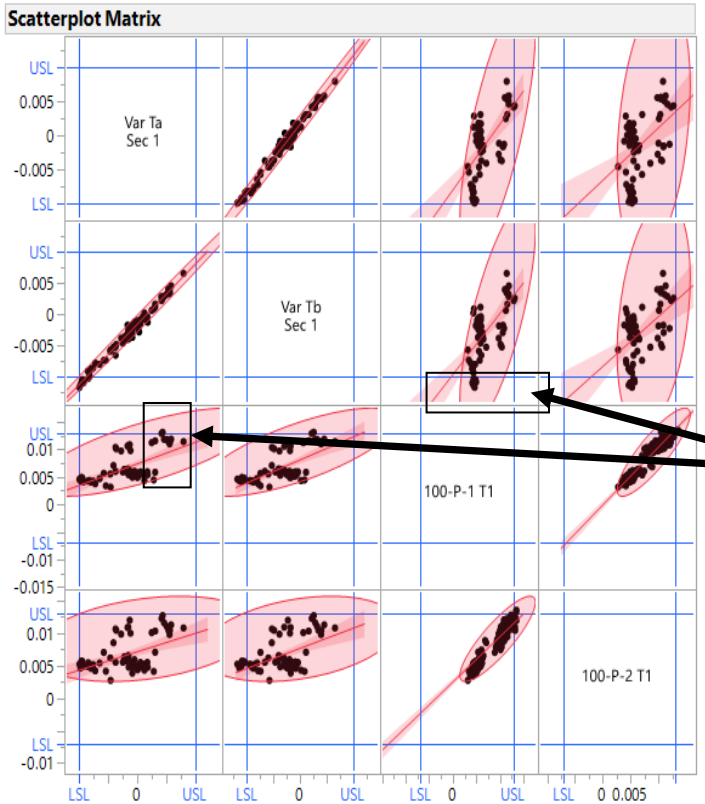
2. Use control chart to know when to investigate and/or adjust process when process isn't in statistical control. Use on-line SPC or JMP control chart platform to qualify and monitor new machines.

Process Steps One and Two will minimize rejects and the over adjustment the process. Google Deming Funnel Effect for details.

Scatter Plots and Multivariate Plots Identify Correlations



Use Multivariate and Scatter Plots to determine effectiveness of in-process me

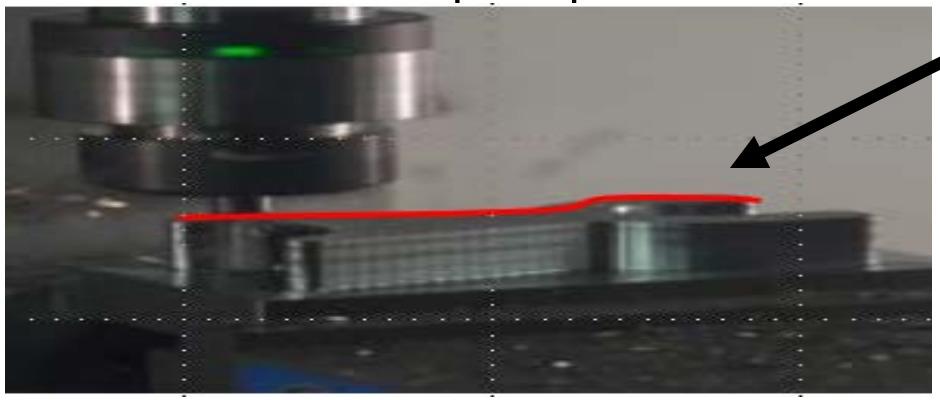


Measurement at Step D is expected to ensure characteristic is within specification at Final Inspection. Characteristics 100 P-1 11 and 100 P-2 11 are in process measurements that are measured several weeks before Final Inspection.

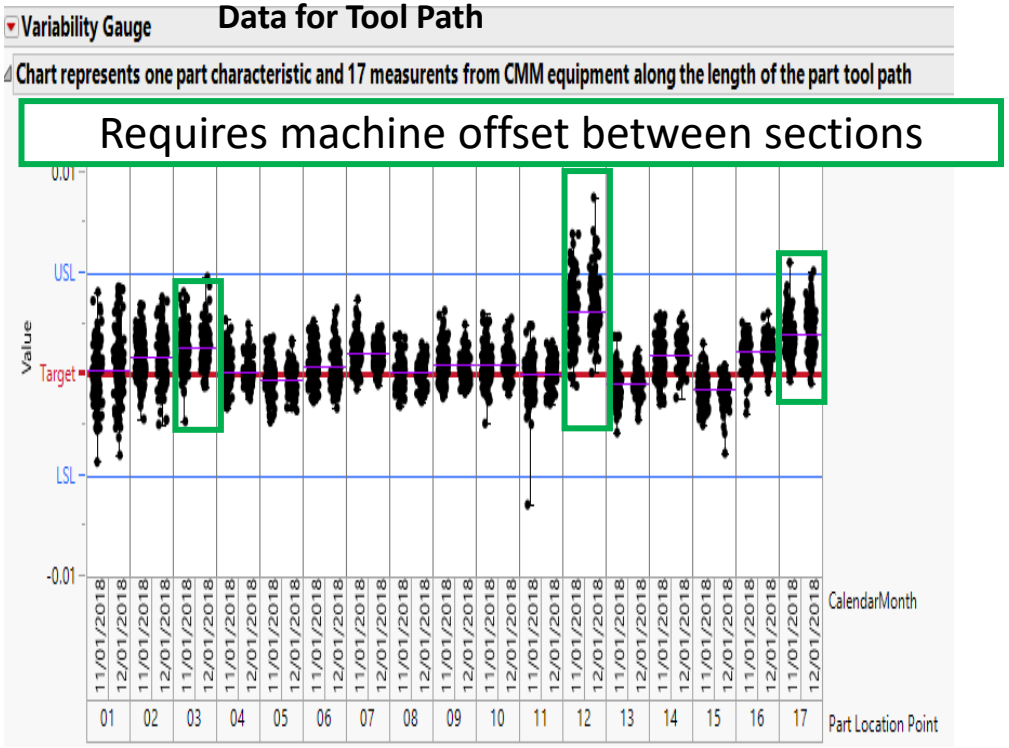
Black Box indicates the in process specification limits at Step D need to be evaluated for 100-P-T1 for predicting Var-Tb Sec 1 conformance to specification and binomial distribution.

Evaluating CNC Machine Tool Path Capability

Use Variability Attribute Gauge platform to measure the ability of a CNC machine to meet part specification within a tool path.



There are 17 points measured along the tool path, and data reports deviation from the CAD model. Y axis of 0 means the part is the same as the CAD model.



Graph reports deviation from part design (model) for each part location and each part location has two months of data.

Action:
Adjust process mean at sections 03, 12, and 17, highlighted with green boxes, to be within 95% CI of mean target of 0.

Additional Actions Completed

We used many other JMP platforms and other activities to understand and resolve unacceptable process performance. Examples of other actions are:

- JMP Response Screening, Fit model, Scatter Plot Matrix to identify interactions and validate in-process and product specifications.
- JMP DOEs, prediction profiler for machine learning.
- Obtaining data from machines, machines controllers, sensors and other sources of data.
- Using analytics to create machine learning and using algorithms in the machine controllers to dynamically adjust processes.

Results of Industry 4.0 and JMP

Current Final Yields are >90%, but still need improvement to meet objective.

- The journey continues from a starting point of 0 to 25% yields.

<u>Measurable Results</u>

- Higher skilled and empowered workforce.
- Higher yields for new products.
- Implement preventive actions, faster problem resolution, and decision making for quicker corrective actions.
- Greater use of JMP Analytics by associates.
- Greater use of Lean/Six Sigma tools by associates.

Training Associates to Enable Change

Associates using JMP should complete the following training:

- JMP free on-line "**Statistical Thinking for Industrial Problem Solving**"
  - JMP awards a "Badge" after completing training and passing a test. https://www.jmp.com/en_us/statistical-thinking.html
- Internal training and additional testing of associates using company data.
- Using outside experts to train associates in special subjects. Having an external resource that knows the latest analytical methods.
- Last step is to train associates in the use of JMP tables created for importing and analyzing data.

Skills Needed for Industry 4.0 Data Analytics

SME - Subject Matter Expert

Six Sigma	Big Data Analytics
External Resource	SME 2 Data Analytics Professional that is outsourced for medium to small companies.
Master Black Belt - No testing of individual's knowledge of databases.	SME1 – Master Black Belt Individual that has a comprehensive understanding of process and database structure. Supported by a Database Engineer.
Black Belt	Individual that has a good understanding of process and database structure.
Green Belt	Individual qualified in Statistical Thinking for Industrial Problem Solving JMP testing.
User of JMP Templates	Associates trained in JMP templates and reaction to analysis.

JMP on-line training

1) Short videos that are less than 10 minutes each subject
2) Self paced on-line training for each individual participating in training.
3) Use JMP training sessions as a reference when solving problems.

Standard Work and Leadership Responsibility

- Standard Work Definition
  Associates using the same JMP scripts tables and platforms for analyzing process/product data and presenting information at TIM (Technical Interchange Meetings.)
- Implement “Standard Work” after training associates in analytics and use of JMP template tables and scripts.
- **Each review period has set expectations for metrics and analysis that is completed prior to the review.**
- Leadership sets the expectations and participates in the use of Standard Work during TIM reviews.

Review of Accomplishments

- Created an integrated SQL database with all sources of data.
- Created JMP QRYs, Scripts, and Tables For Analytics.
- Defined Standard Work for Analytics.
- Defined standard metrics and periodic reviews.
- Performed external and internal training of associates.
- Trained & tested associates in use of databases and analytics
- Created a support structure to help associates in using analytics.
- Many engineering efforts were used to redesign tooling, implemented process adjustments, and SPC charts based on the analytics presented at Technical Interchange Meetings and subsequent investigations.

Implementing Industry 4.0 – Organizational View

- Culture – Leader involvement/accountability in implementation.
- Create a vision and plan for implementing Industry 4.0
- Consistently communicate commitment and progress for Industry 4.0 and Lean/Six Sigma to all associates.
- Create an integrated SQL database with all process information.
- Process knowledge is required for effective analytics.
- Be statistically driven in problem solving and actions.
- Create incentive for associates to learn new skills.
- Assist support functions in applying analytics and JMP to perform their function.
- Follow the process for creating an integrated SQL database.
- Hold associates accountable for analytics and reporting at TIM reviews, measuring process, and problem solving.

Thank you!

Joe Beauchemin Jr. (MBA/MBB)
A Quality and Continuous Improvement Leader that integrates Industry 4.0, Lean Six/Sigma and quality systems for breakthrough process improvements.

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Quality Methods

SAS

Correlation and Regression

SAS

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